



Curriculum 4. Architecture and Planning, Landscape

Anna Maragno

Shaping the memory of the built heritage

The digital record as new historical source



Credits of the cover image: Malraux's Shoes, 2012 (preview), single-channel video, 42 minutes © 2012 Dennis Adams
[<https://neatlyart.wordpress.com/2013/05/30/andre-malraux-chez-lui-maurice-jar-noux-over-the-last/>]

University of Trento
Doctoral School in Civil, Environmental and Mechanical Engineering
<http://web.unitn.it/en/dricam>
Via Mesiano 77, I-38123 Trento
Tel. +39 0461 282670 / 2611 - dicamphd@unitn.it

Abbreviations

ADTn	Archivio Diocesano Tridentino
AFS	Archivio fotografico storico provinciale
APTn	Archivio Provinciale di Trento
ASCTn	Archivio storico del Comune di Trento
ASTn	Archivio di Stato di Trento
AVA	Allgemeines Verwaltungsarchiv, Wien
BCTn	Biblioteca Comunale di Trento
FMSTn	Fondazione Museo storico del Trentino
MDTn	Museo Diocesano Tridentino
TLA	Tiroler Landesarchiv, Innsbruck

All chapter cover images are frames taken from the short film:
Dennis Adams, *Malraux's Shoes* (2012), <https://vimeo.com/75153260>.

Doctoral School in Civil, Environmental and Mechanical Engineering
Topic 4. Architecture and Planning, Landscape - XXXVII cycle
2021/2025
Doctoral Thesis - May 2026

Anna Maragno

Shaping the memory of the built heritage
The digital record as new historical source

Supervisors

Prof. Cristiana Volpi, University of Trento

Prof. Giovanna A. Massari, University of Trento

Prof. Raffaele Mauro, University of Trento, until September 2024,
after Prof. Marco Guerrieri, University of Trento

*To my grandmothers,
forever a tender memory in my heart.*

Contents

00 • Abstract	1
01 • Introduction	5
02 • Memory and history between past and present	13
02.1 The necessity of memory for individuals and society	14
02.2 The substance of memory and history: from historical source to digital record	30
02.2.1 <i>Hidden Trento '900: a project of Digital Public History</i>	48
02.3 Memory through images and visual media	56
03 • Archives and the challenges of the digital age	75
03.1 From analog to digital archives: the evolution of documentary memory	76
03.2 Historical-documentary research in the web era	106
03.2.1 <i>Information Technology for historical research: exploring Trento's public works through static and interactive maps</i>	132
03.3 Toward open and AI-enhanced research	142
04 • From physical object to digital resource. Creating the memory of the built heritage through digital technologies	165
04.1 Surveying as a means of preserving and understanding built heritage in the era of 'archival mania' and new visual culture	166
04.2 Data acquisition through traditional and low-cost 3D digital survey methods	182
04.2.1 <i>Reflections on the survey of Duomo square and Its surroundings</i>	192

Legend

In-depth projects and practical experiences

04.3	The digital model and Its outputs: between physical and AR/VR/MR models	200
04.3.1	The immersive experience of Adamo d'Arogno square	214
05 •	From digital resource to digital record. Constructing the digital cultural heritage	223
05.1	Digital cultural heritage: Italian and European perspectives	224
05.2	A critical review of the main guidelines for the digitisation of the built heritage	252
05.3	Becoming digital built heritage: the challenges of contemporary architectural archives	263
06 •	<i>The Imaginary Map</i> : a web platform to explore Trento's built heritage across the centuries	289
06.1	The web platform project in the research context: objectives, target users, tools and methods	290
06.2	Historical data acquisition: documentary research on Trento's urban transformations in the 19th century and the role of engineers	296
06.2.1	The 19th-century renewal of the Duomo square in Trento	308
06.3	Geometric data acquisition: survey of palazzo Pretorio and the Duomo area	316
06.4	Data processing and management: from digital resources to digital records via FAIR principles and LOD methodologies	324
06.5	Data dissemination: development of the web platform <i>The Imaginary Map</i>	338
06.5.1	User manual	350
07 •	Conclusions and outlooks	355
	References	361
	<i>Sinossi</i>	387
	Acknowledgements	393

00

Abstract



Chapter 00 • Abstract

Over the past century, historiography has witnessed an exponential expansion in the notion of sources. From the historiographical revolution of the *Nouvelle histoire* in the 1920s to the advent of the World Wide Web in the 1990s, not only has the concept of a source evolved, but so too have the typologies and abundance of sources, their relationship with historical method, and the ways in which they can be accessed. Today, this transformation is being further accelerated - often vertiginously - by artificial intelligence, which generates and analyses data on an unprecedented scale.

In the field of built heritage history, the proliferation of digital resources - including 3D virtual models, digital images, and maps - raises pressing questions about authenticity, evidential value, as well as their selection and long-term preservation. With the awareness that the data we produce and preserve today, whether consciously or not, will shape the history of tomorrow, several key questions emerge: how can digitized and born-digital materials effectively convey historical knowledge over time, and how can their accessibility and long-term preservation be ensured? Moreover, do all outputs of contemporary architectural, engineering, and construction (AEC) practice, as well as the digital resources related to built heritage available online, hold potential value as historical sources? And is it conceivable to standardize a process for creating digital resources with recognized source value?

This thesis addresses these questions through an integrated approach that combines theoretical reflection, methodological investigation, and applied experimentation. It is structured into three interrelated sections [Fig. 0.1]. The first section offers a theoretical reflection on the new meanings and instruments of memory emerging from the transition from analogue to digital, clarifying the challenges, opportunities, and risks

that this shift entails for archives, researchers, and all those engaged with the memory of built heritage.

At the heart of the inquiry lies the process through which a physical object or a born-digital file becomes a digital record, understood as a digital resource equipped with structured descriptions, capable of generating meaning and participating in processes of access, interpretation, and valorisation, thereby becoming part of digital cultural heritage (DCH). The second section, divided into two stages, investigates this process from a methodological perspective. The first stage focuses on the acquisition of geometric and qualitative data on built heritage and on the creation of digital resources through both traditional and digital survey methods. The second stage addresses the transformation of these digital resources into fully documented digital records, informed by a critical review of national and European guidelines and support tools for cultural heritage digitization and archiving.

In the final section of the thesis, this theoretical and methodological framework is applied through the practical development of a web platform designed to support historical research on the built heritage of Trento during the nineteenth century. In contrast to the current overwhelming proliferation of unstructured digitization projects and digital repositories on the web, this platform does not simply add isolated resources; rather, it aggregates, contextualizes, and connects existing digital records already available online with new born-digital outputs - such as the results of a geometric survey - within a coherent, interlinked, and semantically enriched framework. This integration is achieved through the application of the FAIR principles in the structuring of the records and the LOD principles in their publication.

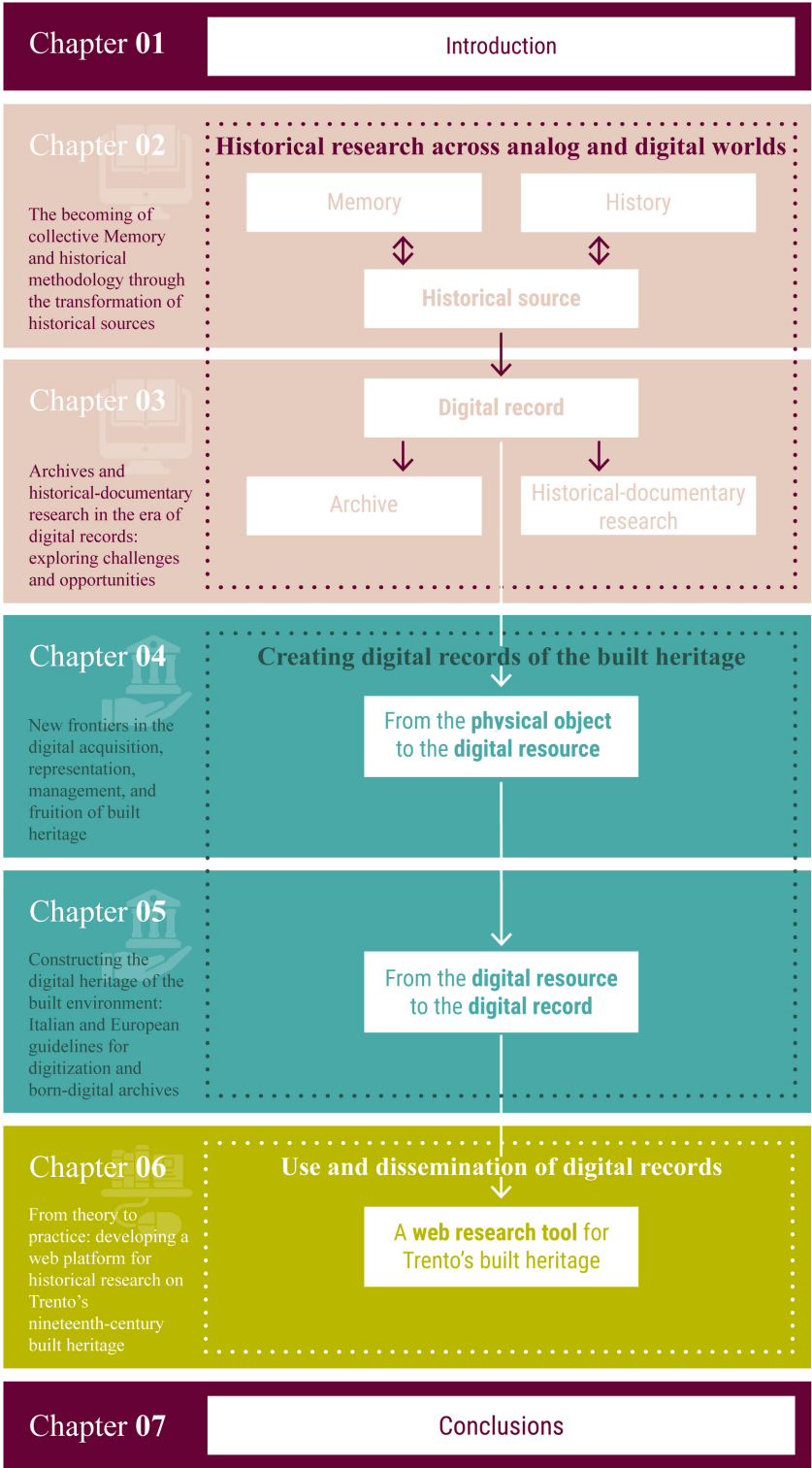
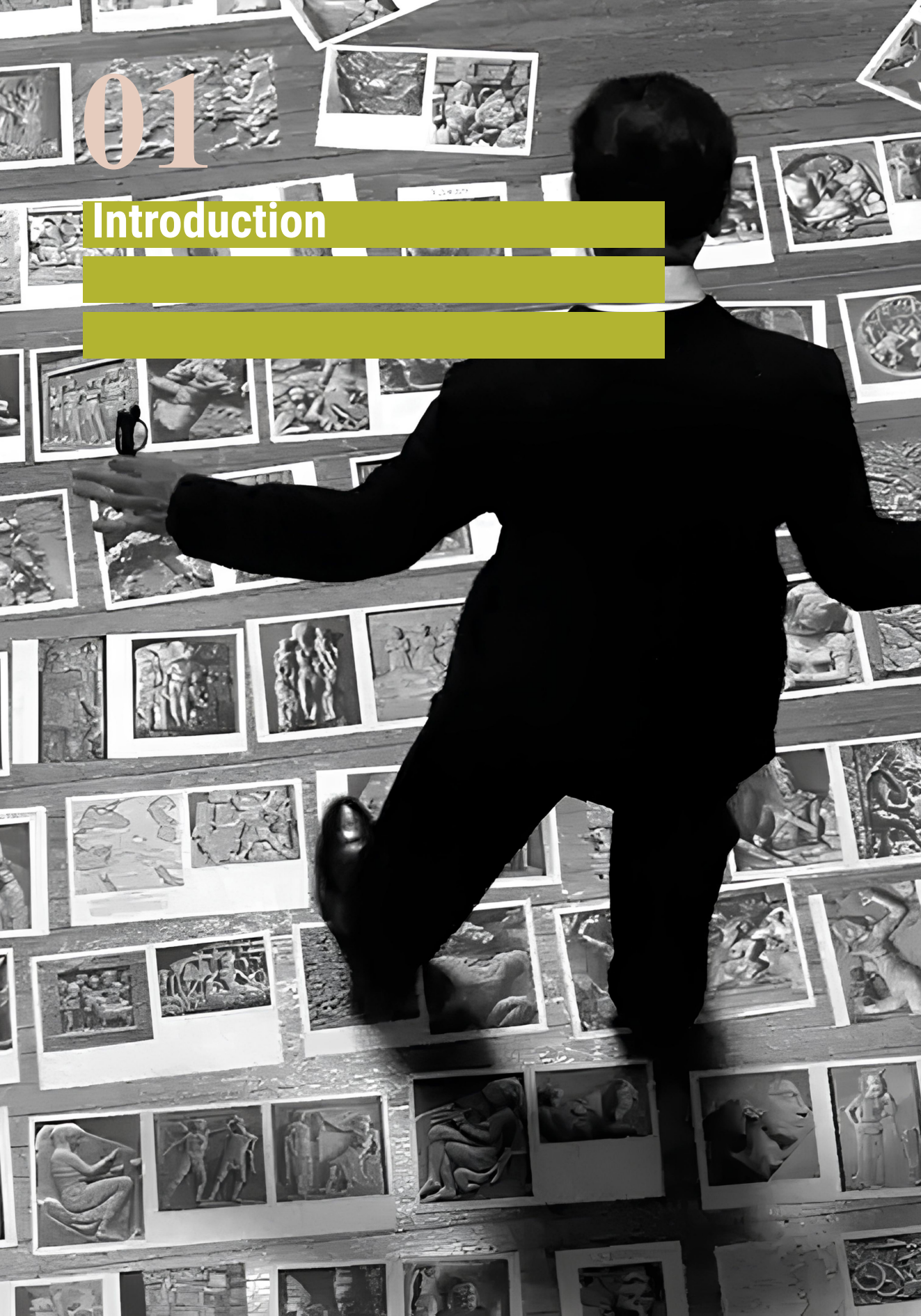


Fig. 0.1 Graphical abstract of the thesis structure.

01

Introduction



Chapter 01 • Introduction

This chapter establishes the conceptual premises of the research by framing digital memory as a central issue in contemporary historical-documentary research, particularly in relation to built heritage. Drawing inspiration from André Malraux's notion of the 'museum without walls' (*musée imaginaire*), the digital environment is introduced as a space in which cultural objects are progressively detached from their original contexts and rearticulated within new semantic and interpretative frameworks.

Within this perspective, the chapter brings together the key questions underpinning the thesis. The growing reliance on heterogeneous sources - ranging from digitized materials to born-digital records - raises critical issues concerning the reliability, authenticity, and status of digital documents as historical sources. At the same time, the exponential expansion of digital data calls for reflection on how such materials can effectively transmit knowledge over time, while ensuring accessibility and long-term preservation.

These challenges are particularly relevant in the field of built heritage, where digital technologies, surveying practices, and archival systems intersect. By outlining these issues, the chapter defines the epistemological, methodological, and cultural foundations of the study, clarifying its scope within the broader debate on memory in the digital age.

The still frame taken from the short film 'Malraux's Shoes' (2012), written and directed by Dennis Adams¹, depicts a man moving inquisitively across an extended arrangement of photographic reproductions scattered on the ground. He appears immersed in a fragmented landscape of objects, memories, and narratives, attempting to reconstruct an interpretative connection among these documentary fragments.

The video work draws inspiration from the well-known photograph by Maurice Jarnoux portraying André Malraux (1901-1976) in his studio, surrounded by the plates collected for *Le Musée Imaginaire* (1947). In this work, Malraux anticipates a radical transformation in the relationship between technology and cultural heritage, theorizing the concept of a 'museum without walls'.

From this perspective, the *musée imaginaire* emerges as a boundary-less dispositif in which technological media - at the time embodied by photographic reproduction - become the primary means for the universal accessibility of art. This project foreshadows the dynamics of the contemporary virtual museum, presciently outlining a paradigm of the digital age: a process of communicative and perceptual transposition that abstracts the physical object from its original context and relocates it within an 'imaginary' semantic horizon.

Within the fragmented setting through which Malraux moves, each image appears as an isolated fragment - a portion of the world awaiting reintegration into a broader interpretative framework. The scene thus lends itself to a dual reading: on the one hand, it celebrates the avant-garde potential of the technical reproducibility² of cultural heritage; on the other, it effectively conveys the inherent tension between the aspiration to produce knowledge and the difficulty of navigating dispersed traces of reality.

This visual suggestion strongly evokes the experience of historical-documentary research. In this domain as well, knowledge is constructed through scattered fragments, partial traces, and documents that demand

1. "In his video *Malraux's Shoes*, Adams takes on the role of André Malraux. The set for the work is a reconstruction of the iconic photograph of Malraux standing in his study with the plates of his book *The Imaginary Museum of World Sculpture* laid out on the floor before him. [...] Adams literally steps into Malraux's shoes, suit, and style - Malraux's blurring of the boundaries between history and legend in coloring his own biography makes him an ideal object of masquerade. We see the Malraux character walk on and over the images as we overhear his interior monologue, which is interrupted by outbursts of mutterings and ravings" - Dennis Adams, *Malraux's Shoes* (KENT Fine Art LLC, 2012), 8.

2. Walter Benjamin, "The Work of Art in the Age of Mechanical Reproduction," in *Illumination*, ed. H. Arendt (Schocken Books, 1969).

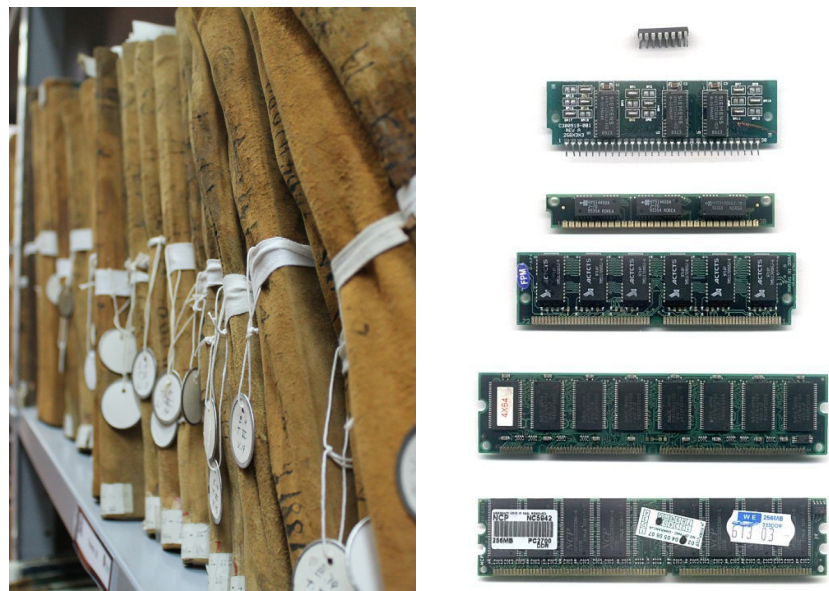
continuous interpretative recomposition. It is precisely within this tension - between the dispersion of mnemonic traces and the effort to confer coherent meaning upon them - that the premises of the present study are rooted, particularly in light of the digital era in which we have long been immersed.

In a context where memory is increasingly externalized and delegated to digital devices, the types of traces guiding historical-documentary research have become progressively more heterogeneous. Consulting databases, digital archives, and online repositories is now common practice, especially in the initial phases of research, in order to obtain preliminary indications that can orient further investigation. Researchers operate among materials that originate in analog form and are afterwards digitized, as well as those that are born digital and therefore lack any physical counterpart [Fig. 1.1].

It is above all the technical reproducibility of these digital traces that has profoundly reshaped the research landscape. On the one hand, the diversification of sources has been accompanied by an exponential growth in the quantity of available documents; on the other, this expansion has raised fundamental historiographical questions: which digital traces can be considered trustworthy? Do all digital documents possess the status of historical sources? How can digitized and born-digital materials effectively convey historical knowledge over time, and how can their accessibility and long-term preservation be ensured?

Fig. 1.1 Left: Archivo Histórico del Colegio de las Vizcaínas, Ciudad de México; right: different RAM types]

[Janetvizcainas, January 2000, https://commons.wikimedia.org/wiki/File:Archivo_Hist%C3%B3rico_del_Colegio_de_las_Vizca%C3%ADnas..jpg; Topory, https://commons.wikimedia.org/wiki/File:RAM_n.jpg?use-lang=it]



These issues become even more urgent when considering the AEC sector (Architecture, Engineering, Construction), and in particular the digital memory of built heritage. With the awareness that the data produced and preserved today - whether intentionally or not - will shape the historiography of the future, further questions arise: do all outputs of contemporary architectural, engineering, and design practices, as well as the digital resources related to built heritage, hold potential value as historical sources? And is it possible to standardize processes for the creation of digital resources with recognized documentary value?

It is from these questions that the present doctoral research originates. This thesis investigates the digital memory of built heritage not merely as a technological outcome, but as a complex cultural and epistemological process that shapes how knowledge of the built environment is produced, organized, and transmitted. It is grounded in the assumption that digitization does not simply translate pre-existing content into new formats, but actively rewrites memory through processes of selection, structuring, and interpretation. The same applies to born-digital records, which, together with digitized materials, constitute the new historical sources underpinning contemporary research. Within this framework, built heritage is understood as a privileged domain in which digital technologies, surveying practices, and archival systems converge, generating a complex infrastructure for documenting and transmitting the past.

In the field of historical-documentary investigation of the city, the consultation of traditional archives often proves to be a complex operation, constrained by practical limitations that can be laborious and, at times, frustrating.

A first critical issue lies in the structural opacity of analog archives, which present themselves as stratified systems governed by internal logics that are not always immediately decipherable. In such contexts, the mediation of archivists is frequently indispensable, yet not always sufficient, due to unprocessed collections, incomplete descriptions, or unexpected document locations. This opacity is compounded by the inherent fragmentation of archival systems: historical research is constitutively incomplete, as the past manifests itself indirectly, discontinuously, and in partial forms. Memory reconstruction thus relies on constellations of fragments dispersed across different institutions, often organized according to heterogeneous criteria. Consequently, knowledge is constructed through successive approximations, with indeter-

minacy becoming a structural condition of historical research. At the same time, the bibliographic field reveals a comparable instability: the body of references may appear either excessively abundant or strikingly sparse, generating phenomena of dispersion or isolation. In both cases, access to the scholarly tradition is never immediate, but rather the result of continuous negotiation between what is known, forgotten, or remains invisible.

These conditions highlight how historical-documentary research is intrinsically a slow temporal process, grounded in sedimentation, verification, and iterative returns to sources. Attempts to artificially accelerate this process risk compromising interpretative depth, leading to simplifications that affect not only results but the very epistemological status of historical knowledge.

Although such complexity often encourages reliance on a supposed ‘digital revolution’ as a universal solution, a critical perspective requires acknowledging the persistent limitations of digital memory - whether digitized or born-digital. The potential offered by contemporary digital infrastructures, increasingly open data practices (such as FAIR principles and Linked Open Data), and advanced analytical tools based on artificial intelligence cannot obscure enduring challenges, including technological obsolescence and fundamental historiographical concerns, such as the definition of authenticity in digital documents.

The present research progresses through an integrated approach combining theoretical reflection, methodological investigation, and applied experimentation. It is structured into three interconnected sections:

I section (chapters 02-03): historical research across analog and digital worlds

The first part of the thesis establishes the theoretical framework for understanding digital memory. Memory is examined in its historical, social, and material dimensions, with particular attention to the transformations introduced by the shift from analog sources to digital record, as well as the parallel evolution of historical methodology. Within this framework, images and visual media are analysed as central mediators of the past and as active agents in the creation of historical knowledge. The reflection then extends to archives and historical-documentary research practices, which are critically reassessed considering the profound changes brought about by the web, open access paradigms, and the growing use of computational and AI-based tools. Within this fra-

mework, a digital public history project functions as an experimental ground for translating theoretical assumptions into practice.

II section (chapters 04-05): creating digital records of the built heritage

The second section shifts the focus from archives and historical research to the memory of built heritage, examining, from a methodological point of view, the process that converts the physical object into a digital record of the built environment.

3D digital surveying is approached not merely as a technical procedure, but as a cognitive and interpretative practice capable of generating new forms of documentation. The discussion considers both traditional and low-cost 3D surveying methodologies, highlighting their potential and limitations in representing the complexity of the built environment. Central to this analysis is the digital model, understood as an interpretative construct rather than a neutral replica, with outputs ranging from precise metric representations to immersive AR, VR, and MR environments. Case studies and experimental applications are used to critically evaluate digital models as tools for questioning established relationships between representation, design, and architectural memory.

The section then addresses the systematic challenge of archiving digital built heritage, focusing on the transition from digital resource to digital record. After situating the discussion within the Italian and European contexts of digital cultural heritage, the thesis critically examines processes of digitization according to key national and international guidelines. Finally, attention is given to the emerging digital heritage of contemporary architecture studios. Building on the previous chapters, the study highlights the challenges in creating, structuring, and archiving these materials, and outlines current approaches to addressing them.

III section (chapter 06): use and dissemination of digital records

This theoretical and methodological framework is applied in the third and final section of the thesis through the practical development of the project *The Imaginary Map*, conceived as a web platform supporting historical research on public works, toponymies and urban evolution of the city of Trento during the 19th century.

The project explores the rationale for the chosen case study (the transformations of the piazza Duomo area) and presents the methodological stages of the research: from the acquisition of historical data through historical-documentary research, to architectural and urban surveying

of buildings and public spaces, and finally to the subsequent phases of data processing, management, and dissemination on the web platform. Particular attention is devoted to issues of accessibility, interoperability, and the long-term preservation of digital data, with specific reference to the application of FAIR principles and Linked Open Data frameworks, which are recognized as essential factors for ensuring the future sustainability of the digital memory of built heritage.

Each section is complemented by dedicated in-depth segments titled “In-depth study and experiences”. These provide a concise overview of some of the most significant work carried out during the doctoral program, including practical experiences, projects, essay excerpts, and coursework assignments. Some were developed collaboratively, while others were completed individually. All have contributed, either directly or indirectly, to the development of this thesis.

02

**Memory and history
between past and present**



Chapter 02 • Memory and history between past and present

The need for a collective memory is inherent in the very existence of any organized society. However, over the course of millennia, societies have not always remembered in the same way; nor have they consistently relied on the same tools to support memory, and, consequently, they have not always attributed the same meaning to it. A similar consideration applies to historical sources and methodology - concepts that evolve alongside, though not always in a linear manner, the very notion of History itself. This chapter traces the key stages in the development of collective memory and historical sources, with particular emphasis on images and visual media. Its primary aim is to establish the historical and cultural framework from which the fundamental questions and reflections explored in the subsequent chapters emerge.

02.1 The necessity of memory for individuals and society

In everyday usage, the concept of ‘memory’ may refer to two distinct yet interconnected meanings. On the one hand, it denotes individual memory, understood as the complex set of psychological functions that enables individuals to recall and actualize past impressions or information¹. On the other hand, it refers to collective memory, defined as “the recollection, or the ensemble of recollections, more or less consciously shared, of an experience lived or mythologized by a living collectivity, for which the sense of the past constitutes an integral part of its identity.”² In Marc Bloch’s well-known formulation, collective memory consists in the preservation of memories shared by an entire human group and in their influence on social life³. Within this conceptual framework, individual memory is primarily the object of study of psychology, parapsychology, neurophysiology, biology, and - when pathological aspects are involved - psychiatry⁴, whereas collective memory belongs chiefly to the domains of history, anthropology, and sociology⁵. It is in this sense that the investigation of collective memory, together with the dynamics and instruments that have shaped its evolution over the millennia up to the present, constitutes both the foundation and the horizon of the present research.

Behind the intuitive idea of collective memory, first introduced in the 1920s by the sociologist Maurice Halbwachs⁶, there lies, however, a

1. Jacques Le Goff, “Memoria,” in *Enciclopedia Einaudi* (Einaudi, 1979), 388-396.

2. Pierre Nora, “Mémoire collective,” in *La nouvelle histoire*, ed. J. Le Goff (Retz, 1978), 398.

3. Marc Bloch, *Storici e storia* (Einaudi, 1997), 210.

4. Le Goff, “Memoria”, 388-396.

5. “Maurice Halbwachs [...] da sociologo empirista non parte da un punto di vista storico-culturale, il suo interesse specifico è determinare cosa tenga insieme gli esseri viventi come gruppo. Per questa strada egli scopre l’importanza dei ricordi collettivi come potente mezzo di coesione. [...] Non sono solo i ricordi a stabilizzare il gruppo, ma anche il gruppo a stabilizzare i ricordi in quanto tali” (Aleida Assmann, *Ricordare. Forme e mutamenti della memoria culturale*, il Mulino, 2002, 146).

6. Maurice Halbwachs (Reims, 1877; Buchenwald, 1945), influenced by his lycée teacher Henri Bergson, initially devoted his studies to philosophy, before definitively turning to sociology in 1904. In 1905 he began collaborating with Émile Durkheim’s journal, *L’Année sociologique*, for which he soon became one of the most active and prominent members of the group gravitating around the review. Halbwachs taught sociology first in Strasbourg and later at the Sorbonne. Between 1920 and 1945 he devoted three distinct volumes to the problem of the relationship between memory and society: *Les cadres sociaux de la mémoire* (1925), *La topographie légendaire des Évangiles en Terre sainte. Étude de mémoire collective* (1941), and *La mémoire collective*, published posthumously in 1950. In 1944, concurrently with his appointment to the Collège de France, he was deported by the Germans, and on 16 March 1945 he died in the Buchenwald concentration camp [Jan Assmann, *La memoria culturale. Scrittura, ricordo e identità politica nelle grandi civiltà antiche* (Einaudi, 1997), 11; Paolo Jedlowski, *Memoria, esperienza e modernità. Memorie e società nel XX secolo* (FrancoAngeli, 2002); Paolo Jedlowski, “Introduzione,” in *La memoria collettiva*, ed. M. Halbwachs (Edizioni Unicopoli, 1987), 7-30. “Halbwachs - writes Paolo Jed-

complex and articulated set of processes and interpretations to which the term refers. Particularly within the sociological field, a lively debate concerning the nature and modes of transmission of collective memory animated the twentieth century until recent years⁷, leading to the fragmentation of the concept into a multitude of variations and meanings⁸. However, since this issue is not strictly connected to the present research and in order to avoid confining to a few lines the rich and complex discussion surrounding the various sociological interpretations of collective memory, the reader is referred to the bibliographical references provided in the notes for further study⁹.

In the present context, it is instead essential to emphasize the existence of a link between individual and collective memory. Despite the limitations of Halbwachs's theories, repeatedly highlighted by historians and sociologists¹⁰, one of the major merits attributed to his research lies in the recognition of the plurality of collective memories. For the French

lowski - left an extraordinarily extensive body of work, of a theoretical depth often more complex and layered than it appears at first glance, whose themes range from statistics to demography, from economic sociology to social psychology, from the analysis of the needs of the working class to the study of memory, reasoning, and emotions" (Paolo Jedlowski, "Introduzione," 7).

7. "In recent years, however, Halbwachs's work has experienced a renewed interest within sociology as well, as evidenced by the reissue of his writings in French, by numerous new translations, and by a series of theoretical and empirical studies that refer directly to them. The reasons for this renewed interest in the sociology of memory, and in Halbwachs in particular, would in themselves constitute an interesting topic of discussion. Among these, it is sufficient here to recall the revival of the biographical method or, in other contexts, the renewed attention that the vitality of traditions and collective memories has aroused among scholars of modernization processes. In some respects, moreover, a sociological theory of memory is required by developments in action theory, and in particular by the study of the forms through which a collective identity is preserved within social movements: in this sense, the interest in memory derives directly from the renewed focus on the temporal dimension of social phenomena" (Jedlowski, *Memoria, esperienza e modernità*, 45). See also the studies by Aleida Assmann and her husband Jan Assmann, two of the most authoritative voices in the field of cultural memory.

8. Halbwachs himself theorized the existence of multiple types of collective memory: family memory, the memory of the religious group, and class memory (Bloch, *Storici e storia*, 212).

9. See: Assmann, *Ricordare*; Assmann, *La memoria culturale*; Giovanni Ciappelli, "Memoria collettiva e memoria culturale. La famiglia fra antico e moderno," *Annali dell'Istituto storico italo-germanico in Trento*, no. 29 (2003): 13-32; Diego Guzzi, "Per una definizione di memoria pubblica. Halbwachs, Ricoeur, Assmann, Margalit," *Scienza & Politica. Per Una Storia Delle Dottrine* 23, no. 44 (2011): 27-39, <https://doi.org/10.6092/issn.1825-9618/2731>; Paolo Jedlowski, "Memoria," in *Parole chiave. Per un nuovo lessico delle scienze sociali*, ed. A. Melucci (Carocci, 2000), 139-147; Jedlowski, *Memoria, esperienza e modernità*; Paolo Montesperelli, *Sociologia della memoria* (Laterza, 2003).

10. By way of example, it is worth recalling the position advanced by Marc Bloch, who, while acknowledging the originality and validity of certain formulations proposed by Halbwachs, nevertheless observes that: "How are collective memories transmitted, within the same group, from generation to generation? The solution must evidently vary according to the group under consideration; but the question is too serious to be neglected. Halbwachs, it seems to me, has done little more than touch upon it" (Bloch, *Storici e storia*, 214). Similarly, Jan Assmann identifies the weak point of Halbwachs's approach in his 'presentism' [*Präsensismus*], emphasizing that theories excessively flattened onto the present lack temporal depth and minimize the influence that the past continues to exert on the present (Guzzi, "Per una definizione di memoria pubblica," 33-34).

sociologist, “the memory of society fragments into a multiplicity of local collective memories, and the memory of the individual comes to be situated as a ‘point of intersection’ among different collective memories”¹¹. This plurality derives from the complexity of modern society: “the more complex a society is, that is, the more it is composed of a multiplicity of groups that coexist and intersect, the more numerous are the local collective memories that are formed within it. Different segments of the past are preserved in different groups, and different interpretations compete for the image of the past where the objects of memory overlap”¹². Indeed, each individual “does not belong to only one group; each of us is integrated into a more or less considerable number of small or large societies upon which we depend, [...] even in our mental operations that appear to be the most private”¹³. It is therefore no coincidence that “collective memory has constituted an important stake in the struggle for power conducted by social forces. To seize control of memory and forgetting is one of the foremost concerns of classes, groups, and individuals who have dominated and continue to dominate historical societies”¹⁴.

The necessity of a collective memory is inherent in the very existence of an organized society, as soon as it moves beyond the narrow limits of early forms of human social organization structured around familial ties. However, throughout history, societies have not always remembered in the same way, nor have they always possessed the same instruments to aid remembrance, and consequently they have not always attributed the same significance to memory¹⁵. In this regard, it is possible to identify a first significant distinction between memory in non-literate societies and in those that possess both oral and written memory¹⁶. According to Jacques Le Goff, among non-literate peoples collective memory is primarily organized around

11. Jedlowski, *Memoria, esperienza e modernità*, 49.

12. Jedlowski, *Memoria, esperienza e modernità*, 49.

13. Bloch, *Storici e storia*, 212.

14. Le Goff, “Memoria”, 1070.

15. Jedlowski, “Memoria,” 139-147.

16. Le Goff, “Memoria,” 1070. As emphasized by the anthropologist Jack Goody, “oral representation in societies that possess writing is undoubtedly influenced, to varying degrees, by the presence of writing and should not be identified with the products of exclusively oral cultures. This is not a purely academic issue, since it affects our interpretation of much of ancient literature and of literary techniques, which many scholars describe as being characterized by the so-called oral style. [...] Many techniques that we consider oral, such as assonance [...], the formula-based composition of the Greeks, and even the widespread use of rhyme, appear to be rare in cultures lacking writing” (Jack Goody, *Il potere della tradizione scritta*, Bollati Boringhieri, 2002, 35).

three major areas of interest: “the collective identity of the group, which is founded on certain myths, more precisely origin myths; the prestige of the dominant family, expressed through genealogies; and technical knowledge, which is transmitted through practical formulas heavily imbued with religious magic”¹⁷. In these societies, the recording of memory is entrusted to ‘memory-men’: elders, bards, priests, who in traditional human groups discharge the highly important function of maintaining the group’s cohesion¹⁸. These ‘genealogists’, who act as custodians and, when necessary, narrators of myth, do not, however, perform a function comparable to that of schoolteachers; rather, no form of automatic or mechanical learning develops around them¹⁹. The memory conveyed by these figures is an internal memory, which does not record and transmit facts ‘word for word’, but rather reconstructs knowledge in a generative way, making it susceptible to new variations²⁰. Occasionally, in non-literate societies, exceptions to the total reliance on individuals’ internal memory can be observed in the form of visual mnemonics. In such cases, “mnemonics serve only to stimulate internal memory; they cannot replace it like a book or a computer. Mnemonic aids are material objects and sometimes graphic signs that do not constitute true writing, because they do not record actual linguistic expressions, but merely make a vague reference to them”²¹. One of the most famous examples of mnemonic devices is the *quipu*, a distinctive tool used in Inca society. It consisted of cords of varying colors and lengths, knotted and arranged in different ways, which made it possible to recall distant events as well as complex statistical information or financial and accounting data²² [Fig. 2.1].

The emergence of writing, understood as the practice of inscribing symbols on a physical *medium*²³, is linked to a radical transformation of collective memory. “The act of expressing oneself through graphic traces responds to a profoundly human need, which cannot be confined to a specific point in time or space, but which always exists within us in a latent state and merely asks to be channelled and regulated within a

17. Le Goff, “Memoria,” 1073.

18. André Leroi-Gourhan, *Gesture and Speech* (MIT Press, 1993), 259; Le Goff, “Memoria,” 1072.

19. Le Goff, “Memoria,” 1072.

20. Goody, *Il potere della tradizione scritta*, 36-39; Le Goff, “Memoria,” 1072.

21. Goody, *Il potere della tradizione scritta*, 39.

22. Elio Lodolini, *Archivistica. Principi e problemi* (Franco Angeli, 1990), 11.

23. Pietro Rossi, *La memoria del sapere* (Laterza, 1988), 11.

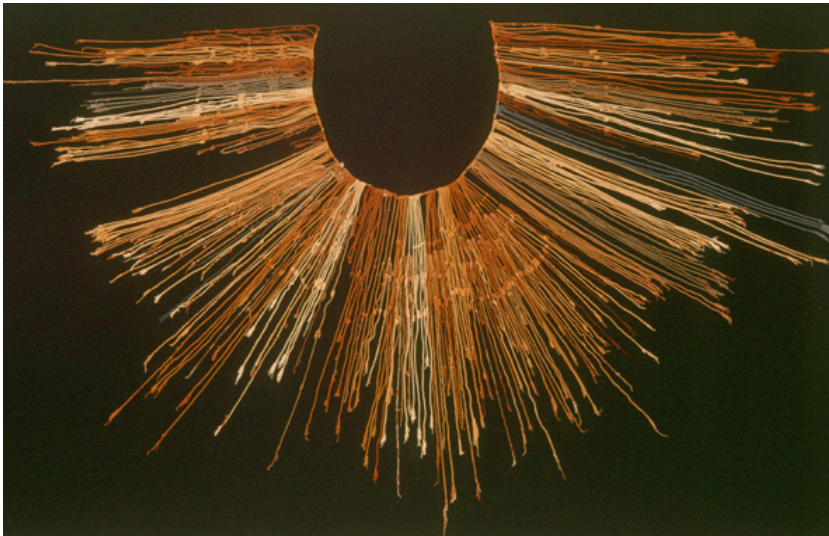


Fig. 2.1 An Inca *quipu* from the Larco Museum in Lima.

[Claus Ableiter, <http://creativecommons.org/licenses/by-sa/3.0/>]

system”²⁴. The appearance and dissemination of writing thus correspond to a progressive externalization of memory, namely the deposition of memory in objects external to ourselves, which symbolically recall both the continuity of time and that of our identity²⁵. Among these objects, the most evident mnemonic role is played by writing and its physical supports. “Through a system of signs, writing allows certain contents intended by the subject to become external”, Jedlowski observes; “they are objectified into traces whose preservation reveals the limits of subjective memory”²⁶. From this perspective, drawing - gradually becoming more stylized and ultimately reduced to essential signs - constitutes the first true form of writing, as exemplified by Chinese ideograms and Egyptian and Aztec hieroglyphs²⁷ [Fig. 2.2].

The remarkable advancement of collective memory triggered by the codification of writing materializes in the emergence of two new forms of memory. The first is commemoration, that is, the celebration of a memorable event through a commemorative monument. Memory then assumes the form of inscription, leading, in the modern era, to the development of an auxiliary science of history: epigraphy²⁸. In the ancient Near East, for example, commemorative inscriptions resulted in the proliferation of monuments such as stelae and obelisks; however, it was during ancient

24. Rossi, *La memoria del sapere*, 11.

25. Jedlowski, *Memoria, esperienza e modernità*, 85-86.

26. Jedlowski, *Memoria, esperienza e modernità*, 85-86.

27. Lodolini, *Archivistica*, 12; Rossi, *La memoria del sapere*, 11.

28. Le Goff, “Memoria,” 1073.

Fig. 2.2 Hieroglyphs, Komombo temple.

[Aoineko, March 2000, https://commons.wikimedia.org/wiki/File:Egypt_Hieroglyphe2.jpg#/media/File:Egypt_Hieroglyphe2.jpg]



Greek and Roman times that inscriptions reached their fullest expression. In temples, cemeteries, public squares and avenues, and along roads, inscriptions accumulated, filling the Greco-Roman world with an extraordinary effort of commemoration and perpetuation of memory²⁹. The second form of memory associated with writing is the written document produced on a medium specifically intended for this purpose. In this case, writing serves as a means of ‘storage’ for information, enabling its transmission across time and space, while also allowing for the re-examination and correction of sentences and even of individual words intended to be preserved³⁰. Thus, with writing, operations not unknown to orality - such as cataloguing, classification, and enumeration - become autonomous practices, even ends in themselves³¹. From this point onward, there emerges a substantial production of documents written on a wide variety of supports: leaves, wood, metals, clay, skin, papyrus, parchment, and paper. The majority of ancient documents written on perishable materials have nevertheless been lost; for instance, almost all those from India, most likely dating back to the third millennium BCE, have disappeared.³²

29. Le Goff, “Memoria,” 1073.

30. Le Goff, “Memoria,” 1074; Rossi, *La memoria del sapere*, 13.

31. Rossi, *La memoria del sapere*, 13.

32. With regard to Italy, “very few Greek and Roman archives have survived to the present day. [...] Among the Greek examples, one may note a small archival corpus consisting of thirty-nine documents, written on bronze tablets and dating to the fourth-third centuries BCE, originating from the sanctuary of Zeus at Locri in Calabria. Roman evidence, by contrast, consists of documents written on wooden tablets, mostly waxed, from Pompei and Ercolano, including part of the

According to Leroi-Gourhan, in the early stages of its diffusion, writing was used selectively to record matters concerning the apex of the social system and “records [exclusively] that which is neither manufactured nor experienced in everyday life”. What was committed to writing, therefore, included financial and religious acts, dedications, genealogies, the calendar - all those things within the new structures of the city that could not be completely consigned to memory either through gesture sequences or through products³³.

In this context, it is not surprising that a form of royal memory began to take shape: a deliberate program aimed at preserving the deeds of the king through the creation of dedicated memory institutions such as archives, libraries, and museums. Notable examples include the palace of Mari, residence of King Zimri-Lim (1782–1759 BCE), which functioned as a true archival center where the monarch collected numerous tablets documenting the most significant events of his reign. Later, in the Hellenistic period, similar initiatives emerged in the form of the great Library of Pergamon, founded by Attalus, and the renowned Library of Alexandria, with its celebrated Museum established by the Ptolemies³⁴. The transition from oral to written memory finds a particularly emblematic case in archaic Greece. A telling example is the institution of the *mnêmon* (μνήμων), a key figure in the emergence of memory as a social and legal function. Entrusted with recalling judgments delivered orally by judges and agreements concluded verbally between private individuals, the *mnêmon* preserved the past in view of future judicial decisions³⁵. “With the development of writing, these ‘living memories’ are transformed into archivists”³⁶.

Throughout the Middle Ages, a relative balance persisted between oral and written memory, at least among the *litterati*, who employed writing as a support for oral recollection. This coexistence remained particularly vibrant in the literary sphere, in schools, and within the emerging university system, reflecting the conviction of an age in which “to know by heart is to know”³⁷.

private archive (153 documents) of the banker L. Caecilius Iucundus at Pompei, dating to shortly before the eruption of Vesuvio that buried the city. Of the Etruscans, only isolated documents have survived, most notably the gold tablets of Pyrgi (Santa Severa, in the province of Rome)” (Lodolini, *Archivistica*, 12; Rossi, *La memoria del sapere*, 13).

33. Leroi-Gourhan, *Gesture and Speech*, 260.

34. Le Goff, “Memoria,” 1075.

35. Lodolini, *Archivistica*, 12; Rossi, *La memoria del sapere*, 11.

36. Le Goff, “Memoria,” 1077.

37. Le Goff, “Memoria,” 1086-1087.

For a considerable period, royal administrations maintained only modest and itinerant archives. It was only around 1200 CE, in Europe, that the archives of royal chanceries and notarial archives began to assume a more stable and institutionalized form. With the growth of cities, urban archives also spread, functioning as repositories of collective and civic identity and, for this reason, being jealously guarded by municipal authorities³⁸. At the beginning of the early modern period, the introduction of printing marked one of the technological revolutions that most profoundly reshaped the history of memory. Through print, “memory is further externalized and progressively acquires new forms of institutionalization, offering itself to a bureaucratization that takes shape in the increasingly systematic collection of administrative, economic, diplomatic, and family documents”³⁹.

The advent of print radically altered the relationship between individuals and collective memory. Whereas “the texts set down in ancient or medieval manuscripts were intended to be committed to the reader’s memory for life, at least firmly enough to enable readers to find their way around the manuscript with ease. [...] The same is by no means true of printed matter, which soon went beyond the range of traditional subjects. Readers not only obtained access to an enormous collective memory whose entire contents they could not possibly register but were also frequently confronted with new material”⁴⁰. Print thus expanded the scale of available knowledge beyond the limits of individual memorization, reshaping both intellectual practice and cultural transmission. Although printing profoundly transformed Western collective memory, it did so gradually. Its effects unfolded even more slowly in China, where printing had been in use since the eleventh century CE; yet, in the absence of movable type and typographic techniques [Fig. 2.3], it remained bound to the labor-intensive practice of woodblock printing⁴¹ until the nineteenth century, when Western mechanical methods were introduced in the East. Because of these technical constraints, printing did not develop on a massive scale in China. Nevertheless, its impact on memory among the educated strata was significant, particularly in the preservation and transmission of scien-

38. Le Goff, “*Memoria*,” 1086.

39. Jedlowski, *Memoria*, 139-147.

40. Leroi-Gourhan, *Gesture and Speech*, 261.

41. A print made by pressing a block of wood with design cut on it onto paper.

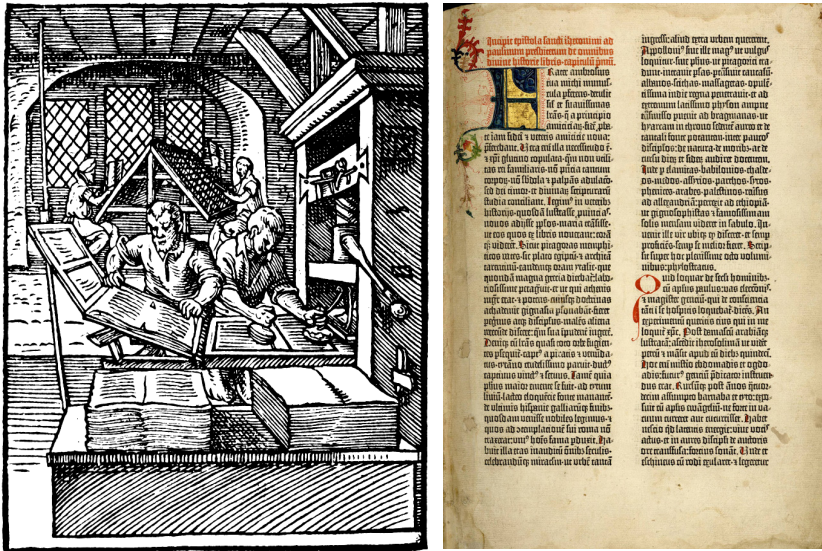


Fig. 2.3 Left: representation of movable-type printing, 1568; right: Gutenberg bible Old Testament epistle of St Jerome, 1454-1455.

[Philip B. Meggs, Alston W. Purvis, *Meggs' History of Graphic Design* (John Wiley & Sons, 1998), 64; *Gutenberg Bible*, Epistle of St. Jerome, 1454-1456]

tific and technical knowledge through the circulation of treatises⁴². The full reverberation of print, however, was realized only in the eighteenth century, when advances in science and philosophy definitively transformed both the content and the mechanisms of collective memory⁴³. “The eighteenth century in Europe marked the end of the ancient world in printing as well as in technology. [...] Within the space of a few decades the social memory had engulfed in books the whole of antiquity, the history of the great peoples, the geography and ethnography of a world now definitely acknowledged to be round, philosophy, law, the sciences, the arts, the study of technics, and a literature translated from twenty different languages”⁴⁴. Dictionaries and glossaries, already widespread for several centuries, attained their fullest expression in the form of encyclopedias, published for the use of manufacturers and artisans as well as for erudites⁴⁵. “The dictionary is a highly developed form of external memory in which thought is broken down into an infinity of fragments; the ‘Great Encyclopedia’ of 1751 is a series of short manuals encased in a dictionary [...]. the encyclopedia is a fractional alphabetically arranged memory each of whose isolated mechanisms contains an animated part of the whole of memory. The relationship between Vaucansson’s automaton and the French encyclopedia - its contemporary - was the same

42. Le Goff, “Memoria,” 1091.

43. Le Goff, “Memoria,” 1091.

44. Leroi-Gourhan, *Gesture and Speech*, 262.

45. Leroi-Gourhan, *Gesture and Speech*, 262.

as that between today's electronic machine and integrated memory"⁴⁶. "The nineteenth century witnessed - no longer primarily in the sphere of knowledge, as in the eighteenth century, but rather in that of sentiment and, indeed, of education - an outburst of contemplative spirit"⁴⁷. Whereas in the Middle Ages the spread of Christianity as both religion and dominant ideology, together with the near-monopoly exercised by the Church in intellectual life, fostered a progressive Christianization of memory and the development of the cult of the dead - above all, of the holy dead⁴⁸ - from the late seventeenth to the late eighteenth century the commemoration of the deceased declined. "Tombs, including those of kings, became exceedingly simple. Burials were abandoned to nature, and cemeteries lay deserted and neglected"⁴⁹.

With the French Revolution, a renewed impetus to the memory of the dead emerged in many European countries, inaugurating a great era for cemeteries, characterized by new types of monuments and funerary inscriptions, as well as by a revived ritual of visiting burial grounds. The Romantic fascination with the cemetery as a site of memory and, concretely, the Napoleonic law of 1804 mandating the relocation of cemeteries outside urban centers restored the tomb to the center of remembrance [Fig. 2.4]. Such sustained attention to funerary commemoration would recur only in the aftermath of the First World War, with the erection of monuments to the fallen⁵⁰.

The progressive secularization of festivals and of the calendar over the course of the nineteenth century encouraged, in many countries, a marked proliferation of commemorative practices, increasingly supported by new physical media such as coins, medals, and postage stamps. From the mid-century onward, "a new wave of statuary and a new civilization of inscription (monuments, street plaques, commemorative tablets affixed to the houses of illustrious deceased figures) inundated the European nations. [...]. At the same time, the scientific movement aimed at providing the collective memory of nations with monuments of remembrance accelerated"⁵¹.

Over the course of the nineteenth century, archives flourished, and exi-

46. Leroi-Gourhan, *Gesture and Speech*, 263.

47. Le Goff, "Memoria," 1094.

48. Le Goff, "Memoria," 1081.

49. Le Goff, "Memoria," 1094.

50. Le Goff, "Memoria," 1097.

51. Le Goff, "Memoria," 1096.



Fig. 2.4 The cemetery of Trento.

[Francesco Ambrosi, *Trento e il suo circondario descritti al viaggiatore* (Giovanni Zippel Editore, 1881), 65]

sting institutions⁵² increasingly opened their holdings to the public⁵³: in 1794 the Archives nationales in France; in 1838 the Public Record Office in London; and in 1881 the Archivio Segreto Vaticano. A new phase thus began, characterized by the public accessibility of documents constituting national memory, accompanied by the gradual establishment of specialized institutions dedicated to training experts in the study of such sources: the École des Chartes in Paris (1821); the Institut für Österreichische Geschichtsforschung in Vienna (1854); and the Scuola di Paleografia e Diplomatica in Florence (1857). Public and national mu-

52. "In the medieval period, marked by the transition from papyrus to parchment and subsequently to paper, and continuing into the modern era, the richest archives were those of Western Europe: Italy, France, Germany, England, and Spain are the five nations without whose archives the history of the world could not be written. The wealth of the Vatican Archives is incomparable; the archives of Austria, Belgium, the Netherlands, and Portugal are also exceedingly rich, as are those of China and certain Asian countries. Africa, by contrast, possesses no archives or written documents, and the Americas have only archives dating from after the discovery, since the archives of the Aztecs and the Maya were completely destroyed" (Lodolini, *Archivistica*, 13).

53. "Until that time, archives - albeit with certain exceptions - had been univocally understood as memory in the sense of self-documentation; from this particular historical conjuncture onward, however, they began to assume the additional role of memory as a source. These transformations, naturally, required a long and not always linear process of maturation. Conventionally, the beginning of this development is traced back to 1794, the year in which the principle of the public nature of archives was proclaimed in France. In reality, this affirmation of principle should be interpreted less as a guarantee of citizens' free access to documentary sources for scholarly purposes than as recognition of the citizen's right to consult documents pertaining to his or her daily life" (Federico Valacchi, *Diventare archivisti. Competenze tecniche di un mestiere sul confine*, Editrice Bibliografica, 2015, 34).

seums likewise proliferated: the Grande Galerie du Louvre inaugurated in 1793; the Altes Museum in Berlin, opened in 1830; the Germanisches Nationalmuseum in Nuremberg, founded in 1852; and the Museo nazionale del Bargello in Florence, established in 1859⁵⁴.

During the nineteenth century, collective memory expanded to such an extent that it became impossible to expect individual memory to assimilate the contents of libraries, archives, and museums. A gradual transition therefore occurred from notebooks and catalogues to documentation organized through index cards, a system that achieved its full institutional form only at the beginning of the twentieth century. “In its most rudimentary form, it already corresponds to the constitution of a veritable externalized cerebral cortex, insofar as a simple bibliographical card index lends itself, in the hands of its user, to various arrangements. [...] Moreover, the image of the cortex is only partially accurate, since, although a card index is memory in the strict sense, it is nevertheless a memory devoid of its own means of memorization, and in order to animate it one must introduce it into the operational, visual, and manual field of the researcher”⁵⁵.

The simple card index and, later, the punched-card system thus marked significant advances in the organization of collective memory, operating as genuine ‘machines’ for the accumulation of records [Fig. 2.5].

Fig. 2.5 Left: a catalog card from Radio Sweden’s archive of recorded broadcasts; right: a punch card from a Decap Dancing Organ at the Technical Museum in Speyer, Germany

[Lars Aronsson, <http://creativecommons.org/licenses/sa/1.0/>; Stefan Kühn, <http://creativecommons.org/licenses/by-sa/3.0/>]



54. Le Goff, “Memoria,” 1096.

55. Leroi-Gourhan, *Il gesto e la parola*, 309-310.

- to establish correlations among all stored items. The decisive transformation in this domain, however, occurred only in the mid-twentieth century, with the emergence of electronic memory⁵⁶.

The emergence of the first large-scale calculating machines capable of electronically writing, storing, and retrieving information dates back to the Second World War. From that point onward, the following decades witnessed parallel developments: the progressive miniaturization of devices, a steady increase in computational power, and the growing interconnection of systems. The large postwar mainframe machines - whose individual units were the size of wardrobes and were used primarily for numerical computation - gave way, in the 1980s, to the widespread diffusion of home and personal computers. The invention of the microprocessor transformed the computer into a familiar presence in both domestic and professional settings, albeit still limited in its capacity for connection, which relied on acoustic couplers and modems to access the earliest network services. Beginning in 1993, the advent of the World Wide Web initiated the rapid expansion of the Internet. Within a decade, it had penetrated a wide range of societal sectors, fundamentally transforming their structures and modes of interaction, and ultimately paving the way for the era of broadband mobile connectivity and permanently connected smartphones⁵⁷.

The digital revolution, briefly outlined above, has had a twofold impact on collective memory. On the one hand, the computer has functioned, “from the era of personal computers onward, and in an increasingly pervasive and evident manner with the spread of the Internet and mobile devices”⁵⁸, as an extraordinary instrument for the externalization of both personal and collective memory, that is, as a new medium through which traces of knowledge, events, activities, individuals, interactions, and impressions are preserved. On the other hand, digital technologies have progressively established themselves as instruments of mass communication, capable of accelerating the circulation of information and of generating ever denser networks of connection across increasingly distant regions⁵⁹.

This technological transformation unfolds within a broader cultural

56. Leroi-Gourhan, *Gesture and Speech*, 264.

57. Gino Roncaglia, *L'architetto e l'oracolo. Forme del sapere da Wikipedia a ChatGPT* (Laterza, 2023), 5-6; Le Goff, “Memoria,” 1098.

58. Roncaglia, *L'architetto e l'oracolo*, 123.

59. Assmann, *Ricordare*, 237.

shift that, from the late 1970s onward, has been described as postmodernity. In *The Postmodern Condition*, Jean-François Lyotard identifies the defining trait of the postmodern condition in an “incredulity toward metanarratives”⁶⁰, namely toward the grand narratives - such as progress, emancipation, or the unity of knowledge - that had previously structured modern historical consciousness and provided a coherent framework for collective memory. As knowledge becomes increasingly mediated by information technologies and evaluated according to criteria of performativity, efficiency, and circulation, its legitimacy no longer derives from universal principles but from its functional integration within networks of communication. In this context, collective memory ceases to appear as a unified and authoritative account of the past and instead takes the form of a plurality of localized, heterogeneous narratives. It becomes fragmented, dynamic, and deeply intertwined with the technical systems that store, process, and disseminate information. The digital environment does not merely multiply memories; it reshapes the very conditions under which they are produced, validated, and transmitted⁶¹. It is precisely this fragmentation and proliferation that prepares the ground for the explosion of mediated memories characteristic of the age of Internet.

In an era preceding the advent of the Web, Jacques Le Goff perceptively observed that “the entire evolution of the contemporary world, under the pressure of immediate history - largely manufactured in real time by the instruments of mass communication - is moving toward the production of an ever greater number of collective memories, and history is written, far more than in the past, under the pressure of these collective memories”. The trajectory of this tendency toward the proliferation of memories finds its fullest realization with the advent of social networks⁶².

Kenneth Goldsmith, an American poet and critic⁶³, identifies Facebook as “the great experiment in collective cultural autobiography,” a virtual space in which “two billion people benefit from the possibility of shaping, on a daily and public basis, both their own biographies and those of others, while simultaneously narrating the events that, day after day,

60. Jean-François Lyotard, *The Postmodern Condition: A Report on Knowledge* (Manchester University Press, 1984), xxiv.

61. Lyotard, *The Postmodern Condition*, 3-23.

62. Le Goff, “Memoria,” 1102.

63. “Kenneth Goldsmith,” Wikipedia, accessed May 1, 2026, https://en.wikipedia.org/wiki/Kenneth_Goldsmith.

delineate the social, cultural, and political characteristics of recent years". Individual and collective memory thus encounter a new point of convergence, merging into one another, "creating daily, on the screens of computers and smartphones, a synthesis between the recollection of personal events and the ensemble of signs and symbolic practices through which group memory is constituted. The historians of the future - Goldsmith maintains - will likely have at their disposal a detailed representation of an entire civilization during a specific epoch, by virtue of that cooperation unbounded by spatial limits which, generated by the everyday use of the Internet, has been amplified by social networks"⁶⁴. If this "experiment" were extended to all major social media platforms, it would yield an unprecedented global autobiographical narrative, the sum of a vast and vertiginous accumulation of words, images, and videos⁶⁵.

In 1965, André Leroi-Gourhan prophetically stated: "if electronic machines learned one day to write perfect plays' and paint inimitable pictures, some serious questions would have to be asked about the future of the human species. By learning how to love they would definitively settle our hash as a zoological species"⁶⁶. Although the foundations for the development of Artificial Intelligence can already be traced to research conducted by the mathematician Alan Turing in the 1930s⁶⁷, Leroi-Gourhan was fully aware, at the time he wrote these lines, that the artificial brain of course was still in its infancy, but they could already be sure that it would be more than just a nine days' wonder with limited applications. "To refuse to see that machines will soon overtake the human brain in operations involving memory and rational judgment - said Leroi-Gourhan - is to be like the Pithecanthropus who would have denied the possibility of the biface, the archer who would have laughed at the mere suggestion of the crossbow, most of all like the Homeric bard who would have dismissed writing as a mnemonic trick without any future. We must get used to being less clever than the artificial brain that we have produced, just as our teeth are

64. Davide Sisto, *Ricordati di me. La rivoluzione digitale tra memoria e oblio* (Bollati Boringhieri, 2020), 60-61.

65. Sisto, *Ricordati di me*, 64.

66. Leroi-Gourhan, *Gesture and Speech*, 265.

67. Turing emphasized the analogy between the notion of an algorithm and that of a procedure executable by a machine - an analogy that would prove to be of the utmost importance both for mathematical logic and for Artificial Intelligence (Barbara Giolito, *Intelligenza Artificiale. Una guida filosofica*, Carocci, 2007, 37).

less strong than a millstone and our ability to fly negligible compared with that of a jet aircraft. [...] Putting it more positively, we could say that if humans are to take the greatest possible advantage of the freedom they gained by evading the risk of organic over-specialization, they must eventually go even further in exteriorizing their faculties”⁶⁸. In conclusion, the progressive diffusion of digital technologies over recent decades, most notably Artificial Intelligence, particularly in its generative forms, has redefined entire cultural models and intervened decisively in the ways (and possibilities) through which what we call memory is sedimented, preserved, and used. Digital memory, in the full range of its manifestations, thus emerges as a complex and articulated phenomenon, departing from the essentially univocal - though inherently elusive - concept with which we have long been familiar in the analog context⁶⁹.

68. Leroi-Gourhan, *Gesture and Speech*, 265.

69. Federico Valacchi, *Gli Archivi tra storia, uso e futuro* (Editrice Bibliografica, 2020), 35-36.

02.2 The substance of memory and history: from historical source to digital record

The portion of reality that survives the selection enacted by time and by human agency constitutes the substance of collective Memory and, in its scientific form, of History¹. These are clues to completed epochs, traces of the past that persist in the present, which can be mutually employed, at times as supports of collective memory, at times as instruments for understanding History². The manner in which these traces are identified and interpreted represents the fundamental distinction between Memory and History. Indeed, conflating the two concepts entails mistaking a source of information, as commonly understood in journalistic parlance, for a source of truth, “that is, one mistakes the witness of certain events for a necessarily reliable interpreter of those same events, and assumes the recollections of their experiences at the time as guiding criteria for our interpretation today. This is an unforgivable methodological error, for the good historian is precisely one who carefully distinguishes between temporal planes and treats the retrospective experiences of their subjects (the labor of their memory) not as an easy measure of truth, but as further and demanding material for study”³. In these terms, historical research is nothing more than the direct relationship a scholar establishes with their sources, which are carefully identified and critically interpreted within the larger, more or less extensive, corpus of traces of the past that have reached the present⁴.

“The proper engagement with sources, which lies at the heart of the historian’s craft, is a delicate operation for several reasons. The historian ‘interacts’ with the source, bringing to the historiographical process the technical and cultural constraints of their own era, their personal knowledge, skills, and values, as well as the perspective of the inquiry they are pursuing. The perception of the past, therefore, is itself a representation - historically conditioned and continuously evolving. The source, in turn, is never truly ‘objective’; it is the product of a conscious or unconscious shaping by the society and era that produced it. Its preservation and transmission to posterity result from both contemporary

1. Jacques Le Goff, “Documento/monumento,” in *Enciclopedia Einaudi*, (Einaudi, 1979), 38.

2. Johann G. Droysen, *Sommario di istorica* (Sansoni, 1967), 33.

3. Sergio Luzzatto, “Premessa,” in *Prima lezione di metodo storico*, ed. S. Luzzatto (Laterza, 2015), 10.

4. Luzzatto, “Premessa,” 6.

and non-contemporary selection mechanisms, deliberate or spontaneous, essentially - but not exclusively - guided by criteria of utility and market value.

Evidently, throughout different historical periods, the concept of the source and the methods of historical inquiry have evolved in parallel - albeit non-linearly - with the very conception of History. According to Benedetto Croce (1866-1952), “History, like philosophy, has no historical beginning, but only an ideal or metaphysical beginning, in so far as it is an activity of thought, which is outside time. Historically speaking, it is quite clear that prior to Herodotus, prior to the logographs, prior indeed to Hesiod and to Homer, history was already, because it is impossible to conceive of men who do not think and do not narrate their deeds in some way or other”⁵. Nevertheless, it is thanks to Herodotus that thought emerges from mythological history, freeing itself from its prodigious and miraculous character and entering into earthly or human history⁶ [Fig. 2.6]. He travels, listens, interrogates, and distinguishes between things seen with his own eyes, things heard, opinions, and conjectures, thereby laying the foundations of an embryonic form of historical method⁷.



Fig. 2.6 Giulio Romano, *Vault of the hall of Giants*, Palazzo Te, Mantova, 1532-1535.

[Photograph by the author]

5. Benedetto Croce, *Theory & history of historiography* (G.C. Harrap, 1921), 181.

6. Croce, *Theory & history of historiography*, 183.

7. “Metodologia della ricerca storica,” *Dizionario di storia*, Treccani, accessed May 1, 2026, https://www.treccani.it/enciclopedia/metodologia-della-ricerca-storica_%28Dizionario-di-Storia%29/.

Although historical thought, transitioning from the mythological to the human stage, gains strength - particularly in aspects related to research and philology - ancient historians do not relinquish the poetic force and elevation inherent to high historical narrative. "What the best historians and theorists sought at that time was not the aridity and dryness of mathematical or physical treatment (such as we often hear desired in our day), but gravity, abstention from fabulous and pleasing tales, or if not from fabulous then from frivolous tales [...]. Above all they desired that history should remain faithful to real life, since it is the instrument of life, and a form of knowledge useful to the statesman and to the lover of his country"⁸. Thus, in Thucydides (5th century BCE), the method becomes more precise and rigorous: historical narrative, for the first time, is based on 'facts', that is, events validated by the historian's personal and direct testimony. The result is a historiography largely confined to the realm of contemporaneity, namely, a recent past which, by its very proximity, largely eludes the influence of myth⁹.

In the Middle Ages, mythology, miracle, and transcendence once again became essential features of history. Although these elements operated with an ancient force and consistency, they did not present themselves in forms historically identical to those of the pre-Hellenic world. As Benedetto Croce observes: "Ancient thought had left fortune, the divinity, the inscrutable, at the edge of its humanism, with the result that the prodigious was never completely eliminated even from the most severe historians [...]. All are aware with how many 'superstitions' philosophy, science, history, and customs were impregnated during late antiquity, which in this respect was not intellectually superior, but indeed inferior, to the new Christian religion. In the latter the fables gradually formed and miracles which were believed became spiritualized and ceased to be 'superstitions' - that is to say, something extraneous or discordant to the general humanistic conception - and set themselves in harmony with the new supernaturalistic and transcendental conception, of which they were the accompaniment"¹⁰.

Medieval thought assigns to history - and, by extension, to historical research - a task that is not autonomous but subordinate to the higher

8. Croce, *Theory & history of historiography*, 187.

9. "Metodologia della ricerca storica".

10. Croce, *Theory & history of historiography*, 203.

ends of ethics and theology. “History becomes an *ancilla* to both, insofar as, through it and through the abundant examples it provides, one can readily demonstrate the omnipotence of God and his absolute dominion over human affairs - affairs that disclose their truth and fragility precisely within historical narrative [...]. Thus history assumes the role of a ‘providential’ admonisher of humankind, a *magistra vitae* of unparalleled efficacy”¹¹.

Borrowed from the Roman age, the Sallustian notion of history as “teacher of life” - conceived as a body of knowledge and ideals functional to the defense of Rome, its customs, and its institutions - was reoriented in the medieval period toward the model of Christian life. History now becomes *vox Dei*, a revealer of God and his power¹², but also *historia Salutis*, that is, the history of salvation, endowed with universal significance¹³.

“Given this wholly subordinate function of history, it is evident that the ‘technical’ problem of historical research does not even arise. Just as medieval universities lacked any specifically and properly historical instruction, and knowledge was condensed into the arts of the *Trivium* (grammar, rhetoric, dialectic) and the *Quadrivium* (arithmetic, geometry, music, astronomy) [...]; so too, among historians themselves, the methodological question simply failed to emerge”¹⁴.

The rigid theological and moral framework that constrained history throughout the Middle Ages was dismantled only in the Renaissance. During this period, the belief in divine providential intervention was gradually replaced by a sharp analysis of individual character and interest, to the extent that even the actions of popes and religious conflicts began to be interpreted according to utilitarian passions and political interests¹⁵.

Within the broader phenomenon of the ‘secularization’ of history¹⁶, the fifteenth and sixteenth centuries witnessed the emergence of the first treatises on *historia*¹⁷, primarily aimed at defining its nature and distin-

11. Federico Chabod, *Lezioni di metodo storico* (Laterza, 2000), 10. “Providence guides and disposes the course of events, directing them to an end, permitting evils as punishments and as instruments of education, determining the greatness and the catastrophes of empires, in order to prepare the kingdom of God” (Croce, *Theory & history of historiography*, 205).

12. Chabod, *Lezioni di metodo storico*, 10.

13. “Metodologia della ricerca storica”.

14. Chabod, *Lezioni di metodo storico*, 12.

15. Croce, *Theory & history of historiography*, 224.

16. Croce, *Theory & history of historiography*, 224.

17. “We have, in fact, an entire series of treatises on history, beginning with the *Actus* of Gio-

guishing it from other forms of human intellectual activity, among them poetry¹⁸. In these treatises, one may indeed find echoes of ancient Greek and Roman thought, along with renewed affirmations of Aristotle, Lucian, and Cicero; yet beyond such particular elements stands a more significant development: the emerging desire to assert history's own distinctiveness and autonomy¹⁹.

During this period, a new awareness of the purpose of history gradually took shape. History was no longer conceived as serving a merely utilitarian function of moral instruction, but rather as directed toward the pursuit of truth. This 'truth', understood as independent from other forms of thought, rendered history worthy of recognition as an autonomous *ars historica*, elevated to the same plane as grammar, rhetoric, and dialectic²⁰. Humanism and the Renaissance represent a pivotal moment in the expansion of the concept of the historical source. "Once, sources consisted almost exclusively of earlier 'narratives', the writings of other historians, from which material was abundantly drawn; now, alongside what we would call 'narrative' sources, scholars began to seek out not only the *monumenta*, that is, public documents - our 'documentary' sources, at least those of a public nature (laws, treaties, decrees, etc.) - but also, beyond strictly written materials, so-called 'figurative' sources": archaeological remains, inscriptions, medals, and similar materials²¹ [Fig. 2.7].

"The broadening of the meaning of 'historical source' was also required by the gradual, progressive expansion of the historian's 'interests'; that is, by the increasingly marked demand, alongside a merely 'political' treatment of history, for an approach encompassing a wider sphere". Within this widening of horizons, a fundamental contribution was made by the recent geographical discoveries, which stimulated the curiosity of European scholars - especially Spanish ones - toward the history of countries and peoples previously unknown²².

However, in the field of source criticism, humanist historians still di-

vanni Pontano (composed before 1501 and published in 1507), continuing, among others - to cite only the most important - with the ten dialogues of *Della historiae universae et eius cum iurisprudencia coniunctione* by the Frenchman François Baudouin (1561), and culminating in the celebrated work *Methodus ad facilem historiarum cognitionem* (1566) by the French thinker Jean Bodin" (Chabod, *Lezioni di metodo storico*, 17).

18. Chabod, *Lezioni di metodo storico*, 17-18.

19. Chabod, *Lezioni di metodo storico*, 22.

20. Chabod, *Lezioni di metodo storico*, 23-24.

21. Chabod, *Lezioni di metodo storico*, 30-31.

22. Chabod, *Lezioni di metodo storico*, 30-31.

Fig. 2.7 The remains of the temples of Castor and Pollux, Valle dei Templi, Agrigento, 2020.

[Photograph by the author]



splay a certain degree of critical insufficiency, stemming from the lack of a widespread and deeply rooted ‘methodical doubt’ in their interpretation of the traces of the past. “While the best historians, from Biondo [1392–1463] onward, reacted against the narrative tradition that preceded them - at times mercilessly attacking earlier chroniclers and placing little trust in virtually any narrative account - at the same time they accorded the ‘document,’ that is, a public act carefully preserved in an archive, a reverence entirely devoid of critical scrutiny [...]: once the document was found, the truth was found!”²³.

The contribution of Lorenzo Valla (1407-1457) and Erasmus of Rotterdam (1466/1469-1536), two of the most important exponents of the European cultural revival, marks a fundamental stage in the development of the historical method. They were pioneers in applying philology to the service of historical research. For the first time, this discipline was employed to “rigorously assess the authenticity of sources, even to the point of calling into question the authority of ecclesiastical tradition. Valla demonstrated the falsity of the *Donation of Constantine*, the document upon which the temporal power of the popes was based (1440), while Erasmus produced a critical edition of the New Testament (1516)”²⁴.

Parallel to these developments, the Scientific Revolution of the late six-

23. Chabod, *Lezioni di metodo storico*, 45-46.

24. “Metodologia della ricerca storica”.

teenth and early seventeenth centuries endowed the natural sciences with a methodology grounded in experimentation and mathematical calculation and thereby indirectly encouraged historiography to move in a similar direction. Historians were thus prompted to abandon definitively any interpretation of the past that claimed to embody sacred contents or values²⁵. Consequently, between the late seventeenth and early eighteenth centuries, a systematically and methodically ordered critique of sources began to spread, at least among scholars²⁶, accompanied by the gradual emergence of the so-called auxiliary sciences of history: palaeography, diplomatics, chronology, numismatics, epigraphy, and others²⁷. For Giambattista Vico (1668-1744), the historian had by then become a true ‘scientist’ who, through rigorous method, accounts for human actions and the processes underlying the maturation of the human mind²⁸.

In this context, Voltaire introduced significant innovations into historical method, including the systematic comparison of different types of sources - political, economic, social, literary, and art-historical - and the juxtaposition of temporally distant moments and events in European history, such as the apogee of Greek and Latin culture, the age of Lorenzo the Magnificent, and the France of the Sun King²⁹. It was, however, the English historian Edward Gibbon who brought eighteenth-century methodological reflection to its highest expression. In his investigation of the decline of Rome, he assembled an exceptionally broad and coherent body of sources and developed conceptual categories capable of engaging modern readers while conveying the distinctive features of ancient culture³⁰.

Only in the nineteenth century, against the background of the progressive affirmation of the absolute historicity of being and thought promoted by German Idealism, that historical methodology attain a fully organic and structured form³¹. In 1857, *Grundriss der Historik* by Johann Gu-

25. “Metodologia della ricerca storica”.

26. Marc Bloch, *Apologia della storia o Mestiere di storico* (Einaudi, 2009), 66.

27. Chabod, *Lezioni di metodo storico*, 49.

28. “Metodologia della ricerca storica”.

29. “Metodologia della ricerca storica”.

30. “Metodologia della ricerca storica.”

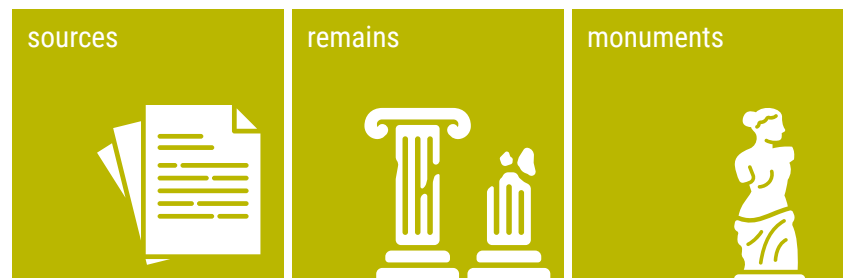
31. Johann Gustav Droysen, one of the leading historians of the second half of the nineteenth century, was among the first to highlight that the scientific nature of historical studies and its relation to historical method were issues “that, until now, have been seriously debated only to a very limited extent, and even less so among historians themselves. This gives rise to the rather unpleasant phenomenon that other sciences are uncertain about their relation to our field and about what properly falls within our competence. Equally disheartening is the fact that other sciences

stav Droysen was published, marking the beginning of a flourishing season of technical and methodological treatises that continued well into the twentieth century³².

Concurrently with his effort to define the historical method, Johann Gustav Droysen proposed an early and noteworthy classification of 'historical material'. He distinguished traces of the past into three fundamental categories³³: *sources*, that is, those things deliberately created by later generations to preserve their memory for posterity (written documents); *remains*, encompassing all those objects from the past that have survived into the present in variously transformed or fragmented forms, which were not intended to transmit memory but solely to meet immediate needs (ancient buildings, relics from old churches or castles, ruins, etc.); and *monuments*, which blend the characteristics of the first two categories, being remains of a past age that societies consciously seek to commemorate by summarizing certain moments or meanings in artistic or symbolic form (a hero's statue, a painted portrait, coins, etc.)³⁴ [Fig. 2.8].

Despite this initial taxonomic effort - and the further attempts that followed - the concept of the source remained highly elusive between the late nineteenth and early twentieth centuries. In France, historians increasingly distanced themselves from the definition of the source advanced by their German counterparts, who remained firmly committed to the rigor of the philological method, relying exclusively on conventional forms of evidence such as inscriptions, coins, diplomas, and official documents³⁵.

Fig. 2.8 The first systematic classification of historical materials undertaken by Johann Gustav Droysen in the mid-nineteenth century.



claim, from time to time, parts of our domain, while regarding what remains to history as either a product of imagination or merely a collection of incidental and external facts, judging it disparagingly" (Johann G. Droysen, *Istorica: lezioni sulla enciclopedia e metodologia della storia*, Ricciardi, 1966, 3).

32. Chabod, *Lezioni di metodo storico*, 51-53.

33. Droysen, *Istorica*, 38-39.

34. Droysen, *Istorica*, 52,63.

35. "Metodologia della ricerca storica".

As later observed by Jacques Le Goff, the French positivist school divided the materials of collective memory into two distinct categories: *documents* and *monuments* [Fig. 2.9]. *Documents* were understood strictly as written texts - laws, charters, formulae, chronicles, and histories - whereas *monuments* comprised the material legacy of historical societies' collective memory, primarily in the form of architectural or sculptural works created for commemorative purposes, such as triumphal arches, columns, trophies, and porticoes, as well as funerary structures intended to preserve remembrance³⁶. Within this framework, the document was regarded as possessing an objectivity that stood in opposition to the intentionality attributed to the monument and, consequently, as constituting the sole legitimate foundation of historical fact³⁷.



Fig. 2.9 classification of historical materials by French positivist school.

In 1888, Fustel de Coulanges, a French historian profoundly shaped by the positivist spirit of his age, argued that the historian's sole competence should lie in extracting from documents all that they contain, without introducing anything not already inherent in them. For de Coulanges, the exemplary historian is the one who remains closest to the texts, interprets them with the utmost precision, and both writes and reasons strictly on their basis³⁸. Such an approach seeks to derive from sources a series of 'factual findings' through a critical procedure structured in two principal stages: external criticism and internal criticism, aimed

36. Le Goff, "Documento/monumento," 38. "Regardez les historiens allemands depuis un demi-siècle, et vous serez frappé de voir à quel point leurs théories historiques sont en parfait accord avec leur patriotisme. Vous serez alors amené à vous demander si leurs systèmes ont été engendrés par la lecture des textes, ou s'ils ne l'ont pas été plutôt par ce sentiment inné qui était antérieur chez eux à la lecture des textes. Ainsi, pendant que les érudits français portaient surtout dans cette histoire leur esprit de parti, les Allemands y ont surtout porté leur amour de leur patrie et de leur race, ce qui vaut peut-être mieux moralement, mais ce qui altère autant la vérité. Le patriotisme est une vertu, l'histoire est une science; il ne faut pas les confondre" (Fustel de Coulanges, *Histoire des Institutions politiques de l'ancienne France. La monarchie franque*, 1888, 31).

37. Le Goff, "Documento/monumento," 38.

38. de Coulanges, *Histoire des Institutions politiques*, 33.

respectively at verifying the authenticity of documents and assessing their credibility as testimony to the events they record³⁹.

The idea that the document, understood as a written text, represents the sole source for reconstructing and unveiling the past persisted until the great historiographical revolution carried out in the 1920s by the pioneers of the *Nouvelle histoire*, Marc Bloch (1886-1944) and Lucien Febvre (1878-1956). In 1929, the two French historians founded the journal “*Annales d’histoire économique et sociale*”, through which they promoted a radical renewal of historical disciplines aimed at definitively overcoming the definition of ‘source’ as conceived by positivist scholars⁴⁰. They argued for the necessity of identifying and interrogating, alongside written documents, other traces of the past in order “to study not only man (and not only great individuals), but also the collective mental frameworks of different periods, as well as the natural and environmental factors characteristic of historical societies, with the awareness that periodization means interpretation, and that the study of moments of rupture between one era and another must not obscure the elements of continuity between past and present”⁴¹.

“History”, declares Febvre, “is made with written documents, certainly - when they exist. But it can be made, and must be made, without written documents when they do not exist”⁴². Bloch similarly maintains that “The variety of historical evidence is nearly infinite. Everything that man says or writes, everything that he makes, everything he touches can and ought to teach us about him. [...] It would be sheer fantasy to imagine that for each historical problem there is a unique type of document with a specific sort of use. On the contrary, the deeper the research, the more the light of the evidence must converge from sources of many different kinds. What religious historian would be satisfied by examining a few theological tracts or hymnals? He knows full well that the painting and sculpture of sanctuary walls and the arrangement and furnishings of tombs have at least as much to tell him about dead beliefs and feelings as a thousand contemporary manuscripts”⁴³.

39. Stefano Vitali, *Passato digitale. Le fonti dello storico nell’era del computer* (Bruno Mondadori, 2004), 130-131.

40. Vitali, *Passato digitale*, 17.

41. “Metodologia della ricerca storica”.

42. “L’Histoire se fait avec des documents écrits, sans doute. Quand il y en a. Mais elle peut se faire, elle doit essayer de se faire à tout prix, sans documents écrits s’il n’en existe point” (Lucien Febvre, “Vers une autre Histoire,” *Revue de Métaphysique et de Morale* 54, no. 3/4, 1949, 235).

43. March Bloch, *The Historian’s Craft* (Alfred A. Knopf, 1959), 66-67.

Throughout the twentieth century, the lesson of the “*Annales*” journal and of the new historiographical school encouraged the historical sciences to incorporate insights from numerous other disciplines - including geography, linguistics, anthropology, sociology, psychology, economics, and statistics - and laid the foundations for the development of specific fields of study. Thus emerged the history of mentalities and emotions, psychohistory, climatology, historical demography, microhistory, and so on⁴⁴.

This expansion of the meaning of the term ‘document’ represents only one stage toward what, beginning in the 1960s, would become a true ‘documentary revolution’. This was “a revolution both quantitative and qualitative. The interest of collective memory and history no longer crystallizes exclusively around great men, events, fast-moving history, political, diplomatic, or military history. It now concerns all people; it implies a new, more or less implicit hierarchy of documents, placing, for example, the parish register at the forefront of modern history, as it preserves in memory all individuals [...]. The parish register, in which births, marriages, and deaths are recorded parish by parish, represents the entry into history of the ‘sleeping masses’ and inaugurates the era of mass documentation”⁴⁵.

On the methodological level, the revolution initiated by the founders of the “*Annales*” and the subsequent documentary revolution appear to have two main consequences. On the one hand, as the concept of the document expands, the debate over the classification of different types of historical sources becomes increasingly irrelevant. “By documents - states Benedetto Croce - we must understand all works of the past that can still be recalled in the signs of writing, musical notation, painting, sculpture and architecture, technical inventions, transformations of the earth’s surface, and those occurring in the depths of the human spirit - that is, in political, moral, and religious institutions, in virtues and sentiments gradually formed over the centuries and still alive and active within us. [...] The documents to which this name is usually restricted in historiographical practice - diplomas, notarial acts, administrative records, diplomatic correspondence, and the like - are certainly, on the one hand, surviving traces of past works, but, on the other, testimonies

44. “Metodologia della ricerca storica”.

45. Le Goff, “Documento/monumento,” 41-42.

concerning facts and must be considered among attested evidence”⁴⁶. For Croce, therefore, the distinction between different kinds of sources - such as written, visual, and oral sources - amounts merely to a matter of practical convenience⁴⁷.

On the other hand, a deeply critical attitude toward documents became established, aimed at definitively overcoming the passive stance of positivist historians toward texts. “Contrary to what beginners sometimes seem to believe”, argues Bloch, “documents do not simply appear here and there by virtue of some mysterious decree of the gods. Their presence or absence in archival collections, libraries, or the soil itself depends on human causes that are by no means beyond analysis”⁴⁸.

Paul Zumthor (1915–1995), a philologist and literary critic, shared this view and rejected the positivist illusion that regarded the document - provided it was authentic - as proof of good faith. According to the Swiss scholar, “the document is not an unsold commodity from the past; it is a product of the society that created it, shaped by the power relations within it. Only the analysis of the document as a document allows collective memory to recover it and the historian to use it scientifically, that is, with full awareness of its nature”⁴⁹.

In other words, from the mid-twentieth century onward, the historical method has been grounded in what Michel Foucault (1926–1984) defined as the ‘questioning of the document’⁵⁰. That is to say, “the document is not the fortunate tool of a history that is primarily and fundamentally memory; history is one way in which a society recognizes and develops a mass of documentation with which it is inextricably linked. To be brief, then, let us say that history, in its traditional form, undertook to ‘memorize’ the monuments [intentional traces] of the past, transform them into documents [objective traces], and lend speech to those traces which, in themselves, are often not verbal, or which say in silence something other than what they actually say; in our time, history is that which transforms documents into monuments. In that area where, in the past, history deciphered the traces left by men, it now deploys a mass of elements that have to be grouped, made relevant, placed in relation to one another to form totalities”⁵¹.

46. Benedetto Croce, *La storia come pensiero e come azione* (Laterza, 1966), 104-105.

47. Chabod, *Lezioni di metodo storico*, 58.

48. Bloch, *Apologia della storia*, 56.

49. Le Goff, “Documento/monumento,” 44-45.

50. Michel Foucault, *The Archeology of Knowledge* (Pantheon Books, 1972), 6.

51. Foucault, *The Archeology of Knowledge*, 7.

It follows that the document can no longer be regarded as something neutral or innocuous; rather, it is “above all the result of a construction - conscious or unconscious - of the history, the period, and the society that produced it, but also of the subsequent periods during which it continued to exist, perhaps forgotten, and during which it continued to be shaped, even through silence. [...] The document is a monument. It is the outcome of the effort made by historical societies to impose upon the future - willingly or unwillingly - a particular image of themselves. Ultimately, there is no such thing as a true document: every document is a lie”⁵². The impact of the revolution in mass documentation expanded exponentially with the advent of the technological revolution. The invention of the electronic computer in the mid-twentieth century gave rise to quantitative history - a development that, once again, called into question the very notion of the document and the ways in which it is used⁵³ - and ushered in a series of profound transformations in historiography, closely linked to increasingly advanced and sophisticated technological progress. The meaning of the document within quantitative history is effectively described by François Furet (1927-1997) in his essay “Quantitative history”. “The document, the datum - Furet writes - no longer exists in and of itself, but in relation to the series that precedes and follows it; what becomes central is its relative value, rather than its relationship to some elusive ‘real’ substance”⁵⁴.

From this follows a shift in the traditional problem of source criticism. “Rather than relying on the conventional criteria of external and internal criticism, the serial historian must be aware of how their sources were constructed, for what purposes, through which systems of recording and preserving written memory they were produced, how and why they were transmitted to posterity, and what kinds of distortions - whether intentional or unintentional - they bear”⁵⁵.

However, throughout the 1970s, quantitative history became the focus of intense debate, particularly regarding the scientific validity and objectivity of quantification itself⁵⁶. During this period, the organizatio-

52. Le Goff, “Documento/monumento,” 46.

53. Le Goff, “Documento/monumento,” 42.

54. François Furet, “Il quantitativo in storia”, in *Fare storia*, ed. J. Le Goff and Pierre Nora (Einaudi, 1981), 9.

55. Vitali, *Passato digitale*, 19. Beginning with the simplest historical series - such as economic, fiscal, or demographic records - the revolution brought about by computers in the collection and analysis of data soon spread to all types of historical information that could be represented in a programmable form (Furet, “Il quantitativo in storia,” 10).

56. Vitali, *Passato digitale*, 24-26.

nal and technological limitations of computer use became increasingly apparent, due mainly to the scarcity of computing resources concentrated in specialized centers and to the relatively high initial investment - both in time and money - required for programming and organizing research workflows. These challenges, combined with methodological difficulties stemming from the rigidity and sterility of data input and management systems, rendered the mainframe an elitist tool, accessible only to a small group of specialized technicians, and contributed to growing dissatisfaction with the application of computing to historical research⁵⁷.

In contrast to the widespread disillusionment with computers that characterized the historiographical field in the 1970s, a new vision began to emerge. Influenced by contemporary youth movements and libertarian countercultural ideologies spreading from the west coast of the United States across the Western world, this perspective promoted an alternative use of the computer as a tool for individual empowerment, capable of challenging the dominance of centralized bureaucracies and large industrial systems. These Californian libertarian ideals strongly shaped technological innovation and led, in the early 1980s, to the development and diffusion of the personal computer - a tool that, in turn, reconfigured the relationship between computing and historiography⁵⁸. "Unlike large centralized systems, it was designed as a flexible tool, adaptable to multiple and diverse uses: a tool, therefore, increasingly within the reach of ordinary people, rather than the exclusive domain of specialized technical elites. Although there is no direct connection between these ideologies and the historiographical trends of the 1980s, it is nonetheless clear that the personal computer immediately proved better suited to the needs of historians than mainframes had been"⁵⁹.

Starting from this period, the computer gradually moves beyond its association with quantitative history and, together with its peripherals (scanners, printers, CD-ROM and DVD drives) becomes an increasingly versatile tool, compatible with a variety of methodological approaches. Historians begin to incorporate the PC into their workflow as a writing instrument, and in certain areas of the discipline, they explore more advanced uses through database management programs and, more

57. Vitali, *Passato digitale*, 24.

58. Vitali, *Passato digitale*, 26-27.

59. Vitali, *Passato digitale*, 27.

rarely, markup metalinguages⁶⁰.

During the 1990s, however, a new technological development opened entirely new horizons in historiography: the emergence of the Web. The advent of the World Wide Web, and later, from 2004, Web 2.0 - the so-called 'participatory web'⁶¹, which marks the definitive shift from Digital History⁶² to Digital Public History⁶³ - had wide-ranging effects on the historical community, particularly in sociological terms. New forms of interpersonal and collective interaction emerged, such as email and newsgroups; at the same time, the scholarly community expanded gradually to a global scale. Traditional distances between students and teachers began to shrink through the creation of new informational spaces, such as wikis⁶⁴, and the gap between different professional roles within the social organization of research - historians, archivists, librarians, and others - also narrowed⁶⁵.

"Other changes seem instead destined to have repercussions on the structure and epistemological status of the discipline [...]. The general acknowledgment of the Web's role as a tool for sharing and exchanging knowledge entails the discovery of the communicative dimension implicit in every research and intellectual production activity.

60. Vitali, *Passato digitale*, 69.

61. Serge Noiret, "Digital Public History," in *A Companion to Public History*, ed. D. Dean (Wiley-Blackwell, 2018).

62. "Digital History, ultimately, is a methodology based on the application of computer technologies for the acquisition and retrieval of sources, followed by their formalization, coding, and processability, with the aim - in Turing's sense - of producing new information about past events, whether analog or strictly digital, in a context where documentary resources are exponentially abundant. It differs, moreover, from quantitative history [...] in terms of its purposes and objectives" (Salvatore Spina, *Digital History. Metodologie informatiche per la ricerca storica*, Edizioni Scientifiche Italiane, 2022, 89).

63. Shawn Graham, Guy Massie, Nadine Feuerherm, "The Heritage Crowd Project. A Case Study in Crowdsourcing Public History," in *Writing History in the Digital Age*, ed. J. Dougherty and K. Nawrotzki (The University of Michigan Press, 2013), 222. "The web forced digital historians to reconsider authority and public participation once new interactive Web 2.0 technologies appeared between 2001 and 2004. The advent of the so-called 'participatory web', or web 2.0, augured even more transformative changes, with the advent of blogging and content management software. As the web grew more dynamic, users became active participants in crafting stories and narratives. Participation transformed digital history into digital public history" (Thomas Cauvin, "Digital Public History in the United States," in *Handbook of Digital Public History*, ed. S. Noiret, M. Tebeau, and G. Zaagsma, De Gruyter, 2022, 236-238).

64. "What is a wiki? First of all, it may be defined as an open, virtual informational space of a communal nature, designed for the social construction of knowledge. It is therefore a tool capable of disseminating information without prior censorship and at minimal cost, making possible the convergence of author, reader, and editor in the production of its content. It has an incremental, monitorable, and modifiable nature, insofar as any user has the ability to add a page and alter its content, which remains permanently accessible to all. [...] Consequently, the true author of a wiki is a collective subject that renounces any claim of ownership over its intellectual work and identifies itself with the principle of collaborative labor" (Miguel Gotor, "L'isola di Wikipedia. Una fonte elettronica," in *Prima lezione di metodo storico*, ed. S. Luzzatto, Laterza, 2010, 186).

65. Vitali, *Passato digitale*, 69; Gotor, "L'isola di Wikipedia," 192.

[...] This revelation implies the increasingly widespread sense that it is now impossible to conceive of any stage of the process of constructing historical knowledge as separate from its communication”⁶⁶. The ease of sharing enabled by this revolutionary tool has two main effects: on one hand, it provides vastly increased and readily accessible sources (whether digitized or born-digital); on the other hand, it allows for the dissemination of the plurality “of doing history and telling it”, as the Web enables the close coexistence of academic, professional, and amateur history.

“Availability of sources on the Internet, it has been said. But perhaps it would be more appropriate to speak of the availability of ‘resources’ - adopting terminology that has now become common for defining the materials and services accessible through the Web. A term [...] whose generality and ambiguity aptly reflect the difficulty of establishing a linear correspondence between the information and knowledge mediation tools typical of traditional media and those present in the digital world⁶⁷. At the same time, it highlights the problematic nature of classifying the latter according to rigid, semantically well-defined categories, and conversely, it underscores the need for flexible taxonomies capable of adapting to a dynamic universe”⁶⁸. Indeed, for several decades historiography has drawn on sources that bear little resemblance to traditional written materials, and historians have become increasingly adept at handling immaterial or even virtual sources: words recorded in audio files, images captured on video, photographs downloaded from websites, and so on⁶⁹. In the last decade, the convergence of exponentially increasing computing power, due to the miniaturization of chips, with the vast amounts of data available online (big data)⁷⁰, and advances in cognitive neuroscience⁷¹, has sparked another technological revolution. This transformation has affected numerous fields, including historiography, within just a few years. At the center of this shift are Artificial Intelligence (AI)

66. Vitali, *Passato digitale*, 69-70.

67. See chapter 05 of the present thesis.

68. Vitali, *Passato digitale*, 72.

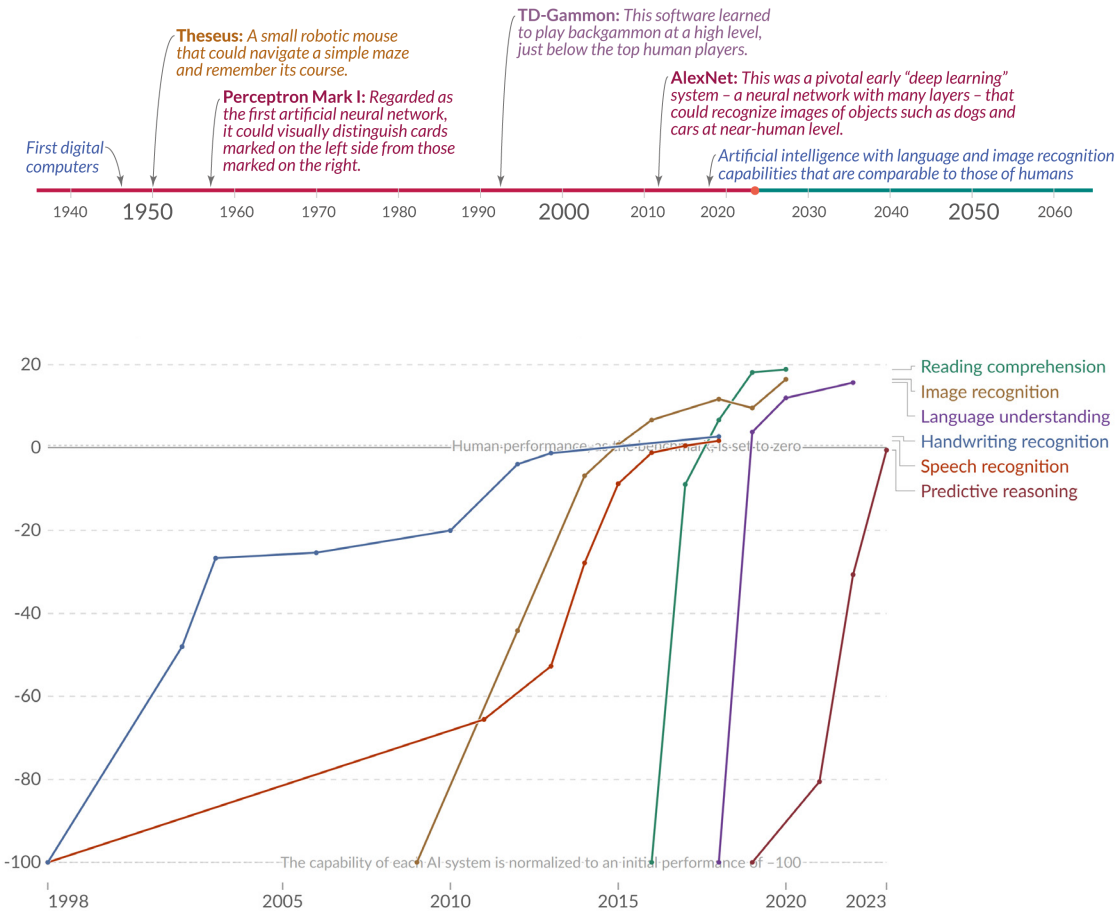
69. Luzzato, “Premessa,” 5.

70. Serge Noiret, “Storia contemporanea digitale,” in *Il web e gli studi storici*, ed. R. Minuti (Carocci Editore, 2015), 273.

71. Annamaria Testa, “La lunga strada dell’intelligenza artificiale,” *Internazionale*, 10 March 2023, <https://www.internazionale.it/opinione/annamaria-testa/2023/03/10/storia-intelligenza-artificiale>; Luca Tremolada, “La storia dell’intelligenza artificiale in due grafici,” *Il Sole 24 ore*, 24 December 2022, <https://www.infodata.ilsole24ore.com/2022/12/24/la-storia-dellintelligenza-artificiale-in-due-grafici/>.

systems, whose theoretical foundations were laid by Alan Turing and John McCarthy in the 1950s, but whose developments over the past ten years have dramatically accelerated research⁷².

“The chart published on Our World in Data [Fig. 2.10] illustrates the development of AI from 1980 to the present. The data are derived from a series of tests designed to assess the performance of both humans and artificial intelligence across five domains, ranging from handwriting recognition to language comprehension. [...] As recently as a decade ago, no machine could reliably perform speech or image recognition. Yet, as the chart demonstrates, AI systems have rapidly improved and now outperform humans across all these domains”⁷³.



72. Tremolada, “La storia dell’intelligenza artificiale in due grafici.”

73. Tremolada, “La storia dell’intelligenza artificiale in due grafici.”

It appears that the time has come for those historians still hesitant to embrace digital tools to acknowledge a fundamental reality: we live in a world increasingly shaped by algorithms. This shift requires adapting to the exponential growth of both digitized and born-digital evidence. Artificial intelligence has already demonstrated its capacity to identify patterns and extract meaningful structures from large-scale visual and textual datasets. For instance, algorithms can be employed to detect correspondence within a vast email corpora or to identify maps, comics, editorial cartoons, and advertisements in digitized historical newspapers.

As ever more historical materials assume digital form - whether through digitization or as natively digital sources - machine learning will become indispensable to historical research. In this sense, artificial intelligence not only reshapes social practices but also transforms the very practice of doing history, ultimately merging with historical consciousness itself. At the same time, reflecting on the impact of AI - and, more broadly, of digital technologies - compels us to reconsider fundamental concepts such as truth, evidence, and authenticity⁷⁴. It also raises pressing questions regarding the selection, preservation, and long-term sustainability of these 'new' forms of evidence. Ultimately, the key question is whether digital and digitized sources will retain the same capacity to 'convey meaning' over time as material traces, such as rock inscriptions, once did for pre-digital scholars⁷⁵.

Fig. 2.10 Top: a timeline of notable artificial intelligence systems; bottom: test scores of AI systems on various capabilities relative to human performance. Within each domain, the initial performance of the AI is set to -100. Human performance is used as a baseline, set to zero. When the AI's performance crosses the zero line, scores more points than humans.

[Max Roser, "The brief history of artificial intelligence: the world has changed fast - what might be next?," *Our World in Data*, 2022, <https://archive.ourworldindata.org/20260304-094028/brief-history-of-ai.html>]

74. Darrell R. Meadows, Joshua Sternfeld, "Artificial Intelligence and the Practice of History: A Forum," *The American Historical Review* 128, i. 3 (2023): 1345-1349, <https://doi.org/10.1093/ahr/rhad362>.

75. Spina, *Digital History*, 86.

02.2.1 In-depth study & experiences

Hidden Trento 900: a project of Digital Public History

Project title	<i>Hidden Trento 900.</i>
Coordinator	Italian-German Historical Institute (Fondazione Bruno Kessler).
Working group	Maurizio Cau (FBK-ISIG), Alessandro Paris (FBK-ISIG), Massimo Rospocher (FBK-ISIG), Elena Tonezzer (Fondazione Museo storico del Trentino), Michele Toss (Fondazione Museo storico del Trentino), Fabio Campolongo (Soprintendenza per i beni e le attività culturali di Trento), Anna Maragno (DICAM, University of Trento), Cristiana Volpi (DICAM, University of Trento).
Funding	Fondazione Cassa di Risparmio di Trento e Rovereto.
Timeframe	November 2023 - November 2024
Dissemination	Oral presentation: Anna Maragno, “Digital Public History through immersive experiences. The ‘Hidden Trento 900’ project,” <i>Making Stones Speak. New Narratives about Europe and the Sites of Dictatorship</i> , Villa Vigoni (Como), July 2024.

Introduction

During the final year of my PhD, I had taken part in an important Digital Public History project, supported by the Fondazione Cassa di Risparmio di Trento e Rovereto (CARITRO), coordinated by the Italian-German Historical Institute¹ of Fondazione Bruno Kessler in Trento, and developed in collaboration with the Department of Civil, Environmental and Mechanical Engineering at the University of Trento, the Fondazione Museo storico del Trentino², and the Soprintendenza per i beni e le attività culturali³ (Provincia Autonoma di Trento)⁴.

The project *Hidden Trento 900*, launched in 2023, is part of a broader initiative known as *HistoryCity Apps*⁵ [Fig. 2.11]. The *HistoryCity Apps* suite (formerly *Hidden Cities Apps*) offers an immersive digital experience via smartphone and consists of a series of applications developed within the framework of the European project *HERA Public Renais-*

1. “Italian-German Historical Institution,” Fondazione Bruno Kessler, accessed May 1, 2026, <https://isig.fbk.eu/en/>.

2. Fondazione Museo storico del Trentino, accessed May 1, 2026, <https://museostorico.it/>.

3. “Umst per i beni e le attività culturali,” Provincia autonoma di Trento, accessed May 1, 2026, <https://www.provincia.tn.it/Amministrazione/Strutture-organizzative/Umst-per-i-beni-e-le-attivita-culturali>.

4. “Hidden Trento 900. The city at the time of fascism,” Fondazione Bruno Kessler, accessed May 1, 2026, <https://isig.fbk.eu/en/projects/detail/hidden-trento-900-the-city-at-the-time-of-fascism/>.

5. “Step into the past,” HistoryCity Apps, accessed May 1, 2026, <https://historycityapps.org/>.

sance. *Urban Cultures of Public Space between Early Modern Europe and the Present* (PURE). These apps provide a variety of guided tours across several European cities, each led by a historical character⁶. Through the app, users can access audio content and historiographical insights related to specific locations, along with additional readings and curated images available on the project's website.

The app's format is characterized by two key features: the inclusion of a historical guide character and the visual overlay of a historic map onto the contemporary base map. These elements serve as forms of Augmented Reality (AR), enriching and expanding the user's perceptual experience⁷.

Between 2023 and 2025, a multidisciplinary research team composed of historians and architectural historians worked on the development of the *Hidden Trento* app, introducing a new tour set in the city during the Fascist period, i.e. *Hidden Trento 900* (HT900). This new addition complements the four pre-existing tours, which focus on the city of Trento in the 16th and 17th centuries.

Notably, the *History City apps* were awarded the prestigious '2025 Heritage in Motion International Award' in the Virtual and Augmented Reality category⁸.



Fig. 2.11 Homepage of *HistoryCity Apps* website.

["Step into the past," HistoryCity Apps, accessed May 1, 2026, <https://historycityapps.org/>]

6. Fabrizio Nevola, "Introduction," in *Hidden Cities: Urban Space, Geolocated Apps and Public History in Early Modern Europe*, ed. Fabrizio Nevola, David Rosenthal and Nicholas Terpstra (Routledge, 2022), 1, 6.

7. Umberto Cecchinato, Alessandro Paris, "Angelo 1563. City of the Council. A Public History Project in Sixteenth-Century Trento," *Storia Urbana. Rivista di studi sulle trasformazioni della città e del territorio in età moderna* XLV, no. 173 (FrancoAngeli, 2022): 122; Nevola, "Introduction," 4-6.

8. Viviana Lupi, "International recognition for the Hidden Trento app developed by Fondazione Bruno Kessler's Italian-German Historical Institute," *Fondazione Bruno Kessler Magazine*, October 9, 2025, <https://magazine.fbk.eu/en/news/international-recognition-for-the-hidden-trento-app-developed-by-fondazione-bruno-kesslers-italian-german-historical-institute/>.

Experience as historical knowledge

“Step into the past. Bring the streets to life with immersive living history trails on GPS-triggered maps”⁹, reads the homepage of the *HistoryCity Apps* website. It is an invitation to immerse oneself in an experience where historical narratives unfold in situ, blending digital storytelling with the physical environment to create a sense of history lived in the present.

Recent developments in the digital humanities have emphasized that experience itself can constitute a legitimate and powerful form of historical knowledge. Traditional historiography relies on textual mediation (reading, writing, and interpretation) whereas DPH opens up the possibility for embodied learning, allowing individuals to encounter history through sensory, spatial, and affective dimensions¹⁰.

The concept of ‘experiential history’ suggests that history is not only about the past but also performed and felt in the present. In digital environments, users engage in situated cognition, meaning that understanding arises from direct interaction with reconstructed spaces and narratives¹¹. Walking through a city, hearing historical sounds, and following a digital guide all become forms of ‘doing history’, in which users’ bodies and emotions are integrated into the interpretive process.

Video games such as *The Oregon Trail* (1971) and *Assassin’s Creed: Origins* (2017) pioneered this approach by embedding historical scenarios into interactive frameworks that stimulate decision-making and empathy. As historical reenactments in digital form, they allow players to explore ethical dilemmas and social contexts rather than memorize facts. In this sense, digital immersion functions as a ‘gateway to historical imagination’, blurring the line between historical reconstruction and personal experience¹².

9. “Step into the past,” HistoryCity Apps, accessed May 1, 2026, <https://historycityapps.org/>.

10. Sandra Camarda, “Cybermemorials: Remembrance and Places of Memory in the Digital Age,” *Handbook of Digital Public History*, ed. Serge Noiret, Mark Tebeau, and Gerben Zaagsma (De Gruyter, 2022), 339.

11. “Immersion is the subjective impression that one is participating in a comprehensive, realistic experience. Interactive media now enable various degrees of digital immersion. The more a virtual immersive experience is based on design strategies that combine actional, symbolic, and sensory factors, the greater the participant’s suspension of disbelief that she or he is “inside” a digitally enhanced setting. Studies have shown that immersion in a digital environment can enhance education in at least three ways: by allowing multiple perspectives, situated learning, and transfer. Further studies are needed on the capabilities of immersive media for learning, on the instructional designs best suited to each type of immersive medium, and on the learning strengths and preferences these media develop in users” (Chris Dede, “Immersive interfaces for engagement and learning,” *Science* 323, no. 2, 2009: 66-9, [10.1126/science.1167311](https://doi.org/10.1126/science.1167311))

12. James B. Gardner and Paula Hamilton (ed.), *The Oxford Handbook of Public History* (Ox-

For *Hidden Trento 900*, this experiential model is central. Users are prompted to move through the city of Trento, compare past and present urban layers, listen to commentary, and engage with archival materials. Thus, knowledge is not passively transmitted but actively constructed through movement, curiosity, and affective engagement. This underscores the project's deliberate use of immersive and interactive mechanisms to produce historical knowledge as lived experience.

The immersive experience of the *HistoryCity* tours

The *HistoryCity Apps* suite of applications represents a pioneering model for digital heritage mediation in urban contexts¹³. At its core, the framework translates rigorous historical research into accessible, interactive experiences. Each app offers a series of geolocated tours through European cities, guided by fictional or historical characters whose narratives interweave personal memory with broader historical developments [Fig. 2.12]. This narrative strategy is not a superficial storytelling device but a deliberate pedagogical choice: the guide acts as a mediating presence that humanizes historical space and encourages user identification. Each walk in the *HistoryCity Apps* “is structured as an itinerary that is built up through the character’s comments, additional audio content provided in short expert ‘discover more’ pieces and is supported by a linked website where the more interested user can explore a wealth of further research, presented in the form of short articles with related images”¹⁴. Through this structure, users enter a dialogic relationship with the past, moving through the city alongside figures who embody its tensions and complexities.

The *HistoryCity Apps* fully align with contemporary digital humanities practices while contributing to the growing field of Digital Public History. “In the most general terms, the widespread uptake of smartphones is taken as an opportunity for the researcher to communicate directly with a wider public, GPS and familiarity with digital mapping functions facilitate location-based interpretation, while fast-growing processing speed for mobile computing make it possible to deliver a good deal of information (data) in the form of mapping features, audio files and images to most devices. As such, in digital humanities terms,

ford University Press, 2022).

13. Fabrizio Nevola, David Rosenthal, and Nicholas Terpstra (ed.), *Hidden Cities: Urban Space, Geolocated Apps and Public History in Early Modern Europe* (Routledge, 2022).

14. Nevola, “Introduction,” 1.



Fig. 2.12 List of the cities where the *HistoryCity* walking tours can be experienced.

[“Apps,” HistoryCity Apps, accessed May 1, 2026, <https://historycityapps.org/>]

the affordances of smartphones are being harnessed to the age-old humanities practice of interpretation of evidence and its communication to audiences of peers, students and the wider public”¹⁵.

A distinctive feature of the *HistoryCity* walking tours is their capacity to merge spatial exploration with narrative immersion. Through GPS tracking, soundscapes, and historical maps - deliberately misaligned with the contemporary urban fabric - users experience a productive temporal dissonance that exposes the city as a site of transformation, memory, and loss. This form of situated digital storytelling turns walking into an interpretive act. By listening to voices from the past while navigating present-day streets, participants inhabit a multilayered temporality in which past and present coexist. The result is both affective and reflective: history becomes not static information but a lived, continuously renegotiated presence within urban space. The recognition by the ‘Heritage in Motion Award’ explicitly highlights how the app is “an innovative augmented reality initiative that transforms city streets into Living History trails. Combining first-person narratives, expert commentary, and archival collections, the free apps allow users to explore georeferenced urban landscapes with the guidance of historical characters through stories tied to real places of the past”¹⁶.

Ultimately, the *HistoryCity Apps* methodology is grounded in four in-

15. Nevola, “Introduction,” 4-5.

16. Lupi, “International recognition for the Hidden Trento app”.

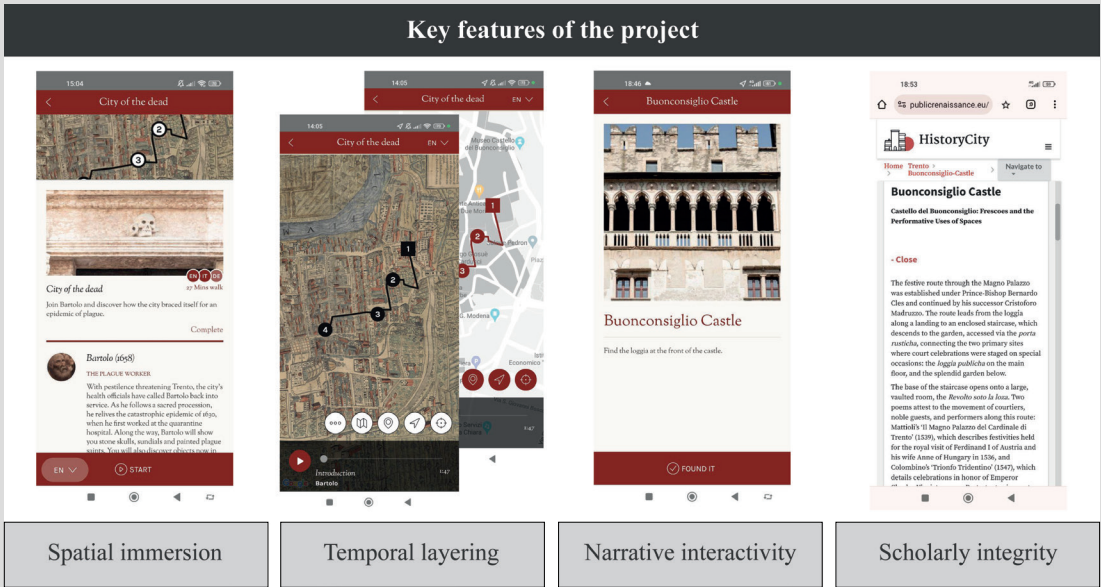
terrelated principles [Fig. 2.13]:

1. Spatial immersion: the use of GPS-based mapping allows users to explore urban space as an open-air archive, merging physical presence with virtual interpretation.
2. Temporal layering: the visual overlay of historical maps onto contemporary layouts creates a palimpsest effect, highlighting how urban identities evolve through continuity and rupture.
3. Narrative interactivity: missions, dialogues, and tasks transform historical exploration into an active process of discovery rather than a passive tour.
4. Scholarly integrity: all materials (texts, images, and audio) are based on peer-reviewed historical research, ensuring that interactivity serves accuracy rather than spectacle.

Fig. 2.13 The methodological principles on which the *HistoryCity Apps* project is based are, from left to right: spatial immersion, temporal layering, narrative interactivity, and scholarly integrity.

Hidden Trento 900 walking tour

Building upon this framework, *Hidden Trento 900* (HT900) expands the *Hidden Trento* platform with a new walking tour dedicated to the Fascist period in the city. The tour “allows an immersive and guided experience in the main urban spaces affected by architectural transformations during fascism (railway station, Raffaello Sanzio school, Piazza Littorio, new post office building)”¹⁷.



17. “Hidden Trento 900. The city at the time of fascism”.

The narrative unfolds through two fictional guides: Emma, a twelve-years old girl raised in Fascist Italy as a *piccola italiana* - the Fascist youth organization mandatory for all girls between eight and fourteen - and her father Guido, a journalist working in the Party's press office. In this tour, the user is drawn into Emma and Guido's story, which takes place on 8 September 1943, the armistice day, shortly after the first bombing of the city. The tour accompanies their dialogue as they move through familiar urban spaces, reshaped by ideology and war. The dual perspective, one innocent and one ideologically aligned, invites users to confront moral ambiguity and emotional complexity, transforming the city into a stage for historical empathy and critical reflection.

The app is structured as a form of interactive game [Fig. 2.14]. Users are invited to follow Emma and Guido as they carry out their tasks on this pivotal day. Moving through the main locations of Fascist-era Trento, users complete simple missions guided by the two historical characters.

To experience the tour, users must download the app from the App Store and select the thematic itinerary "The Fascist City". At the outset, the historical guide introduces users to the context in which the narrative unfolds and explains, step by step, the mission they are about to undertake (1).

The tour is organized into multiple stages, each corresponding to a significant site in the city. At each stop, the app proposes a small challenge known as a "found it": users are encouraged to observe their surroundings and identify specific architectural or urban features that are still visible today (2). Once the objects are identified, users can listen to short audio explanations that contextualize each element historically (3). Finally, those seeking additional information may access further readings and visual materials prepared by the research team, available on the project website (4).

Since 2023, the interdisciplinary team responsible for developing the new *Hidden Trento* tour has consisted of professionals with diverse training and expertise. The technological implementation was carried out by computer scientists at the University of Exeter, while the written, audio, and visual contents were developed collaboratively by historians and architectural historians from Fondazione Bruno Kessler, the Fondazione Museo Storico del Trentino, the Soprintendenza per i beni e le attività culturali, and the DICAM at the University of Trento.

The team's work progressed through several stages. First, they iden-

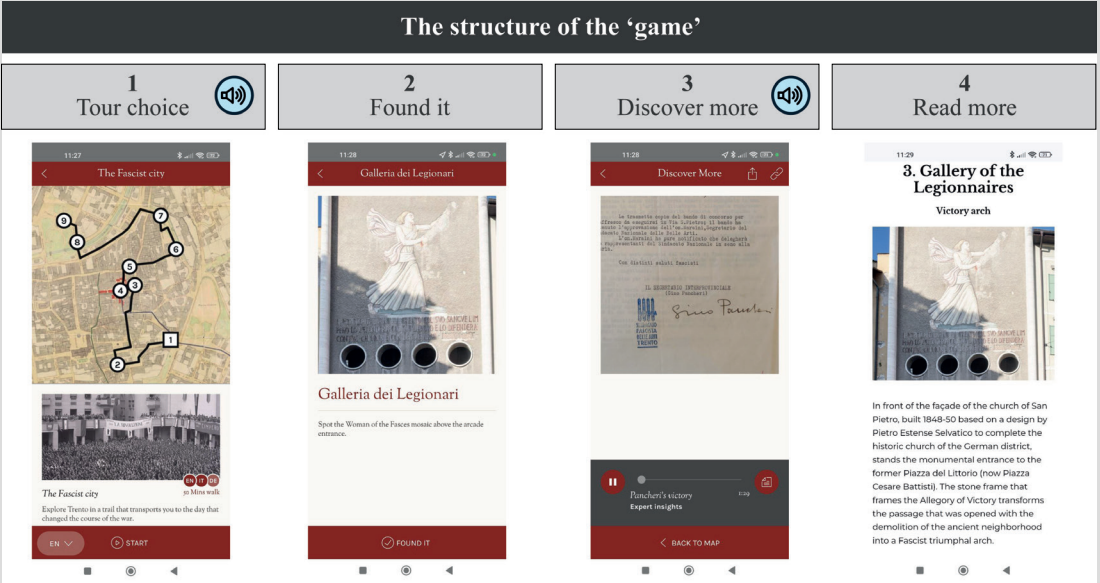


Fig. 2.14 The walking tour is conceived as a structured, game-based experience articulated in several sequential steps. From left to right: (1) upon selecting a thematic route, users are provided with an introduction to the relevant historical context; (2) at each stop, they are prompted to identify a specific object within their surrounding environment; (3) the identified object subsequently serves as a point of departure for the exploration of a related theme; (4) users seeking further depth may consult the “learn more” section, which offers additional written material accessible via the website.

tified the most historically relevant sites in Trento during the Fascist period. For each stop, a building or urban feature was selected as an anchor for exploring specific themes, such as public ceremonies, the press, or schooling under Fascism. Historians then prepared the accompanying images and the in-depth written and audio materials. Finally, they selected and developed the historical guides and composed the storyboard, which defines the narrative structure and overall storytelling strategy.

Conclusion

Hidden Trento 900 exemplifies how Digital Public History can transcend traditional modes of historical communication by integrating immersive technologies and narrative design. It demonstrates that history, when experienced through digital interaction, becomes a form of public engagement that fosters empathy, critical awareness, and civic identity. In this way, the project not only documents Trento’s past but reactivates it within the collective consciousness of contemporary citizens. As a living interface between scholarship, technology, and memory, *HT900* embodies the transformative potential of Digital Public History to make the past speak once again.

02.3 Memory through images and visual media

“Image as a copy of the ‘real’, image as the way reality presents itself, image as a form of knowledge. Fragments, messages of culture, obsessions of dreams, fantasies, games, stereotypes, memories, traces... the vertigo of the image. Limits of the observable, the allure of the invisible, the rhythm of ritual, the narration of myth, the symbolism of power, the drama of vision, the tenderness of memory. [...] Shadows, doubles, projections, representations, messages that become fixed, not only by virtue of their symbolic efficacy, forever or for a moment in memory, immediately or over the long term, as if thinking were seeing and seeing were also thinking, in a circularity that is difficult to interrupt. [...] Reference to the absent and the order (perhaps fallacious and provisional) of the ‘present’: herein lies the ambiguity of the image, *unda* and *corpus*. As a form of mediation, no culture can do without it; and it is perhaps precisely in these possibilities - both object and medium of knowledge, of life not only ‘symbolic’ - that its character of necessity resides”¹. In these few lines introducing the entry ‘image’ in the “Enciclopedia Einaudi” (1979), Gian Paolo Caprettini - an Italian semiotician and journalist - condenses, in a vertiginous sequence, the ambiguities inherent in the very nature of images and the reasons for their indispensability to human beings. From pictographic inscriptions in caves to digital photography, “throughout the evolution of civilization and culture, the image has constantly participated in the formation of thought and has been recursively embedded in modes of communication - that is, in the exchange of knowledge concerning the various domains of human activity [...]. In every social context or collective behavior, messages transmitted through sound waves and light energy acquire particular significance once they can be recorded - namely, once a means has been found to ‘represent’ speech and optical perception through writing and the image, thereby preserving and transmitting systems of information across time and space”².

1. Gian Paolo Caprettini, “Immagine,” *Enciclopedia Einaudi* (Einaudi, 1979), 93.

2. Roberto de Rubertis and Giovanna A. Massari, “Il ruolo dell’immagine nella cultura, nella scienza e nell’arte. Una riflessione sulla dimensione visuale nei diversi ambiti del sapere e sulle possibili applicazioni interdisciplinari,” *UniTrentoMag*, September 1, 2015, <https://mag.unitn.it/eventi/6214/il-ruolo-dell-immagine-nella-cultura-nella-scienza-e-nell-arte>.

Societies, therefore, rely on images. As the sociologist Vanni Codeluppi observes, “If this is the case, it is because the language of images [...] is generally seen as a tool capable of effectively reproducing reality”³. Indeed, “images, when well crafted, resemble things so closely that they can take their place; [...] so much so that they appear other than themselves, standing in for, and concealing their own nature as, signs”⁴. According to Codeluppi, this is where the power of images lies: in their ability to evoke, in a single instant, something distant or elusive - something that may no longer exist, or perhaps never existed - and “to endow it with such presence that it completely fills the space of human attention”⁵. “Images thus lead us to believe they reflect our world, when in reality they transform it before our eyes, making it, in some respects, resemble a fiction”⁶. Perhaps, after all, “images that stand in for things ultimately betray them”⁷ [Fig. 2.15].

Fig. 2.15 René Magritte, *La Trahison des images* (or *Ceci n'est pas une pipe*), 1929, Los Angeles County Museum of Art.

[<https://www.lacma.org/art/exhibition/magritte-and-contemporary-art-treachery-images>]



The ambiguities of images are rooted in the etymology of the word itself: the Latin *imago*, *imaginis* signifies, on one hand, ‘imitation’; on the other, ‘visible form’. “These shifts in meaning are complementary.

3. Vanni Codeluppi, “Il ruolo sociale delle immagini digitali,” *Mediascapes journal*, no. 19 (2022): 218.

4. Gianfranco Marrone, *Prima lezione di semiotica* (Laterza, 2018), 37.

5. Gottfried Bohem, *La svolta iconica* (Meltemi, 2009), 75.

6. Codeluppi, “Il ruolo sociale delle immagini digitali,” 225.

7. Marrone, *Prima lezione di semiotica*, 37.

Indeed, the image has been conceived both as a reproduction of reality that is offered to the eye (the Greek *eikon*) and as the result of a formalization: not simply a copy of the sensible, but a product, a formal construction. In this sense, an image simultaneously imitates the object it represents while also signaling its own distance from that object. Representation and construction, thing and form, absence and presence: it is along these tensions that the complex interplay between imitation and expression - the very heart of philosophical reflection on images - unfolds”⁸.

The historical evolution of images shows that between simple imitation and full-fledged iconic expression lies a vast terrain of figurative possibility⁹. As art historian and philosopher Gottfried Boehm observes, “images do not operate as rigid mirrors that simply reflect a reality we must take for granted; they are not mere doubles. Simple reproduction is the most banal, albeit widespread, expression of a wholly empty figurativity. Authentic images, by contrast, offer not just confirmation of what we already know, but an added dimension, a ‘growth in being.’ They involve an internal process, an inherent iconic tension [...]. It is precisely this internal tension that allows meaning to emerge in material form. The Greeks likely intuited this dynamic when they called the image *zoon*, a living thing. Across history, this ‘living thing’ has continually assumed new forms, taking on particularly diverse manifestations in the modern era”¹⁰ [Fig. 2.16].

The power of images to reproduce and yet transform reality is reflected in the subtle conflicts they enact with time and memory. As Georges Didi-Huberman, art historian and philosopher, notes, “when we stand before an image, we stand before time”¹¹. In encountering an image, “no matter how ancient, the present is continually reconfigured [...]. And no matter how recent or contemporary, the past is never static, since the image can only be apprehended through the work of memory. [...] Ultimately, we must humbly acknowledge that the image will likely outlast us: we, the viewers, are the fragile, transient element, whereas

8. Paolo Bertetto and Silvio Alovio, “Immagine,” *Enciclopedia Treccani. Enciclopedia del Cinema*, 2003, [https://www.treccani.it/enciclopedia/immagine_\(Enciclopedia-del-Cinema\)/](https://www.treccani.it/enciclopedia/immagine_(Enciclopedia-del-Cinema)/).

9. Pier Giorgio Gabassi and Mariselda Tassarolo, *Disegno e comunicazione* (FrancoAngeli, 1991), 19-20.

10. Bohem, *La svolta iconica*, 77; de Rubertis and Massari, “Il ruolo dell’immagine nella cultura, nella scienza e nell’arte”.

11. Georges Didi-Huberman, *Storia dell’arte e anacronismo delle immagini* (Bollati Boringhieri, 2007), 11.

Fig. 2.16 Antonio Canova, *Cupid and Psyche*, 1796-1800, Gipsoteca canoviana, Possagno (TV).

[Photograph by the author]



the image embodies the future, the enduring element. Often, it carries more memory and more potential than the one who beholds it”¹².

Within the philosophical debate on the image and its relationship with time, the position of Walter Benjamin (1892-1940) stands out for its authority and influence. According to him, “the image is not the imitation of things, but the interval made visible, the line of fracture between things. [...] [It] brings together and, as it were, shows the contrast between different ways of being: on the one hand presence, and on the other representation; on the one hand the becoming of what changes, and on the other the complete stasis of what remains”¹³.

For Benjamin, the authentic image is a ‘dialectical image’ - “a spherical flash of lightning that runs across the entire horizon of the past”¹⁴ - positioned at the very center of the historical process, since “history breaks down into images, not into stories”. This dialectical image is a site where the ‘Now’ (the present instant, the flash) meets the ‘Has-been’

12. Didi-Huberman, *Storia dell’arte e anacronismo delle immagini*, 13.

13. Didi-Huberman, *Storia dell’arte e anacronismo delle immagini*, 109-110. “Even the most perfect reproduction of a work of art - argues Benjamin - is lacking in one element: its presence in time and space, its unique existence at the place where it happens to be. This unique existence of the work of art determined the history to which it was subject throughout the time of its existence. This includes the changes which it may have suffered in physical condition over the years as well as the various changes in its ownership. The traces of the first can be revealed only by chemical or physical analyses which it is impossible to perform on a reproduction; changes of ownership are subject to a tradition which must be traced from the situation of the original” (Walter Benjamin, “The Work of Art in the Age of Mechanical Reproduction,” in *Illumination*, ed. H. Arendt, Schocken Books, 1969, 220).

14. Didi-Huberman, *Storia dell’arte e anacronismo delle immagini*, 109-110.

(the latent past, the fossil), a space where “all the times that constitute history collide [*se télescopent*] and differentiate themselves”. Within the image, moreover, all the layers of the “involuntary memory of humanity” are condensed¹⁵.

“What consequences”, asks Georges Didi-Huberman, “does this point of view have for the very understanding of historicity? Does placing the image at the center of time not mean losing its thread, undoing the course of history? Or introducing dissemination into the historical sciences and, even worse, subjecting them to the uncontrollability implicit in the term ‘image,’ particularly illusion and fantasy? Yet this is the price of a ‘Copernican revolution’ in history: acknowledging the processes of memory, and thus of the unconscious and the image, demands a radical shift in the role of Hegelian reason within historical thought. Historicity is constructed and deconstructed no longer along the thread of the Absolute Spirit, but along the very frayed rope of entirely relative images [...]. It is no longer the universal that is realized in the particular, but the particular that disseminates itself everywhere, without definitive synthesis”¹⁶.

Once again, therefore, ‘truth’ returns to the center of the discourse, within the fragile boundary that separates it from the ‘suggestion’ that intervenes in the act of observing an image and, even earlier, in the act of producing an image of reality.

When observing, “the truth of an image” - according to the art historian and architect Manlio Brusatin - “arises from its suggestion, which is its possible extension, the space where its shadow stretches. Subsequent memories will drag those images elsewhere, images that move with difficulty from the sanctuary in which they are placed”¹⁷. On the other hand, “subjective perception depends significantly on the cultural model within which one is situated and is directly related to a body of experiences that gradually accumulates, so that, slowly and progressively, the individual is transformed”¹⁸. In other words, when faced with an image of reality, the author’s ‘truth’ fragments into ‘particular suggestions’, that is, into the subjective interpretations of observers.

In the second case, when producing an image of reality, the one repre-

15. Didi-Huberman, *Storia dell’arte e anacronismo delle immagini*, 113-114.

16. Didi-Huberman, *Storia dell’arte e anacronismo delle immagini*, 113-114.

17. Manlio Brusatin, *Storia delle immagini* (Einaudi, 1989), XVIII.

18. Margherita De Simone, *Disegno, rilievo, progetto. Il disegno delle idee, il progetto delle cose* (La Nuova Italia Scientifica, 1990), 22.

sented is the author's 'truth', which reveals itself through a subjective and tendentious critical act, albeit one that may be carried out with varying degrees of awareness¹⁹. Indeed, "representation has always been the preferred tool that man uses to realize his identity through the construction of memory. In fact, in the act of representing the three connotative actions of memory are expressed: archiving, that is to say storing the perceived information; remembering, that is to say bringing back to life the information stored in the form of images; obliging, that is to say choosing only the essential information and removing all the superfluous ones. Thus, each representation is at the same time the archive of a segment of knowledge, the visual memory of a knowledge considered 'memorable' and the testimony of the oblivion of everything that has not been graphically transcribed"²⁰.

"The connection established between memory and representation highlights and fully expresses the dual nature of memory itself: there is no memory without oblivion. Forming memory necessarily implies filtering one's own experience, retaining only the essential elements and renouncing all the others. Like two sides of the same coin, memory and oblivion are also the opposite factors that coexist in representation, at the same time graphic testimony of what one wants to keep in memory (and consequently remember) and what has been forgotten. Just think for example of the cultural activity of architectural survey, in which the *continuum* of reality is discretized through a critical and hermeneutical approach"²¹.

The arbitrariness inherent in reproducing reality is equally evident in what, in the first half of the nineteenth century, was arguably the most significant and revolutionary invention in the field of representation: photography. While some proclaimed the 'death of painting' as a means of reproducing external reality upon encountering the daguerreotype (the first photographic process) over time the ambiguities of using this new medium became increasingly apparent, as it was soon noted that

19. Valeria Menchetelli, "Reproduce to preserve. From the disappearance of the original to the multiplied memory," *XY. Rassegna critica di studi sulla rappresentazione dell'architettura e sull'uso dell'immagine nella scienza e nell'arte*, no. 4 (2019): 74-91, <https://doi.org/10.15168/xy.v4i7.126>.

20. Valeria Menchetelli, "Archiving, remembering obliating. Notes on interdisciplinary connections between memory and representation", in *Connettere. Un disegno per annodare e tessere*. Proceedings of 42° Convegno Internazionale dei Docenti delle Discipline della Rappresentazione, ed. A. Arena, M. Arena, R.G. Brandolino, D. Colistra, G. Ginex, D. Mediat, S. Nucifora, and P. Raffa (FrancoAngeli, 2020), 2446.

21. Menchetelli, "Archiviare, ricordare, obliare," 2448.



Fig. 2.17 Louis-Jacques-Mandé Daguerre, *Boulevard du Temple*, Paris, 1838. Daguerreotype considered the first photograph to depict human figures.

[https://commons.wikimedia.org/wiki/File:Boulevard_du_Temple_by_Daguerre.jpg?uselang=it]

“photography cannot lie, but liars can photograph”²² [Fig. 2.17].

From its very inception, photography’s dual and inseparable status - as both a means of reproduction and a means of expression - has fueled debate about its true nature²³ and, by extension, its reliability as a historical source. On one hand, “photography is, like phonetic writing, a process that advantageously duplicates the primordial function of memory: to fix and preserve information [...]. This strictly reproductive function was what impressed Daguerre’s contemporaries most strongly, as can be inferred from Arago’s or Gay-Lussac’s reports to the Chamber of Deputies: ‘the daguerreotype’, said this scientist, ‘represents inanimate nature with a degree of perfection unattainable by drawing or painting, with a perfection equal to that of nature itself’”²⁴. In addition, “the novelty and significance of photography lie in its most obvious capacity: its rendering of a precise moment in time. The ‘click’ of the shutter captures an instant that immediately becomes past, yet is, nonetheless, the closest thing to knowledge of the present”²⁵.

22. Quotation attributed to Lewis Wickes Hine (1874-1940), American sociologist and photographer.

23. Roman Gubern, *Immagine e messaggio nella cultura di massa* (Liguori Editore, 1992), 41.

24. Gubern, *Immagine e messaggio nella cultura di massa*, 40. See also Nicholas Mirzoeff, *Introduzione alla cultura visuale* (Meltemi Press, 2020), 130.

25. Mirzoeff, *Introduzione alla cultura visuale*, 132. “The nature of photography, at least in its early stages, was equally striking and similarly engaged with questions of time and mortality. For this reason, Benjamin observed that, for the earliest photographic portraits, the phenomenon of photography represented ‘a great and mysterious experience’: for in its ability to capture an image, it appeared as something that defied time as it was known. An image of a single moment was

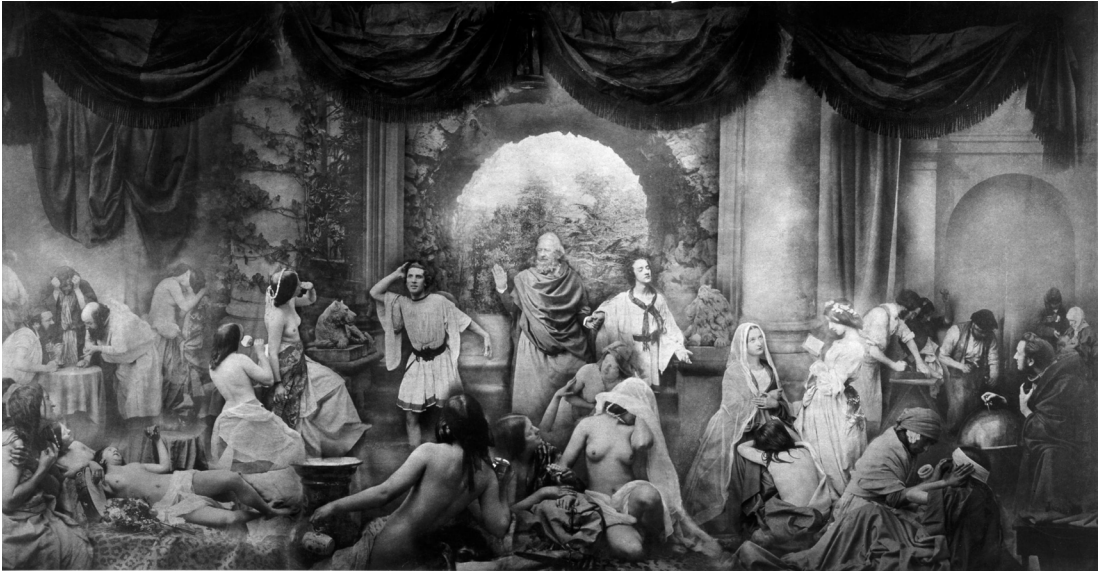


Fig. 2.18 Oscar Gustave Rejlander, *Two ways of life*, 1857. The picture is a composite photograph created from over thirty separate negatives, meticulously combined into a single print to achieve its elaborate allegorical scene.

[https://commons.wikimedia.org/wiki/File:Oscar-gustave-rejlander_two_ways_of_life.jpg]

On the other hand, as Susan Sontag emphasized, photographing means appropriating “the thing photographed. It means putting oneself into a certain relation to the world that feels like knowledge - and, therefore, like power. [...] But print seems a less treacherous form of leaching out the world, of turning it into a mental object, than photographic images [...]. What is written about a person or an event is frankly an interpretation, as are handmade visual statements, like paintings and drawings. Photographed images do not seem to be statements about the world so much as pieces of it, miniatures of reality that anyone can make or acquire [...]. But despite the presumption of veracity that gives all photographs authority, interest, seductiveness, the work that photographers do is no generic exception to the usually shady commerce between art and truth”²⁶ [Fig. 2.18]. In conclusion, Sontag asserts that “photographs do not explain; they acknowledge [...]. Contrary to what is suggested by the humanist claims made for photography, the camera’s ability to transform reality into something beautiful derives from its relative weakness as a means of conveying truth”²⁷.

The relationship between art and photography has been a subject of reflection since the mid-nineteenth century, fueled by what were considered its “three fundamental ‘defects’”: its unavoidable connection to re-

delivered to eternity” (Paolo Jedlowski, *Memoria, esperienza e modernità. Memorie e società nel XX secolo* (FrancoAngeli, 2002), 88).

26. Susan Sontag, *On Photography* (RosettaBooks, 2005), 2-4.

27. Sontag, *On Photography*, 86-87.

ality, its technical nature, and its reproducibility. These criticisms have accompanied it throughout its history [...] and they concern not only the debate on the artistic status of photography, but more generally its relationship with the developments of art history and the influence that these have exerted on cultural history”²⁸.

“In principle” - Benjamin observes - “a work of art has always been reproducible. Man-made artifacts could always be imitated by men. Replicas were made by pupils in practice of their craft, by masters for diffusing their works, and, finally, by third parties in the pursuit of gain. Mechanical reproduction of a work of art, however, represents something new. Historically, it advanced intermittently and in leaps at long intervals, but with accelerated intensity [...]. For the first time in the process of pictorial reproduction, photography freed the hand of the most important artistic functions which henceforth devolved only upon the eye looking into a lens. Since the eye perceives more swiftly than the hand can draw, the process of pictorial reproduction was accelerated so enormously that it could keep pace with speech”²⁹ Indeed, the advent of the photographic matrix represented a true revolution in comparison with the existing methods of reproducing images at the time, such as woodcut, engraving, and lithography. “Not only did it open incredible possibilities for the photographic image, but in a sense it summarized all previous forms of iconographic expression. If each of these had represented a technical advancement (though not necessarily an expressive one) over its predecessor, the photographic matrix was able to reproduce the print of an image obtained through any technique, thus perpetuating the forms and content of popular iconography. It would be a grave mistake to underestimate the social significance of this change [...]. The countless images that belong to our culture or daily life, including those of artistic content, became possible through photography”³⁰.

Gabriele D’Autilia, professor of Photography, Cinema, Media, and Visual Culture, explains that “when the photographic matrix comes to encompass the characteristics of woodcuts, engravings, and lithographs, and demonstrates the capacity to produce an infinite number of identical documents, the era of technical reproducibility of ima-

28. Gabriele D’Autilia, *L’indizio e la prova. La storia nella fotografia* (Bruno Mondadori, 2005), 39.

29. Benjamin, “The Work of Art in the Age of Mechanical Reproduction,” 218-219.

30. D’Autilia, *L’indizio e la prova*, 47.

ges is inaugurated. The next step from this phase is the introduction of the halftone screen, which is already part of media history"³¹. "The halftone screen (a product of the 1880s) gave rise to a new type of image and once again represented a revolution: the image passing through the screen is no longer the same; it is transformed into a multitude of dots, which allow it to be printed and disseminated immediately, though no longer reproduced with its original qualities and characteristics. [...] For informational printing, at least until other needs arise, quality is not essential: the image primarily communicates content. Yet this process was slow; [...] photographic printing only became widespread between the First and Second World Wars. [...] As a mass phenomenon, photography transcended national borders like other media, but with one crucial difference: it was the tool for production that spread extraordinarily, not just its product, as happened with cinema and television [...]. Photography shares the characteristics of media and therefore exerts enormous influence on life and mentality, but not only as a means of communication; it has always functioned as an individual and family object as well"³². For a long time after its introduction, sociologists regarded "photography as a minor art form, unworthy of trust, and underestimated its immense social significance [...]. Yet from the moment of its appearance in the first half of the nineteenth century, photography gradually established itself in everyday life and, thanks to its capacity for easy multiplication, enhanced the social role of images"³³. "Recently," - Sontag notes in 1973 - "photography has become almost as widely practiced an amusement as sex and dancing which means that, like every mass art form, photography is not practiced by most people as an art. It is mainly a social rite, a defense against anxiety, and a tool of power [...]. Cameras go with family life [...]. Not to take pictures of one's children, particularly when they are small, is a sign of parental indifference, just as not turning up for one's graduation picture is a gesture of adolescent rebellion"³⁴.

Beyond its social effects, the cultural consequences of technical reproduction introduced by photography are equally significant. Through it, millions of people around the world finally gained access to painting, sculpture, and architecture. "Photography has democratized art, making

31. D'Autilia, *L'indizio e la prova*, 50.

32. D'Autilia, *L'indizio e la prova*, 54.

33. Codeluppi, "Il ruolo sociale delle immagini digitali," 219.

34. Sontag, *On Photography*, 5.

it accessible to all, and at the same time has changed our perception of art; moreover, it has eliminated spatial limitations, allowing us to know the world, but it has also served - and continues to serve - another function, that of manipulation, aimed at 'creating needs, selling goods, shaping minds'"³⁵.

Regarding technical reproducibility, it is also worth recalling Valeria Menchetelli's observation, professor of Architectural Drawing and Survey: "in the era of analogues, the act of copying an analogue original in turn creates new analogue originals, which will be mostly used in the same way as the former. This leads to significant implications in relation to the duration of a work of art through its copies which, while remaining anchored to so-called 'traditional' experiential practices, ensures its almost eternal immortality"³⁶.

Historically, however, two opposing views coexist regarding replication: "one sees the author as a 'copyist' i.e. a person endowed with specific competence capable of elevating the act of copying and giving it a value of cultural enhancement, the other views the author as a 'forger', or as the perpetrator of an illicit act of cultural impoverishment [...]. The theoretical watershed in the practice of replication is undoubtedly represented by the iconic proliferation stigmatised by Walter Benjamin and associated with the loss of the aura (i.e. that concentration of authorship, uniqueness and unrepeatability of the artistic object) determined by the reproduction of works of art by mechanical means. Two decades later, the pop art movement adopted mechanical reproduction as its *modus operandi*, which became an expression of cultural evolution (embodied by the so-called consumer society), definitively recognising the artistic value of replication and legitimising it as an authorial creative act"³⁷ [Fig. 2.19].

With the advent of technical reproduction, images spread widely and permeated society to such an extent that by the 1960s some began speaking of an 'image civilization', a term that nonetheless met with authoritative criticism³⁸.

The true 'pictorial turn'³⁹ however, occurred with the transition from

35. D'Autilia, *L'indizio e la prova*, 118.

36. Menchetelli, "Reproduce to preserve," 76.

37. Menchetelli, "Reproduce to preserve," 76.

38. Roland Barthes, *Elementi di semiologia* (Einaudi, 2002), 117.

39. Thomas W.J. Mitchell, *Picture theory* (University of Chicago Press, 1994). See also Michele Di Monte and Maria G. Di Monte, "Introduzione," in *La svolta iconica*, ed. G. Bohem (Meltemi, 2009), 8-9.

Fig. 2.19 Museum of Modern Art (MOMA), 2008.

[Gorup de Besanez,
https://commons.wikimedia.org/wiki/File:Ame02128_22.jpg?uselang=it]



analog to digital imagery. These are representations in digital files that, lacking a direct connection to an original, can be reproduced and manipulated without limit, dramatically increasing the number of images circulating in society⁴⁰. “The considerations on the analogue/digital dichotomy thus weave a dialectical relationship with the cultural implications of the original/copy dichotomy and open up a series of difficult questions”⁴¹, including the new social role of images, their value as historical sources, and the temporality of digital images.

With remarkable foresight, in 1934 Paul Valéry (1871-1945) anticipated the scenario that the technical reproducibility of images and their dissemination through digital media would create by the end of the century. “In all the arts” - Valéry argued - “there exists a physical component that can no longer be treated as it has been until now, one that cannot disregard the achievements of modern knowledge and capabilities. Neither matter, nor space, nor time are what they have always been for twenty years. Such profound innovations will inevitably transform artistic techniques, act upon invention itself, and perhaps even reshape the very notion of art. At first, it will be the reproduction and transmission of works that are most affected. We will be able to transport or reconstruct anywhere the system of sensations - or, more precisely, the system of excitations - that emanates in any place from any object or

40. Codeluppi, “Il ruolo sociale delle immagini digitali,” 219.

41. Menchetelli, “Reproduce to preserve,” 82.

event. Works will acquire a kind of ubiquity. Their immediate presence, or their availability at any time, will obey our call. They will no longer exist solely in themselves, but wherever there is someone and some instrument. They will only be a kind of source or origin, and their benefits will be found or restored intact wherever desired. Just as water, gas, and electricity reach our homes from afar to meet our needs with almost no effort, so we will be supplied with visual or auditory images, which will appear and vanish at the slightest gesture, almost on command. Just as we are accustomed, if not subjugated, to receiving energy in our homes in various forms, so we will find it quite simple to obtain or receive those rapid variations or oscillations with which our sense organs, which perceive and integrate them, accomplish all that we know. I do not know if a philosopher has ever dreamed of a society for the home distribution of sensible reality. [...] We are still quite far from having domesticated visible phenomena in this way”⁴².

As noted, and as Valéry predicted, digital reproduction has expanded the audience for visual artifacts, making them accessible to all and definitively overcoming traditional physical and geographic barriers⁴³. Digital media, and more recently social media, have played a decisive role in the dissemination and proliferation of images, altering their meaning and social function. Indeed, “before the arrival of digital photography, images were clearly distinguished as public or private - that is, institutional and non-appropriable on the one hand, and family or otherwise private on the other, confined to a personal domain. Now, however, the fluidity of the digital allows a process of increasing ‘leveling’ among images, since public photographs can be reused and reworked by anyone, while personal images can circulate beyond the private sphere. This does not entirely eliminate previously existing differences [...]. Digital photographs have carved out a broad social space primarily because they operate differently from previous photographs: rather than serving merely as tools of documentation or expression, they function as means for fostering conversations and enabling individuals to connect with others [...]. As a result, these images often do not possess novelty per se, but instead act as recordings of everyday events or simple reworkings

42. Paul Valéry, *Scritti sull'arte* (TEA, 1996), 107-108. Published the first time in: *De la musique avant toute chose* (Éditions du Tambourinaire, 1928).

43. Enrico Cicalò, “Saving images. Memory and oblivion of knowledge in the digital age,” *XY. Rassegna critica di studi sulla rappresentazione dell'architettura e sull'uso dell'immagine nella scienza e nell'arte*, no. 4 (2019): 103, <https://doi.org/10.15168/xy.v4i7.121>.

of content already present on the Web”⁴⁴.

Beyond social consequences, the digital dimension of the image raises significant and complex questions regarding its temporality and, by extension, the preservation of memory through it. Considering that the durability of an image determines its likelihood of survival over time, and consequently its capacity to persist in individual and collective memory⁴⁵, the rapid turnover and progressive dematerialization of digital media seem to foreshadow an inevitable shortening of an image’s lifespan.

In practice, it is observed that the greater the technological complexity used to produce and store an image, the shorter its lifespan; in general, any technology used inevitably tends toward obsolescence⁴⁶. “Faced with the surge in technological progress in recent decades, today’s society is thus faced with the paradox that images carved in stone or painted on rock thousands of years ago have come to us substantially unchanged, while the information stored in a floppy disk in the 1990s is now illegible”⁴⁷.

Within this context, and aware of the impossibility of preserving all currently available information for future generations, crucial questions arise: which images deserve to be transmitted? What methods and tools are best suited for their safeguarding? “Conservation strategies are effectively sustained by the broadly accepted and ennobled concept of replication, according to which the replica becomes a representation of the original, assuming a substantially different and independent identity on its own terms: reproduction is production of the new; in other words, each copy is an original in its own right and is fully capable of asserting itself”⁴⁸.

At this point, it is important to clarify a key issue regarding digital images and, more broadly, digital visual products: their creation can stem either from the digitization of an originally analog image or from native digital processes and tools. In the first case, “digital preservation works in parallel with the preservation of physical artifacts and represents a further opportunity for their reproduction, capable of multiplying the possibilities of transmission in time and in the space of knowledge.

44. Codeluppi, “Il ruolo sociale delle immagini digitali,” 221.

45. Menchetelli, “Reproduce to preserve,” 74.

46. Cicalò, “Saving images,” 96-98.

47. Menchetelli, “Reproduce to preserve,” 82.

48. Menchetelli, “Reproduce to preserve,” 82.

The perspectives are different for the second typology, which includes all the visual artifacts of various nature produced and used directly and only through software, applications and digital technologies that complete their entire lifecycle in the immaterial dimension of digital⁴⁹. These artifacts are at greatest risk of oblivion, as they cannot be reproduced or fully experienced in any form other than digital. For example, “the representation of a building exclusively consists of a digital copy: although the practice of creating analogue three-dimensional models (in almost all cases in a reduced scale) also survives, the ‘image’ of the architectural element under examination is entirely digital in nature, completely devoid of tangible elements and necessarily subjected to a form of ‘mediation’. This occurs both for the representation of surveyed matter (cognitive representation), giving rise to semantically enriched digital models configured as databases that can be explored via appropriate filters and search keys, as well as for the representation of a design (ideational representation), in which case the original does not actually exist yet in the physical sense but as a mental model⁵⁰”.

In recent years, archivists have made significant efforts to ensure the preservation of digital documents with guarantees comparable to those for analog materials, primarily through the definition of operational protocols; “nevertheless, we must acknowledge the evident impossibility of proving the authenticity of a given document. Indeed, whereas analogue sources can be preserved indefinitely and their authenticity can be verified at any time, digital sources are subject to continuous modification linked to technological advancement and their survival is entrusted to a repeated process of transcription that implicitly and irreparably alters the original format. This, in turn, leads to the loss of the authenticity inherent in the identity of the source itself. The phenomenon of the ‘disappearance of the original’ is definitively established: each transcription requires a transformation of the indispensable encoding required to ensure the accessibility and future usability of the source. However, this also inevitably corresponds to a loss of adherence to the primary document, to the extent that for the digital source one can no longer speak of the original but only of ‘true copies’ (the authenticity

49. Cicalò, “Saving images,” 102.

50. Menchetelli, “Reproduce to preserve,” 78.

of which opens up further complex questions)”⁵¹.

It is also important to note that in the digital era, not only the visual products and technologies used to create them have changed, but also the media and modalities of experiencing such artifacts. While immersive representations have long historical roots, the use of Virtual Reality (VR) and Augmented Reality (AR) in architecture has consolidated in recent years, becoming increasingly common in many other sectors. “The total freedom to exploit the digital model in a virtual environment, completely free from the concreteness (and restrictions) of the physical dimension, enables actions that cannot be performed in an analogue reality, affording the user the utopian opportunity to delve into a parallel universe that is materially unreachable but at the same time hyperreal [...]. For the first time in history, the digital dimension enables the material (immaterial) embodiment of what was previously only the mental image of a building’s model, which in fact could only be represented by inevitably partial two-dimensional drawings”⁵². Andrea Pinotti, philosopher and visual culture expert, reflects on the theoretical and political implications: “the powerful effects of immediacy and transparency produced by virtual immersive environments bring with them [...] the impression of direct and unmediated access to reality, free from manipulation or interference, guaranteeing an unfiltered opening to truth itself. In the case of historical falsifications, where manipulations of photographs (indexical images meant to document historical events) could be exposed by investigating alterations to the medium, this possibility of demystification now seems radically reduced. If pre-virtual images (icons) were framed, representational, and mediated, the fact that virtual images tend to deny such markers through their unframedness, presentness, and immediacy suggests we recognize them as ‘an-icons’, images that paradoxically strive to negate themselves and their status as images, presenting themselves as if they were the reality they represent. VR does not emerge from nowhere, nor are an-icons exclusive to our present. Rather, the current an-iconic condition is the result of a millennia-long history in which, through the representational and media technologies available (from *trompe-l’œil* painting to 3D cinema, animated statues, participatory theater, and pre-cinema projection devices), each era aimed to produce images that

51. Menchetelli, “Reproduce to preserve,” 82.

52. Menchetelli, “Reproduce to preserve,” 78.

deny themselves - or at least dreamed of doing so, in myth, anecdote, literature, and other forms of externalizing imagination”⁵³.

In architectural drawing, Edoardo Dotto, architect and professor, reflects on the analogy between hyperrealist images and rendering: “those images, made with the support of specialized software, that can simulate with incredible precision the effect of light on the matter. Renders, as we know, propose images very similar to the optical image, sometimes detailed with such obstinacy that they can be confused with photo images [...]. The one proposed by the render is the construction of a naive image, basically neutral, in which there is revealed no hierarchy between the parties, where such leaves, curtains, stone walls and supporting beams have the same identical relevance. And levelling these hierarchies, in the name of absolute ‘optical truth’, the image loses effectiveness, proposing - in fact - a false picture. Butler recalls, however, that ‘There is no such source of error as the pursuit of truth’”⁵⁴.

In the digital era, or the era of Big Data⁵⁵, “images are deposited, stored, published and accumulated through mobile devices almost free of charge. Images are less and less the product of processes of design, selection, classification and are losing their value that the cost of the production process had always safeguarded. The images of our everyday life hardly cross the threshold that leads from digital to material. The iconographic heritage that accumulates daily and represents our lives is stored in the personal profiles posted in the databases of digital service providers, whose fate after our death is still unclear. The debate on the fate of the digital heritage that each of us is going to leave has not yet outlined policies for the preservation of personal visual memories, putting at risk one of the most important sources with which today we study the history and culture of the past [...]. The most promising solution for the preservation of digital knowledge, being in turn based on digital technology and therefore theoretically subject to the same risks that it tries to counter by revealing the problem, further reinforces the doubts

53. Andrea Pinotti, *Alla soglia dell'immagine. Da Narciso alla realtà virtuale* (Einaudi, 2021), XV-XVI.

54. Edoardo Dotto, “Making visible. Learning from sciences and arts,” *XY. Rassegna critica di studi sulla rappresentazione dell'architettura e sull'uso dell'immagine nella scienza e nell'arte*, no. 1 (2016): 25-27, <https://doi.org/10.15168/xy.v1i2.32>.

55. “Although the term *big data* is relatively recent, the tendency to collect and store large volumes of information for possible future analysis is much older. The concept gained traction in the early 2000s, when industry analyst Doug Laney formulated the now well-known definition of the three Vs of big data: Volume. [...] Velocity. [...] Variety.” (Maurizio Caminito, *La biblioteca nella nuvola. Utenti e servizi al tempo degli smartphone*, Editrice Bibliografica, 2018, 14-15).



Fig. 2.19 Image generated with Google Gemini using the prompt: “Image as a copy of the ‘real’, image as the way reality presents itself, image as a form of knowledge. Fragments, messages of culture, obsessions of dreams, fantasies, games, stereotypes, memories, traces... the vertigo of the image”.

[Caprettini, “Imagine,” 93]

on the transmission of digital images beyond a short period of time”⁵⁶. We are therefore facing a fluid, unstable memorial space, subject to continuous reorganization⁵⁷, in which, in addition to the questions already raised, many others emerge, even more complex to address. In light of the increasingly widespread generation of images using Artificial Intelligence, we must once again ask what cultural and social role these images assume, what their meaning is, and how durable they are. «When considering the future of cultural heritage in the age of genAI, we need to move beyond the considerations of what benefits genAI can bring to the discipline as a tool, however, and need to consider to what extent creations facilitated by genAI are or can become cultural heritage items in their own right. Beyond that, we also need to consider whether or when genAI can be considered to have a heritage of its own»⁵⁸. But that is another story.

56. Cicalò, “Saving images,” 104-106.

57. Pietro Montani, “La funzione testimoniale dell’immagine,” Treccani.XXI Secolo, 2009, [https://www.treccani.it/enciclopedia/la-funzione-testimoniale-dell-immagine_\(XXI-Secolo\)/](https://www.treccani.it/enciclopedia/la-funzione-testimoniale-dell-immagine_(XXI-Secolo)/).

58. Dirk H.R. Spennemann, “Generative Artificial Intelligence, Human Agency and the Future of Cultural Heritage,” *Heritage*, no.7 (2024): 3597-3609, <https://doi.org/10.3390/heritage7070170>.

03

Archives and the challenges of the digital age



Chapter 03 • Archives and the challenges of the digital age

The chapter examines the transition of archives from analog to digital forms, highlighting the evolving role they play in the preservation and enhancement of cultural heritage. Starting from the definition of the archive, it explores the lifecycle of documents and addresses the challenges posed by digitization and long-term digital preservation, with particular attention to issues of quality, authenticity, and accessibility. The second part of the chapter focuses on digital tools and platforms supporting historical research. It analyzes both the opportunities and the limitations offered by the web, emphasizing how digitization, while expanding access to sources, inevitably entails processes of selection that can significantly influence the work of historians. The discussion considers new digital tools and explores the potential of emerging technologies such as the Semantic Web, Linked Open Data, and artificial intelligence applied to historical research.

The chapter also presents a range of online archival resources, contributing to a critical and up-to-date overview of documentary research in the digital age.

03.1 From analog to digital archives: the evolution of documentary memory

The origin of the term ‘archive’ is deeply rooted in the juridical-administrative culture of the Greek and Latin worlds. As Eugenio Casanova (1867-1951), considered the father of Italian archival science¹, observes, “the most logically and scientifically accepted opinion traces the word ‘archive’ [...] back to the noun *αρχεῖον* [*archeion*], which denotes the magistrate’s palace, the curia: a place where, naturally, alongside the *ἄρχων* - that is, the one who holds authority - were kept the acts issued by him”. From the Greek *αρχεῖον* derives the Latin *arcivum*, *archivum* or *archivium*, terms used to designate both the container and the content: that is, both the physical place and the documents preserved within it².

To date, the most widely accepted definition of ‘archive’ in the Italian context is that of “a body of documents produced or otherwise acquired in the course of activity by magistracies, organs and offices of the State, public entities and private institutions, families, and individuals”³. On the international level, the International Council on Archives (ICA)⁴ have adopted and expanded this concept, defining the archival fonds as “the whole of the records, regardless of form or medium, organically created and/or accumulated and used by a particular person, family, or corporate body in the course of that creator’s activities and functions”⁵. From this definition derives the structurally functional nature of the archive: it does not originate as a historical source, but rather as an operational and administrative tool - a spontaneous and necessary outcome of individual or institutional activity. Every human being, like every institution, thus becomes an often unaware producer of archives, whose origin responds primarily to practical needs⁶. Over time, however, documents gradually lose their immediate evidentiary function and “progressively become sources - that is, vehicles of memory, and of

1. Giuseppe Plessi, *Compendio di archivistica* (CLUEB, 1990), 13.

2. Eugenio Casanova, *Archivistica* (Arti Grafiche Lazzeri, 1928), 11.

3. Federico Valacchi, *Diventare archivisti. Competenze tecniche di un mestiere sul confine* (Editrice Bibliografica, 2015), 62-63.

4. “ISAD (G),” Istituto Centrale per gli Archivi - ICAR, accessed May 1, 2026, <https://icar.cultura.gov.it/standard/standard-internazionali/isad-g>.

5. “ISAD(G): General International Standard Archival Description,” International Council on Archives, accessed June 1, 2026, <https://www.ica.org/resource/isadg-general-international-standard-archival-description-second-edition/>.

6. Isabella Zanni Rosiello, *Andare in archivio* (il Mulino, 1996), 13.

historical memory in particular”⁷.

As the French anthropologist, ethnologist and philosopher Claude Lévi-Strauss (1908-2009) writes, “if we were to lose our archives, it would not mean that our past would be erased; rather, it would be deprived of what we might call its diachronic flavour [...] archives give history a physical existence”⁸. In this perspective, the archive may be regarded as a repository of memory - not only of the past but also of the present - preserving essential attestations for daily life. Especially within public administrations, the archive acquires a “strong political value”, serving as “reciprocal certification of the rights and duties of the State and its citizens” and as a “guarantee of mutual requirements for efficiency and transparency”⁹. Archives have always maintained a strong and intrinsic connection with political authority and other forms of societal power. Throughout history, changes in governing structures and institutional frameworks have significantly influenced not only the spatial distribution of archives but also their internal organization, the control exercised over them, and ultimately, the fundamental motivations underpinning their creation, preservation, and long-term use¹⁰.

The definition of the archive also highlights the centrality of the ‘creator’ or ‘records creator’ - that is, the entity, institution, or individual from which the documentary body originates. This connection distinguishes an archive from a collection (or repository)¹¹: in the former, the documentation arises necessarily, involuntarily, and functionally from the activity performed; in the latter, aggregation occurs retrospectively, based on thematic or subjective criteria¹².

The archive thus takes shape as an organic and historically determined construct, which evolves over time in accordance with the tran-

7. Valacchi, *Diventare archivisti*, 13.

8. Claude Lévi-Strauss, *Il pensiero selvaggio* (il Saggiatore, 1964), 262-263.

9. Valacchi, *Diventare archivisti*, 14.

10. Stefano Vitali, “Premessa,” in *Il potere degli archivi. Usi del passato e difesa dei diritti nella società contemporanea*, ed. L. Giuva, S. Vitali, and I. Zanni Rosiello (Bruno Mondadori, 2007), VIII.

11. The General International Standard Archival Description defines a ‘collection’ as “an artificial assemblage of documents accumulated on the basis of some common characteristic without regard to the provenance of those documents. Not to be confused with an archival fonds” (ICA, *ISAD(G): General International Standard Archival Description, adopted by the Committee on Descriptive Standards*, Stockholm, Sweden, 19-22 September 1999, https://www.ica.org/app/uploads/2024/01/CBPS_2000_Guidelines_ISADG_Second-edition_EN.pdf).

12. In this regard, the notion of the ‘archival bond’ is fundamental. It represents the logical and functional link that ties documents to one another and to their creator, thus conferring coherence and organic unity to the fonds (“Archival bond,” Dictionary of Archives Terminology, accessed June 1, 2026, <https://dictionary.archivists.org/entry/archival-bond.html>).

sformations of its creator and the surrounding context. Each archive is a unique and unrepeatable entity, not only because of its documentary content, but also due to the structure that supports it, the relationships it embodies, and the meanings it conveys. In this sense, “to conceive of an archive as a mere collection of documents fails to capture the complexity and articulated richness of these documentary bodies”¹³.

Archival documentation rarely, if ever, provides a comprehensive record of the activities carried out by its creators. Rather, it documents only those activities that have given rise to a written record. Moreover, “archival documentation rarely, if ever, maintains unchanged the original form it possessed at the time of creation. Alterations may range from superficial to substantial, and generally arise from factors related to:

1. the passage of time;
2. the use made of the documentation by its creators as a means of memory or self-documentation;
3. specific events attributable to human or natural causes;
4. the methods and criteria employed in its preservation and transmission.

It is not difficult to realize that the older the documentation is, the more likely it is, barring exceptions, to have undergone events and circumstances that altered its original arrangement; the longer its history, the more evident are the traces left upon it”¹⁴.

In the course of time, documentation moves from the places where it was originally produced or collected to locations where it must be preserved and made accessible to those who wish to consult it as a historical source - a passage often characterized by nonlinear trajectories and far from transparent influences. From this perspective, the concept of the lifecycle of a document is fundamental; it rests on the assumption that both juridical-administrative purposes and scientific-cultural aims coexist within an archive. According to archival theory and current regulations, archives generally progress through three stages: current (*corrente*), semi-current (*di deposito*), and historical (*storico*)¹⁵. “Current archives consist of documents that are continuously used in

13. Valacchi, *Diventare archivisti*, 62-63.

14. Zanni Rosiello, *Andare in archivio*, 18-19.

15. Refer to the glossary issued by the Direzione Generale Archivi for further definitions (“Glossario,” Direzione Generale Archivi, accessed May 1, 2026, <http://2.42.228.207/archivi/index.php/abc-degli-archivi/glossario>).

the handling of ongoing affairs. Semi-current archives contain documentation that is seldom or no longer utilized for the activities of their respective creators. Historical archives encompass documentation that no longer holds any practical utility and, having been recognized for its historical value, must be preserved for posterity”¹⁶. Thus, within this framework, as previously highlighted, a document originates for practical purposes but may subsequently acquire historical and cultural value over time [Fig. 3.1].

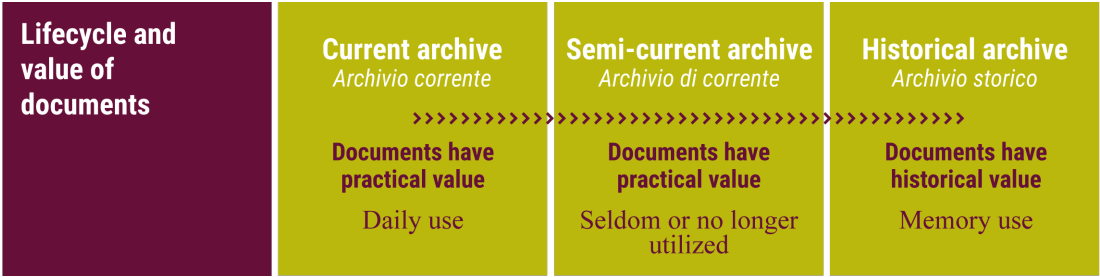


Fig. 3.1 Document lifecycle and value in relation to the stages of archive.

The document constitutes the minimal unit of an archive, representing the ‘elementary particle’ of any documentary complex. In the diplomatics, that is “the discipline concerned with the critical study of documents [...] aimed at determining their value as historical evidence”¹⁷, a document is defined as a “written testimony of an act of legal nature, composed according to specific formal requirements intended to ensure its authenticity and probative value”¹⁸. Such a definition is particularly restrictive and inadequate to account for all writing records within an archive. “Archivists did not devote significant attention to theoretical considerations regarding the concept of the document as long as their activities remained almost exclusively confined to the traditional sphere of paper-based media, and particularly within the limited chronological span of the medieval and modern periods. [...] The issues, and consequently a renewed scholarly interest, arose in their full complexity only when archivists had to confront the contemporary world, characterized by its fragmentation, but also by its richness”¹⁹. Today archival science provides a broader definition, describing a document (or a record) as all “recorded information in any form or medium, created or received and

16. Zanni Rosiello, *Andare in archivio*, 48.
17. Alessandro Pratesi, *Genesi e forme del documento medievale* (Jouvence, 1987), 13.
18. Cesare Paoli, *Diplomatica* (Le Lettere, 1987), 18.
19. Maria Guercio, *Archivistica informatica. I documenti in ambiente digitale* (Carocci editore, 2021), 19-20.

maintained, by an organization or person in the transaction of business or the conduct of affairs”²⁰. According to ISO 15489, the international standard on records management, the four main characteristics of authoritative records are reliability, integrity, usability and authenticity²¹ [Fig. 3.2]. These elements are directly connected to their primary function, which is to provide stable and verifiable evidence of a fact or action over time. This definition expands the traditional concept, moving beyond paper-based supports alone to include audio and video recordings, optical or magnetic media, and born-digital resources²².



Fig. 3.2 Main characteristics of the archival document.

This expansion of the concept of the document reflects the high degree of documentary hybridization that characterizes contemporary archives, increasingly linked to the phenomenon of the dematerialization of professional practices and routines. Borrowed from the financial sector, the term ‘dematerialization’ has now entered the common vocabulary of records management projects, particularly following the *Decreto Legislativo No. 82 of March 7, 2005* (“Codice dell’Amministrazione Digitale”)²³, which devotes Article 42 to the “Dematerialization of documents of public administrations,” defined as “the recovery in digital format of paper-based documents and records whose preservation is mandatory or advisable, and the implementation of corresponding plans

20. ICA, *ISAD(G)*, 11.

21. Julia Kastenhofer, “The logic of archival authenticity: ISO 15489 and the varieties of forgeries in archives,” *Archives and Manuscripts* 3, no. 43 (2015): 166-180, <https://doi.org/10.1080/01576895.2015.1074085>.

22. “Document. Recorded information regardless of medium or characteristics” (ICA, *ISAD(G)*, 10).

23. Dario Altobelli, Francesca Blasetti, and Ornella Stellavato, “Scenari della dematerializzazione in Italia. Finalità, criticità, approccio metodologico,” in *Reti di archivi per gli archivi in rete. Conservazione e accesso ai patrimoni digitali*, ed. G. Crupi and M. Guercio (ANAI, 2017), 90.

to replace analog archives with digital archives”²⁴. This phenomenon, which gained significant momentum with the introduction of information technologies, has evolved rapidly in recent decades, leading not only to a change in the medium but also to profound transformations in the methods of document creation, management, preservation, and access²⁵. Within the broader process of dematerialization, two main areas of application can be identified: the digitization of archival fonds and series originally produced on analog media, and the creation of born-digital documents²⁶.

With reference to the former, the glossary curated by the Digital Technologies Commission of ICOM Italy defines ‘digitization’ as the “process of creating digital records that reproduce, in visual, audio, or audiovisual form, analog artifacts”²⁷. However, the guidelines issued by the European Union²⁸ call for a substantial rethinking of this approach. The aim is to reinterpret the digitization of analog artifacts not merely as technical reproduction, but as a cultural act embedded within the broader framework of contemporary Digital Transformation (DT). In light of recent methodological developments and best practices, it is now possible to assert that digitization should be understood as a comprehensive process comprising methodologies, techniques, and enabling technologies that allow for the creation and materialization of digital entities²⁹. These entities are made intelligible through the association of metadata³⁰ narrative descriptors that fully define their components and identify them as structured and meaningful resources. This expanded conception elevates digitization from a mere act of replication to a culturally significant process of knowledge production and preservation.

“The main reasons for digitization that have emerged in recent years

24. Codice dell’amministrazione digitale, Decreto Legislativo 7 March, 2005, no. 82.

25. Stefano Pigliapoco, “Prefazione,” in *Records management. ISO 15489: progettare sistemi documentali*, ed. P. Ciandrini (Editrice Bibliografica, 2020), 7.

26. Altobelli, Blasetti, and Stellavato, “Scenari della dematerializzazione in Italia,” 91.

27. Commissione Tecnologie Digitali di ICOM Italia, ed., *Digitale e Tecnologie. Glossario* (2020), <https://www.icom-italia.org/wp-content/uploads/2020/10/ICOMItalia.CommissioneTecnologie.2020.GlossarioTecnologie.pdf>.

28. Commission Recommendation of 27 October 2011 on the digitisation and online accessibility of cultural material and digital preservation.

29. Nicola Barbuti, *La digitalizzazione dei beni documentali. Metodi, tecniche, buone prassi* (Editrice bibliografica, 2022), 17-22.

30. “The term ‘preservation metadata’ refers to the information required by a digital repository to ensure the process of digital preservation, namely the set of essential data needed to guarantee, over the long term, the integrity, accessibility, intelligibility, and authenticity of digital resources” (Stella Di Fazio, “Processi di metadattazione semantica e piattaforme tecnologiche per la conservazione delle risorse digitali,” in *Reti di archivi per gli archivi in rete. Conservazione e accesso ai patrimoni digitali*, ed. G. Crupi and M. Guercio, ANAI, 2017, 172)

pertain to various objectives, which are not necessarily mutually exclusive:

1. to overcome the difficulties in locating and accessing documents;
2. to gather and make available documentation capable of integrating into or forming information systems, thereby simplifying and accelerating document consultation and procedural execution, and allowing for a more efficient use of professional resources;
3. to reduce the physical space occupied by paper documents within offices.

Moreover, public administrations are driven by economic imperatives aimed at reducing the costs associated with the management of paper-based documentation. [...] Lastly, institutions also resort to the digitization of paper-based archival material in order to comply with legal obligations, such as those deriving from regulations concerning privacy, administrative procedures, or transparency. The digital management of documents facilitates a simplification of processes and activities, thereby ensuring transparency and safeguarding the citizen's right of access"³¹.

The rapid acceleration driven by Information and Communication Technologies (ICT) in the systems of document production, management, and transmission has triggered a mechanism of multiplication and overlap in documentary sedimentation, which is, in some cases, difficult to interpret and even more complex to manage and contextualize. The very concepts of library and archive as physical repositories of preservation no longer seem sufficient to contain or regulate this rising tide, brought about by the continuous migration of documents from the analog to the digital realm and the growing proliferation of records natively generated in digital form³².

In light of this scenario, it is possible to identify three principal forms of documentary sedimentation within contemporary archives: analog archives, digital archives, and integrated archival systems. "Analog archives encompass all archival complexes composed predominantly of paper-based documents, which may also include materials recorded on various other media such as audio and video cassettes or magnetic tapes. This is consistent with the definition of an analog document provi-

31. Altobelli, Blasetti, and Stellavato, "Scenari della dematerializzazione in Italia," 91-92. Concerning the motivations behind digitization, refer also to Stefano Allegrezza, ed., *La digitalizzazione del patrimonio culturale. Linee guida, standard, esperienza* (Civita Editoriale, 2021).

32. Valacchi, *Diventare archivisti*, 70.

ded in CNIPA (Centro Nazionale per l'Informatica nella Pubblica Amministrazione) Resolution No. 11/2004, Article 1, paragraph 1, letter B: 'a document created using a physical quantity that assumes continuous values, such as traces on paper (e.g., paper documents), images on film (e.g., medical films, microfiches, microfilms), or magnetization on tape (e.g., audio and video cassettes and magnetic tapes). A distinction is made between original and copy documents'³³. By contrast, a digital archive refers to the sedimentation of digital records³⁴ - that is, documents that are produced, used, managed, and (ideally) preserved entirely within a digital environment. Finally, integrated archival systems - which currently represent, at least in quantitative terms, the most prevalent model - are the result of the intersection and coexistence of the two aforementioned types and their respective management approaches. The integrated, or hybrid³⁵, archive is therefore a composite structure whose components and degree of integration vary depending on the predominance of one type of medium over another'³⁶.

The central issue, therefore, becomes ensuring that the digital transition preserves, over time, the same guarantees of reliability traditionally associated with analog documentation. Specifically, the issue can be distilled into three main themes: on one hand, the digitization of analogue documents and the creation of digitally-born documents must ensure both the quality of information and the authenticity of the documents themselves; on the other hand, digital preservation must guarantee long-term data accessibility and usability, or the so-called 'long-time preservation' [Fig. 3.3].

Within this framework, the intrinsic distinction between analog and digital documents proves to be of critical importance. The primary difference between analog and digital documents - whether digitized or born-digital - lies in the method of encoding information and in their

33. "Analog document: a document created using a physical quantity that assumes continuous values, such as marks on paper (e.g., paper documents), images on film (e.g., medical films, microfiche, microfilm), and magnetic recordings on tape (e.g., audio and video cassettes and magnetic tapes). It is classified as either an original document or a copy" (Regole tecniche per la riproduzione e conservazione di documenti su supporto ottico idoneo a garantire la conformità dei documenti agli originali, Deliberazione CNIPA n. 11/2004 del 19 February, 2004, no. 57, 2).

34. "Electronic document: the digital representation of acts, facts, or data that are legally relevant" (Regole tecniche per la riproduzione e conservazione di documenti, 2).

35. Gabriele Bezzi, "Modelli per la conservazione e l'accesso a lungo termine degli archivi digitali e ibridi," in *Reti di archivi per gli archivi in rete. Conservazione e accesso ai patrimoni digitali*, ed. G. Crupi, and M. Guercio (ANAI, 2017), 118.

36. Valacchi, *Diventare archivisti*, 68-70.

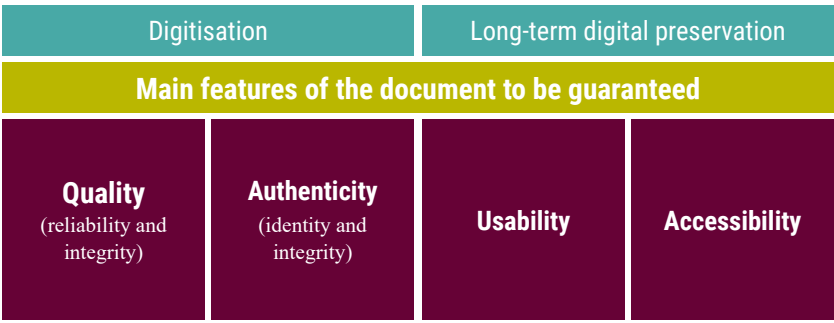


Fig. 3.3 Main characteristics of the digital document to be guaranteed during the digitization and the long-term digital preservation

accessibility³⁷. Analog documents, typically paper-based, employ continuous physical variables and are immediately readable by humans, as the symbols (alphabetic or figurative) are directly intelligible. Conversely, born-digital (or electronic) documents “can be understood as true artifacts produced by creative processes - intangible material entities [...] possessing their own specific physicality, composed of sequences of digits, algorithms, binary code, pixels, and so on”³⁸. They consist of binary information created and managed through electronic systems. These include texts, images, videos, and structured data, the decoding and long-term preservation of which require specific digital tools and environments³⁹.

In the context of digitization, Stefano Vitali argues that the organic reproduction of fonds, the safeguarding of the documentary and production context, and the use of philologically rigorous descriptive apparatuses constitute the minimum conditions necessary for a critically informed engagement with the digital transposition of analog archives. The crux of the matter lies in the need to offer researchers genuine documentary sources, with the primary aim of digitally restoring the ar-

37. Valacchi, *Diventare archivisti*, 75-78.

38. Barbuti, *La digitalizzazione dei beni documentali*, 17-22.

39. Valacchi, *Diventare archivisti*, 75-78. “Every aspect of today’s society involves some type of technology. Technology offers new opportunities for information access, like multiple language and media compatibility, assistive devices (as screen magnifiers, Braille displays, speech recognition software, and screen readers), adaptive and perceptual interfaces, and software for translation, intuitive search, intelligent data mining, dimensional modelling, information retrieval, data analysis, etcetera. However, the functionalities of technology are complex. Our society’s heritage has been recorded on many different materials, like bones, stone, clay, papyrus, vellum, silk, and paper. All of these writing materials and the information recorded on them have their own accessibility challenges, but none of them needs another interpretive, technological environment to realise access. That has changed in computerized environments: information exists in digital forms and always needs a software environment to render it. Keeping information accessible over time needs up-front planning, intentional action, and investment” (Geert-Jan van Bussel, “Determining the value of a Digital Archive: The Framework for the ‘Archive-As-Is’,” in *From Dust to Dawn. Archival Studies After the Archival Turn*, ed. A. Öhrberg, T. Berndtsson, O. Fischer, and A. Mattsson, Uppsala Rhetorical Studies, 2021, 58-59).

chival context in which they are embedded. This must be done with the level of accuracy necessary to preserve, for both individual documents and archival collections as a whole, their full historical depth and inherent polysemy - so that the digital image on the screen can always be recognized as an archival document originating from specific historical contexts. These contexts not only contribute to the document's interpretive richness, but are also essential reference points for a complete and meaningful understanding of its content⁴⁰.

The internationally adopted system for ensuring the long-term quality, reliability, and usability of documentary data is that of standards⁴¹. From a technical perspective, a standard can be defined as a "formalized reference model for the exchange of compatible information, which meets users' needs and is understood and shared by them"⁴². Archival standards are generally divided into two main categories: on the one hand, descriptive standards, developed by the International Council on Archives (ICA)⁴³, - as noted in the introduction to ISAD(G)⁴⁴ - which govern the representation of the context and content of archival fonds in order to promote accessibility; on the other hand, records management standards, issued in particular by the International Organization for Standardization (ISO)⁴⁵, aimed at harmonizing the practices related to the design and administration of records systems, with particular attention to digital environments. These tools respond to the need to develop organizational and communicative models suited to the complexity of archival objects⁴⁶.

40. Stefano Vitali, *Passato digitale. Le fonti dello storico nell'era del computer* (Bruno Mondadori, 2004), 101-104.

41. "The term standard derives from the old French *estandard* ('banner'). Standards, like banners, symbols, and models, are conceived, organized, and developed by individuals who, through reflection, identify criteria and reference points to be adopted as models for common use and benefit. This constitutes a social action aimed at fulfilling a social function" (Paola Ciandrini, ed., *Records management. ISO 154889: progettare sistemi documentali*, Editrice Bibliografica, 2020, 15-16).

42. Valacchi, *Diventare archivisti*, 107-108.

43. International Council on Archives (ICA), accessed May 1, 2026, <https://www.ica.org/>.

44. "This standard provides general guidance for the preparation of archival descriptions. It is to be used in conjunction with existing national standards or as the basis for the development of national standards. The purpose of archival description is to identify and explain the context and content of archival material in order to promote its accessibility. This is achieved by creating accurate and appropriate representations and by organizing them in accordance with predetermined models. Description-related processes may begin at or before records creation and continue throughout the life of the records. These processes make it possible to institute the intellectual controls necessary for reliable, authentic, meaningful and accessible descriptive records to be carried forward through time" (ICA, *ISAD(G)*, 7).

45. International Organization for Standardization, accessed May 1, 2026, <https://www.iso.org/home.html>.

46. Valacchi, *Diventare archivisti*, 92-93.

Within the framework of digital records, the centrality of descriptive standards is closely linked to the issue of metadata, which is recognized as a key element for the identification, access, interoperability, and reuse of digital resources⁴⁷. Metadata constitutes a structured set of information that describes, identifies, contextualizes, and renders digital data intelligible, thereby transforming simple digital entities into cultural records endowed with both documentary and cultural value⁴⁸.

“Metadata can be classified based on their characteristics and purposes as follows [Tab 3.1]:

- *Descriptive metadata*: for the identification and retrieval of digital objects.
- *Administrative and management metadata*: for managing digital objects; these can be further subdivided into:
 - *Technical metadata*: related to intrinsic characteristics of the files composing digital objects or their production processes.
 - *Rights metadata*: information regarding copyright and usage licenses.
 - *Preservation metadata*: aimed at ensuring the long-term preservation and usability of digital objects
- *Structural metadata*: for describing the internal structure of documents (e.g., for a book: introduction, chapters, table of contents) and managing relationships among various components within digital objects”⁴⁹.

The selection of metadata for archival documents must be based on shared standards and descriptive frameworks capable of capturing the full semantic and documentary complexity of the digital resource. Only in this way is it possible to move from a simple datum to a digital cultural record, an enriched, contextualized resource that can be meaningfully accessed and reused by multiple user communities.

To ensure the quality and sustainability of digital resources, it is essential to adopt agreed-upon criteria for metadata creation. The FAIR principles⁵⁰, published in 2016 for the management of scientific data,

47. Livio De Luca, and David Lo Buglio, “Geometry vs Semantics: Open Issues on 3D Reconstruction of Architectural Elements,” in *3D Research Challenges in Cultural Heritage*, ed. M. Ioannides and E. Quak (Springer, 2014), [10.1007/978-3-662-44630-0_3](https://doi.org/10.1007/978-3-662-44630-0_3).

48. Barbuti, *La digitalizzazione dei beni documentali*, 177-184.

49. Istituto Centrale per la Digitalizzazione del Patrimonio Culturale - Digital Library, *Linee guida per la digitalizzazione del patrimonio culturale. Versione 1.0 – giugno 2022* (Ministero della Cultura, 2022), 29.

50. “FAIR Principles,” GO FAIR, accessed May 1, 2026, <https://www.go-fair.org/fair-principles/>.

Metadata type	Purpose	Example properties	Primary uses
Descriptive	For finding or understanding a resource	Title, author, subject, genre, publication date	Discovery, display, interoperability
Administrative			
Technical metadata	For decoding and rendering files	File type, file size, creation data/time, compression scheme	Interoperability, digital object management, preservation
Rights metadata	Intellectual property rights attached to content	Copyright status, license terms, rights holder	Interoperability, digital object management
Preservation metadata	Long-term management of files	Checksum, preservation event	Interoperability, digital object management, preservation
Structural	Relationships of parts of resources to one another	Sequence, place in hierarchy	Navigation

Tab. 3.1 Types of metadata and their uses.

[Jenn Riley, *Understanding metadata. What is metadata, and what is it for?* (National Information Standards Organization, 2017), 7]

provide a valuable methodological framework that is also applicable to cultural heritage. FAIR identifies four key dimensions: Findability (F), Accessibility (A), Interoperability (I), and Reusability (R). Although originally conceived for scientific data, these principles can be successfully applied to digital cultural resources, provided they are supplemented by additional qualitative requirements⁵¹[Fig. 3.4].

In particular, for metadata to serve as effective instruments of cultural enhancement, they must also meet the requirements of readability, reliability, relevance, and resilience. Readability ensures the intelligibility of content; reliability attests to the quality of information throughout the resource’s lifecycle; relevance guarantees the structural coherence of the metadata; while resilience enables the resource to adapt to technological and functional transformations over time⁵².

“The concept of the lifecycle [of a document] is founded upon the well-known assumption that archives simultaneously serve admini-

51. Barbuti, *La digitalizzazione dei beni documentali*, 177-184; Elisabetta Caterina Giovannini, “Digital Transitions for the Use and Reuse of Digital Assets for Museum Collections,” in *Trasizioni. Atti del 44° Convegno Internazionale dei Docenti delle Discipline della Rappresentazione/ Transitions. Proceedings of the 44th International Conference of Representation Disciplines Teachers*, ed. M. Cannella, A. Garozzo, and S. Morena (FrancoAngeli, 2023), 2755-2766, doi.org/10.3280/oa-1016-c435.

52. Barbuti, *La digitalizzazione dei beni documentali*, 177-184; Giovannini, “Digital Transitions,” 2755-2766.



Fig. 3.4 Schematic overview of the FAIR principles

[Keith Russell, Kerry Levett, Richard Ferrers, and Andrew White, “FAIR Go: New resources to support FAIR data,” eResearch Australasia Conference, accessed May 1, 2026, <https://conference.eresearch.edu.au/fair-go-new-resources-to-support-fair-data/>]

strative and legal purposes, as well as scientific and cultural ones. In other words, those who produce documentation do so primarily for their own memory rather than for that of others. [...] The best guarantee of fulfilling these two fundamental characteristics of the archive lies in the correct management of the document creation process, enabling the pursuit of administrative and legal purposes without losing sight of the document’s potential cultural value. Nevertheless, this consolidated model has begun to falter when confronted with issues posed by digital archives”⁵³. Indeed, the advent of digital archives has necessitated a substantial revision of the traditional lifecycle concept. Historically articulated into three stages - *corrente*, *di deposito*, and *storico* - this model reflects an analog reality where archival intervention occurs *ex post facto*⁵⁴. In other words, the document is initially created for practical purposes but can acquire historical and cultural significance over time. In the digital context, however, the complexity of electronic documents demands a more anticipatory and integrated approach⁵⁵. Consequently, a new document lifecycle has emerged, structured into the phases of conception, creation, and maintenance⁵⁶ [Fig. 3.5].

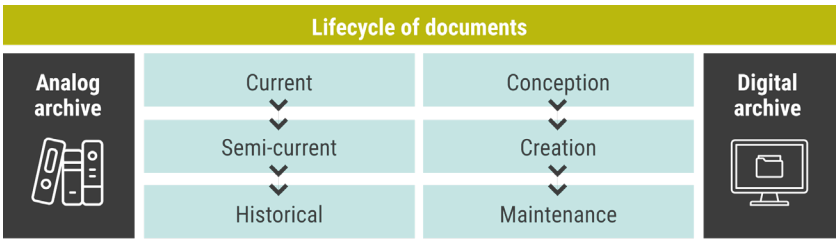
53. Valacchi, *Diventare archivisti*, 81-82.

54. Bezzi, “Modelli per la conservazione e l’accesso,” 121-122.

55. Bezzi, “Modelli per la conservazione e l’accesso,” 122-123.

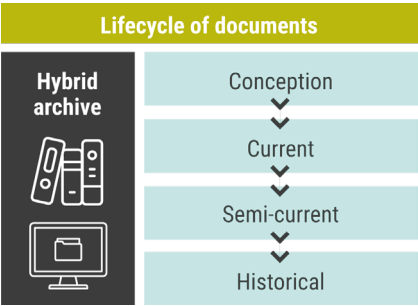
56. Valacchi, *Diventare archivisti*, 81-82.

Fig. 3.5 Lifecycle of documents in analog archives (left) and in digital archives (right).



“Within this theoretical context, particular emphasis is placed on the design phase of documentation systems, which, especially in digital archives, is arguably the most critical stage of the entire process. Specifically, a conception phase is explicitly introduced, during which decisive choices must be made, essential for the creation and subsequent preservation of the documentary complex. [...] At this stage, the archive does not yet exist, but precisely here, its fundamental ‘genetic codes’ are conceived, which will later enable it not only to function but, remarkably, through preservation, to outlast itself. [...] However [...], purely digital archives do not exist in the documentary reality; instead, it is more accurate to speak of hybrid archives. [...] This reality necessitates the integration of the two life-cycle models previously examined, leading to the formulation of a third model that inherits and synthesizes the characteristics of both. [...] From this integration emerges a third life-cycle model, which can be articulated as follows: conception (designing the documentation system and defining descriptive requirements aimed at the management, selection, and preservation of documents); active phase (*corrente*); semi-active phase (*deposito*); and permanent preservation phase (*storico*)”⁵⁷ [Fig. 3.6].

Fig. 3.6 Lifecycle of documents in hybrid archive.



The advent of digitization in archival science has deeply challenged some fundamental principles of the discipline. Among these is the con-

57. Valacchi, *Diventare archivisti*, 81-82.

cept of document authenticity. The question of authenticity has long been a cornerstone of archival theory and practice. In the analog world, authenticity was traditionally guaranteed by preserving the original physical medium, which inherently carried material and contextual evidence, what diplomatics calls ‘extrinsic’ (i.e., the medium, the writing, the annotations on the document) and ‘intrinsic’ (i.e., the language, structure or form of the document, conceptual content and arguments, etc.) characteristics. As long as the physical support remains intact, the message retains its stability and is inseparable over time⁵⁸.

In the digital environment, this assumption collapses. The “perfect and infinite reproducibility of digital objects makes the multiple instances of a single file indistinguishable”⁵⁹. The very concept of an ‘original’ becomes elusive, if not meaningless. The physical support is replaced by a set of bit sequences, which can be copied without loss and without visible trace of modification. As a result, traditional criteria for determining authenticity prove inadequate⁶⁰.

“Records created and maintained in electronic form are continually at significant risk of inadvertent or intentional alteration, and such alteration may also not be readily perceptible. The authenticity of electronic records is threatened whenever they are transmitted across space (that is, when sent between persons, systems or applications) or time (that is, either when they are stored offline, or when the hardware or software used to process, communicate, or maintain them is upgraded or replaced). Requirements for assessing the authenticity of electronic records that are preserved over the long term are necessary, therefore, to support the presumption that an electronic record is, in fact, and continues to be, what it purports to be and has not been modified or corrupted in essential respects”⁶¹.

According to the *Authenticity Task Force* of InterPARES⁶² (Internatio-

58. Vitali, *Passato digitale*, 155.

59. Vitali, *Passato digitale*, 155-158.

60. “With regard to the need to ensure the authenticity of digital records, ISO 15489-1:2016 states that organizations should implement and document all policies and procedures necessary to control the creation, receipt, transmission, maintenance, and final disposition of records. It also emphasizes the need to ensure that records are protected against unauthorized additions, deletions, alterations, use, or concealment. The use of the conditional form of the verb ‘should’, typical of a non-mandatory standard such as ISO 15489, outlines an approach that risks not being fully implemented if the organization lacks sufficient awareness and archival understanding” (Pigliapoco, “Prefazione,” 8).

61. InterPARES, *Preservation Task Force Final Report* (2001), 2, https://www.interpares.org/documents/ptf_draft_final_report.pdf.

62. InterPARES, *Preservation Task Force*, 3.

nal Research on Permanent Authentic Records in Electronic Systems), an international research project that investigates how to ensure the long-term preservation and authenticity of electronic records, authenticity primarily concerns two key attributes: identity and integrity⁶³. In the project's final report, the *Task Force* stated that "the identity of a record refers to the distinguishing character of a record, that is, the attributes of a record that uniquely characterize it and distinguish it from other records. From an archival-diplomatic perspective, such attributes include: the names of the persons concurring in its formation (that is, its author, addressee, writer, and originator); its date(s) of creation (that is, the date it was made, received, and set aside) and its date(s) of transmission; an indication of the action or matter in which it participates; the expression of its archival bond, which links it to other records participating in the same action (for example, a classification code or other unique identifier); as well as an indication of any attachment(s) since an attachment is considered an integral part of a record. The integrity of a record refers to its wholeness and soundness: a record has integrity when it is complete and uncorrupted in all its essential respects. This does not mean that the record must be precisely the same as it was when first created for its integrity to exist and be demonstrated. Even in the paper world, with the passage of time, records are subject to deterioration, alteration and/or loss. In the electronic world, the fragility of the media, the obsolescence of technology and the idiosyncrasies of systems likewise affect the integrity of records. When we refer to an electronic record, we consider it essentially complete and uncorrupted if the message that it is meant to communicate in order to achieve its purpose is unaltered. This implies that its physical integrity, such as the proper number of bit strings, may be compromised, provided that the articulation of the content and any required elements of form remain the same"⁶⁴. The attributes that constitute the identity and integrity of

63. "The goal of the Authenticity Task Force was to identify conceptual requirements for assessing and maintaining the authenticity of electronic records. To achieve this goal, the Task Force adopted two distinct, yet related analytical approaches. The first approach was a theoretical and deductive one, based on contemporary archival diplomacies. The second approach was an inductive and empirical one that employed selected case studies of extant electronic systems. The primary outcome of the work of the Task Force has been the development of two sets of requirements: the first set includes requirements that support the presumption of the authenticity of electronic records before they are transferred to the preserver's custody; while the second set includes requirements that support the production of authentic copies of electronic records after they have been transferred to the preserver's custody" (InterPARES, *Authenticity Task Force Final Report* (2001), V, https://www.interpares.org/documents/atf_draft_final_report.pdf).

64. InterPARES, *Authenticity Task Force*, 2.

a record may be explicitly expressed in an element of the record or in metadata related to the record, or be implicit in its various contexts⁶⁵.

In this framework, the digital signature and timestamp are often invoked as technological tools to ensure authenticity. The Agenzia per l'Italia Digitale (AgID) defines the former as “the result of an IT procedure, called validation, which guarantees the authenticity, integrity and non-rejection of electronic documents. The digital signature allows users to exchange documents online with full legal validity. All natural persons can have a digital signature: citizens, directors and employees of companies, as well as public administrations”⁶⁶. In Italy, in order to obtain a digital signature, it is necessary to contact qualified trust service providers authorised by AgID.

On the other hand, timestamps can be defined as “a sequence of characters or bytes denoting the time and date that a particular event occurred. In the digital world, timestamps are often used to indicate when a document was created, modified, or accessed. [...] Timestamps can be applied to any type of document that needs to have a verified creation or modification date. They can be PDFs, Word Documents, images, and other types of digital files”⁶⁷. However, both of these mechanisms are time-limited and dependent on trusted third parties⁶⁸.

In recent years, other technologies aimed at providing secure, transparent, and immutable methods for verifying authenticity in the digital realm have also emerged, notably Blockchain and Non-Fungible Tokens (NFTs). «Blockchain is a distributed ledger technology that is decentralized, does not require trust, and has strong anticalculation modification»⁶⁹. Blockchain technology⁷⁰ is currently employed predominantly

65. Luciana Duranti, and Jean-François Blanchette, *The Authenticity of Electronic Records: The InterPARES Approach* (2004), https://www.interpares.org/display_file/ip1-2_dissemination_cpr_duranti_paris_2001.pdf.

66. “Qualified Electronic Signature,” Agenzia per l'Italia Digitale, accessed May 1, 2026, <https://www.agid.gov.it/en/platforms/qualified-electronic-signature>.

67. “Documents for which you may need a time stamp,” Namiral Focus, accessed May 1, 2026, <https://focus.namiral.com/en/documents-for-which-you-may-need-a-time-stamp/>.

68. Vitali, *Passato digitale*, 155-158.

69. Shen Lvping, “Blockchain Technology for Management of Intangible Cultural Heritage,” *Hindawi. Scientific Programming* 2021 (2021), <https://doi.org/10.1155/2021/2613656>.

70. “Think of the blockchain like a book of transactions or a ledger. A new page is added to the book and people are able to write their transaction onto the new page. Since everyone is able to access the book, we might be worried that someone would come along and tear a page out, add a new page, or erase and alter a transaction from an earlier page in the book. Blockchain solves those problems. You know that a page is missing if the book goes from page two to page four without page three. You know a page is added if there are additional pages or more than one page seven. Each page is made impossible to alter by laminating and sealing each page. The blockchain provides similar protections for each information and transaction in virtual space by allowing each person to maintain a copy of the book and constantly checking each copy against one another. A

in commercial cryptocurrency transactions, notably involving Bitcoin, the electronic cash system introduced by Satoshi Nakamoto in 2009⁷¹. Nevertheless, blockchain's substantial potential for applications in various other sectors is widely recognized⁷².

The fundamental component of a blockchain is the 'block', which acts as a permanent, immutable container aggregating multiple transactions. The collection of these blocks, linked together in chronological order, constitutes the blockchain itself. Each block possesses a unique identifier known as a 'hash', generated by applying a cryptographic algorithm to the preceding block's identifier combined with the data contained within the current block. This cryptographic linkage ensures the integrity of the entire blockchain. Indeed, if any data within a block were altered, the hash algorithm would yield different results, immediately indicating a breach of integrity⁷³. "In other words, blockchain is a database on a distributed network and all nodes on the network contain a stored copy of it. A distributed network is used to eliminate central institutions such as banks, which store data on their ledgers, thereby reducing transaction costs and increasing data security. In order to ensure data protection from malicious modifications, the ledger is shared with all nodes, thereby achieving record security, which is one of the main features of blockchain technology"⁷⁴.

This innovation "holds a great potential to change and revolutionize many aspects of our daily lives. It started as a technology that enabled the use of cryptocurrencies and challenged the existing finance and payments systems, but this is not its only possible use. A new and advan-

blockchain is a database that remembers state, and thus can itself serve as a database of anything, including another layer of executable code. In the next iteration of the technology, other applications, called distributed apps ('dapps'), can then be programmed to run on a blockchain. Ethereum is a good example. Think of the Ethereum blockchain as a large, decentralized computer. Each app runs on that computer. Every computation on Ethereum requires some computing power from that distributed computer to run the transaction. That processing power is paid for with ether. Users must expend some ether for every transaction they run, known as a "gas fee." Ether is burned to generate "gas" which pays the individual people who maintain the Ethereum Virtual Machine on their computers" (Joshua A.T. Fairfield, "Tokenized: The law of non-fungible tokens and unique digital property," *Indiana Law Journal*, v. 97, 2021, 1271-1272, <https://www.repository.law.indiana.edu/ilj/vol97/iss4/4>).

71. Satoshi Nakamoto, Bitcoin: A Peer-to-Peer Electronic Cash System (2009), <https://bitcoin.org/bitcoin.pdf>.

72. Rossana Morriello, "Blockchain, intelligenza artificiale e internet delle cose in biblioteca," *Aib Studi*, no. 59, i. 1-2 (2019): 45-68, <https://doi.org/10.2426/aibstudi-11927>.

73. Concetta Damiani, *Gli archivi dell'arte. Gestione e rappresentazione tra analogico e digitale* (Editrice Bibliografica, 2023), 137-140.

74. Helena Stublić, Matea Bilogrivić, and Goran Zlodi, "Blockchain and NFTs in the Cultural Heritage Domain: A Review of Current Research Topics," *Heritage*, no. 6 (2023): 3801-3819, <https://doi.org/10.3390/heritage6040202>.

ced use of blockchain technology has already been implemented within the archival sector that deals with the issues of digital-born documents and the need to provide their security and authenticity”⁷⁵. Even so, as Damiani underlines, blockchain technology is not a synonym for an archive or a document management system. Rather, as a digital ledger designed to record transactions systematically, it functions as a supporting tool capable of generating portions of an archival record⁷⁶.

Nevertheless, blockchain’s advantages make this technology particularly well-suited for the preservation of cultural heritage⁷⁷, especially when combined with another recently emerged innovation, namely NFTs. NFTs are cryptographic tokens created on blockchain technology and characterized by their ability to contain unique, immutable, and non-interchangeable information. NFTs gained significant popularity within mainstream culture in 2021, primarily due to the artist Mike Winkelmann, also known as Beeple, and his digital artwork *Everydays: The First 5000 Days*. Beeple’s image, a jpg file, is a Non-Fungible Token and it was sold for 69 million dollars⁷⁸.

These tokens possess the attribute of non-fungibility, a characteristic which confers upon them a specific individuality, thereby rendering them irreplaceable. “Unlike bitcoin, where one coin is the same as another, NFTs are unique, each with different attributes”⁷⁹. As a consequence, NFTs enable the unique identification and certification of a digital object or even the legal rights associated with a physical asset, ensuring the authentication of ownership and property rights. Thus, digital entities such as images, illustrations, videos, animations, photographs, or musical compositions can each be represented by a unique and irreplaceable token⁸⁰. “For digital artworks, the use of ERC-721 tokens, developed in 2018 by William Entriken, Dieter Shirley, Jacob Evans, and Natassia Sachs, is increasingly popular. These elements have specific identity characteristics that make them clearly distinguishable from one another: each token has its own DNA (a 256-bit alphanumeric string that identifies it) and a set of attributes”⁸¹. Compared to other tokens,

75. Stubić, Bilogrivić, Zlodi, “Blockchain and NFTs in the Cultural Heritage Domain”.

76. Damiani, *Gli archivi dell’arte*, 137-140.

77. Morriello, “Blockchain, intelligenza artificiale e internet”.

78. Kellie Dalton, *The Rise and Fall of the NFT Empire: The Social Phenomenon of Non-fungible Tokens*, degree of Master of Information at Dalhousie University (2023), <http://hdl.handle.net/10222/82412>.

79. Fairfield, “Tokenized”.

80. Damiani, *Gli archivi dell’arte*, 137-140;

81. Siti Ima Mustajap, Adzira Husain, Syamsul Bahrin Zaibon, Mohd Amirul Helmi, and Mohd

the ERC-721 standard allows for the inclusion of metadata. In other words, in addition to enabling identification of the token itself or of the physical or digital objects it represents, it introduces the possibility of associating an image with the specific object to which the token refers. In essence, “on a reliability scale, ERC-721 ranks significantly higher than other tokens, though it entails increased costs: a larger amount of data implies higher processing expenses, greater security, and enhanced traceability”⁸² [Fig. 3.7].

Fig. 3.7 Left: Mike Winkelmann (a.k.a. Beeple), *Everydays, the First 5000 Days*, 2001; right: one of the 5000 digital images used in the artwork.

[Mike Winkelmann, https://en.wikipedia.org/wiki/File:Everydays,_the_First_5000_Days.jpg]



There are already examples of Italian and international museums that have experimented with NFTs. In Italy, the most popular and debated example is represented by the creation of a Digital ArtWork (DAW) of Michelangelo's *Tondo Doni* [Fig. 3.8]. This initiative was carried out in 2022 based on an agreement between the Uffizi Gallery and Cinello, a company specializing in digital art⁸³. The agreement between the parties stipulated that the museum would receive 50% of the sale price for each DAW created, net of expenses incurred for its digitization. Purchasers of a DAW receive a hardware device (a kind of tablet), a certificate confirming the authenticity of the DAW, a monitor, and a handcrafted frame faithfully replicating the original. The artwork itself is presented through a high-definition digital reproduction, developed and patented by the commercializing company, thus ensuring the visual experience

Noor Abdul Hamid, “The Potential of Non-Fungible Tokens (NFTs) In Enhancing Malaysia's Arts and Cultural Heritage Preservation,” *paperASIA*, no. 40 (2024): 72, <https://doi.org/10.59953/paperasia.v40i6b.282>.

82. Damiani, *Gli archivi dell'arte*, 137-140.

83. Francesca Vessia, “DAW, NFT, IA e diritti sulle immagini dei beni culturali,” *IMMERSIN-SCENA*, November 25, 2024, <https://www.immersinscena.org/daw-nft-ia-e-diritti-sulle-immagini-dei-beni-culturali/>.



Fig. 3.8 Michelangelo Buonarroti, *Tondo Doni*, 1506, Galleria degli Uffizi.

[\[https://commons.wikimedia.org/wiki/File:Tondo_Doni_2021.jpg\]](https://commons.wikimedia.org/wiki/File:Tondo_Doni_2021.jpg)

closely resembles the original piece⁸⁴.

It must be emphasized, however, that these technologies are not without limitations, notably their dependency on energy-intensive processes, potential legal uncertainties, and challenges regarding interoperability and long-term digital preservation⁸⁵. In addition, “despite the initial promises of blockchain technology, several cybersecurity attacks and manipulation attempts have been documented”, revealing vulnerabilities particularly relevant when handling sensitive cultural data⁸⁶.

Nevertheless, the primary concerns remain environmental and economic sustainability⁸⁷. Indeed, the generation processes underlying Blockchain and NFTs rely upon complex calculations that demand extremely high computational performance. Specifically, dozens of processors operate simultaneously to produce digital files, employing sophisticated cooling systems that are both highly efficient and significantly energy-consuming, necessary in turn to prevent machine overheating.

Beyond these limitations, however, it remains evident that the “true innovation of blockchain technology lies in the underlying vision and

84. Francesca Vessia, “DAW, NFT, IA”.

85. Mustajap et al., “The Potential of Non-Fungible Tokens”.

86. Morriello, “Blockchain, intelligenza artificiale e internet”.

87. There is an ongoing debate on the environmental sustainability of blockchain and NFT technologies, which typically rely on high energy consumption through Proof of Work (PoW) consensus mechanisms. While alternative methods such as Proof of Stake (PoS) have emerged to mitigate these issues, challenges related to scalability, security, and decentralization still remain prominent (Morriello, “Blockchain, intelligenza artificiale e internet”).

in its attempt to provide an advanced technological solution to a fundamentally socio-cultural issue: managing authenticity within digital society”⁸⁸.

Alongside traditional extrinsic and intrinsic markers, there is a third criterion for assessing the authenticity of an analog document, which may be termed the relational or contextual approach. This approach “bases the evaluation of authenticity on the relationships that a single [physical] document maintains with other documents and with the broader archival context to which it belongs”⁸⁹. It recognizes that documents do not exist in isolation, but within structured aggregations - files, series, and fonds - that provide them with meaning and legitimacy. Digital documents complicate this further by introducing issues of obsolescence and volatility. The hardware and software environments necessary to render a file intelligible may become unavailable within a few years. What is preserved is not the object itself, but the capacity to reproduce it, the ability to activate a process involving file format, software compatibility, and metadata coherence. In this sense, digital preservation becomes a matter of ensuring, rather than material continuity.

In recent years, the discussion has been further complicated by the widespread adoption of Artificial Intelligence in various areas of daily life, capable of producing deepfakes and synthetic documents or altering digital documents, potentially undermining historical accuracy. Consequently, traditional methods of authentication may no longer be sufficient to detect manipulations performed by advanced AI technologies.

In the face of the emergence of this novel and revolutionary technology, Valacchi offers an insightful perspective on the affinities between archives and generative artificial intelligences. Specifically, he argues that generative AI, much like archives, “respond to induced generative needs; they create entities from existing entities and operate solely by analyzing and classifying data stored somewhere and destined for unpredictable uses. Thus, it is not entirely inappropriate to conceive of artificial intelligence as a luminous constellation of archives that are constantly evolving and reconfiguring, relying on data to produce further data that infiltrate the fabric of a society dependent on information - artificial to the extent that we shape it ourselves through technological

88. Damiani, *Gli archivi dell'arte*, 137-140.

89. Vitali, *Passato digitale*, 155-158.

means”⁹⁰. According to Valacchi, considerable caution must be exercised concerning these similarities, as we stand “on the threshold of a vast learning archive that selects, destroys, reconstructs, and disseminates information based on professionalized algorithms, progressively detached from the human criteria underlying the original sedimentation. The risk lies in replacing the natural and spontaneous character of traditional archives with the perceptions and desires embedded within algorithms and dictated by those who design them. Consequently, evident issues emerge concerning the reconversion of knowledge - bordering on plagiarism - or, even worse, the creation of a predatory collective memory devoid of nuances and resistant to any form of informational competition. It is thus essential to evaluate the ‘circular’ relationship that might develop between artificial intelligences and archives; that is, between two domains presumed to offer informational reliability, yet both, for distinct reasons, susceptible to problematic cognitive biases”⁹¹. Thus, ethical and regulatory frameworks, such as the EU’s pioneering AI regulation⁹² - emphasizing safety, transparency, traceability, non-discrimination, environmental sustainability, and human oversight - are urgently required to mitigate these risks⁹³.

Faced with the uncertainty surrounding the concept of authenticity in the digital domain, Vitali questions whether “both the scope of the integrity requirement and its implications for the identity of individual objects and documents ought to be reconsidered. Given the fluidity and dynamism of the digital world, as well as the necessity to implement strategies to counter hardware and software obsolescence, it seems that identity and integrity can no longer be regarded as two inseparable sides of the same coin. A document may remain fundamentally the same despite undergoing changes to some of its characteristics over time; conversely, it does not necessarily follow that a document which has lost its integrity should no longer be considered authentic. In the digital environment, therefore, the requirement of integrity cannot be interpreted in the strict sense of fully preserving all characteristics of the original or initial documents over time. Rather, it is the quality and the

90. Federico Valacchi, *L'archivio aumentato. Tempi e modi di una digitalizzazione critica* (Editrice Bibliografica, 2024), 123-124.

91. Valacchi, *L'archivio aumentato*, 123-124.

92. “EU AI Act: first regulation on artificial intelligence,” Directorate General for Communication, February 19, 2025, https://www.europarl.europa.eu/pdfs/news/expert/2023/6/story/20230601STO93804/20230601STO93804_en.pdf.

93. Valacchi, *L'archivio aumentato*, 126.

purpose of these modifications that determine their implications for the identity, and consequently for the authenticity, of the document”⁹⁴.

The questions concerning authenticity are particularly crucial, as they relate directly to another significant issue in the context of digital archives: namely, how to ensure the long-term preservation of digital documents. Indeed, long-term digital preservation is an increasingly critical issue in contemporary archival practice due to rapid technological evolution and growing production of digital data. Before proceeding with further reflections on this subject, it is worth posing two fundamental questions: why do we preserve documents, and for how long should they be preserved? Indeed, “the essential reason underpinning the design of any records management system should ultimately be to ensure continued accessibility to the preserved documents for various purposes over time. Documents are preserved to be consulted, and archival work, irrespective of the formats or media involved, would lack meaning if not oriented towards this goal. Nevertheless, the most pressing - and in many respects most anxiety-provoking - issue raised by the forthcoming digital transition is that of the future of memory. Transformations in archives and the inherent nature of digital documents risk prioritizing the immediate, understood as the urgent creation of documentary systems designed to meet short-term needs, over the transcendent, understood instead as the awareness of our power and duty to leave a meaningful memory of our digital society to future generations”⁹⁵. Within this framework, the central and paramount issue remains the challenge of preservation itself.

Preservation of digital documents over time faces at least three major problems. One significant concern involves hardware obsolescence. The swift pace at which storage devices evolve renders older media rapidly outdated and incompatible with newer technologies. One need only consider the rapidity with which USB flash drives and hard disks have replaced CDs for file storage, the latter having previously supplanted floppy disks with similar swiftness.

Software obsolescence constitutes another significant challenge, manifesting itself at both the operating system and specific application levels. It renders data recorded with software that is no longer in use or incompatible with current operating systems unintelligible or inaccessible.

94. Vitali, *Passato digitale*, 158.

95. Valacchi, *Diventare archivisti*, 171-173.

ble for editing. This phenomenon affects not only specialized software applications but also widely used formats⁹⁶.

Additionally, digital storage media themselves are inherently fragile. Magnetic media are especially vulnerable to environmental factors such as temperature fluctuations, humidity, and electromagnetic interference, leading to irreversible data loss. Even optical media, relatively resistant to environmental conditions, are susceptible to subtle surface damage causing permanent readability issues⁹⁷.

In recent years, significant international efforts have been made in the archival and library sectors to address the limited longevity of digital materials. Regarding the fragility of storage media, the only widely agreed-upon method thus far is periodic ‘refreshing’, that is, copying files onto new media, although this approach is not free from risks related to data loss.

More complex is the management of hardware and software obsolescence, for which two contrasting strategies have emerged: preserving digital objects within their original technological context, or progressively transforming them to ensure compatibility with newer technologies⁹⁸.

In the first scenario, the approach focuses on preserving original digital files, along with their corresponding hardware and software platforms, maintaining their availability over time. This strategy involves the creation of so-called ‘computer museums’, which enable sustained accessibility and intelligibility of the original files. Within this framework falls the technique of emulation, which combines the preservation of digital objects with their associated software and operating systems, alongside an ‘emulator’ - a specialized program designed to replicate, on contemporary hardware platforms, the behavior of the original systems. Consequently, this should allow continued access to individual digital objects within a technological context closely resembling the environment in which they were originally produced, thus preserving, as accurately as possible, their initial characteristics, including interfaces for viewing and retrieval⁹⁹.

The second approach encompasses all practices involving the migration

96. Paul G. Weston, “Digital curation. Nuove opportunità per bibliotecari e archivisti,” in *Il libro, gli archivi e la memoria digitale*, ed. P.G. Weston (Edizioni Unicopli, 2013), 9-10.

97. Vitali, *Passato digitale*, 141-143.

98. Vitali, *Passato digitale*, 182-183.

99. Vitali, *Passato digitale*, 182-183.

of data into new formats that remain compatible with evolving hardware platforms, operating systems, and specific software applications or their subsequent market releases. This ensures continued data accessibility even when original software becomes technically unusable due to obsolescence. The timely execution of these migration processes is essential, particularly to prevent software obsolescence from coinciding with hardware obsolescence. Another migration strategy involves converting data from proprietary formats into platform-independent formats, increasing interoperability and reducing dependence on specific commercial software. More recently, migration strategies have evolved towards adopting standardized, open formats that decouple preservation from rapid technological changes, thereby better maintaining data semantics and original representation methods over the long term¹⁰⁰ [Fig. 3.9].

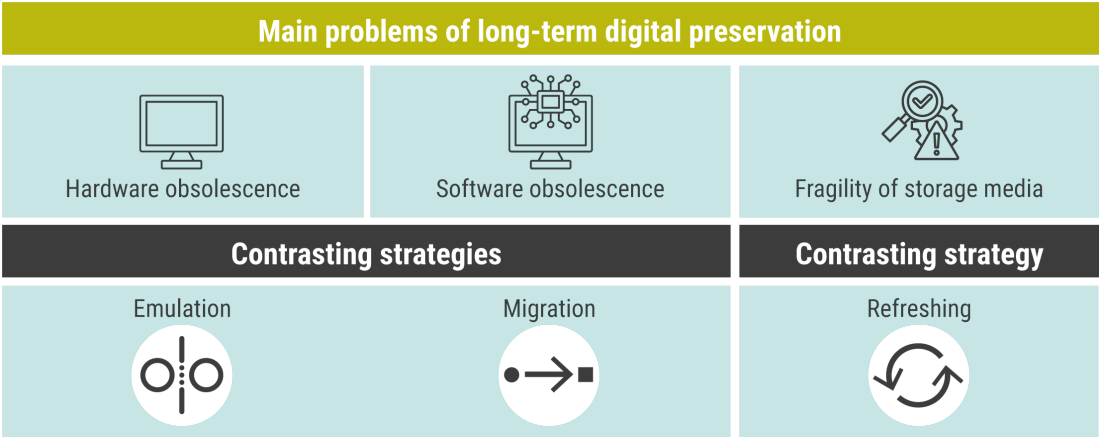


Fig. 3.9 Main technical problems and contrasting strategies for long-term digital preservation.

Clearly, none of the proposed strategies is without risk; however, as Vitali emphasizes, it is essential to question which solution is least likely to compromise, either in the near or distant future, the usability of digital objects as complex and richly meaningful historical sources. “It should be noted, for example, that a migration process which progressively erases traces of the original technological context in which documents were created could result in the complete disappearance of the capacity of documents and historical artefacts to evoke - through their very physical appearance - a tangible sense of the passage of time. [...] The gradual loss of chronological depth arising from the homogenization dynamics imposed by hardware and software migration ulti-

100. Vitali, *Passato digitale*, 182-183.

mately leads, within the sphere of documentary sources, to what Walter Benjamin described as the ‘loss of aura’ associated with reproduction techniques of artworks. Such processes not only deprive researchers of specific insights connected to the original modes of perception and use of a given document, but also affect other crucial aspects of their relationship with the sources. [...] Ultimately, there is a dimension in the relationship with sources that cannot be reduced merely to the amount of information they contain, but extends to their deeper quality - the complex interplay of sensations and cognitive mechanisms, including perceptual and aesthetic experiences, which these sources can evoke and activate”¹⁰¹.

It is appropriate, finally, to make a concluding remark about preservation systems and archives in their complexity. Indeed, “the crucial problem concerns how the preservation system - beyond merely conserving individual documents, files, and aggregations, namely entities, objects, or series - will be able to effectively represent the original production system. This original system supported the administrative functions and constitutes the context and, in certain respects, the original arrangement, namely the current archive. In other words, the central and still unresolved question about the methods and conditions required to shift from a preservation approach focused solely on maintaining the legal value of individual documents to one dedicated to preserving archives as organic collections. Only through the preservation of their original arrangement can archives fully convey the informational richness of the documentation they contain”¹⁰².

Thus, ensuring long-term digital preservation demands comprehensive strategies addressing hardware and software obsolescence and media fragility. Crucially, it requires a deeper, theoretically informed approach, acknowledging archives not merely as collections of digital objects, but as complex repositories reflecting the socio-cultural contexts from which they originate. This holistic understanding must inform both archival policies and digital preservation practices, ensuring that archives maintain their fundamental role as authentic, reliable sources of historical knowledge¹⁰³.

All the reflections developed thus far lead us to inquire about what futu-

101. Vitali, *Passato digitale*, 182-183.

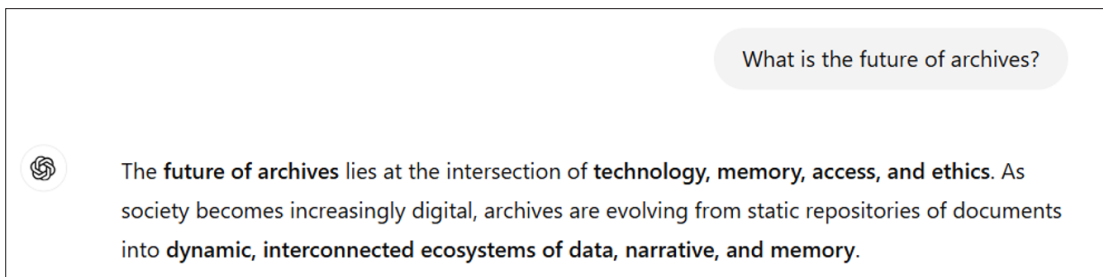
102. Bezzi, “Modelli per la conservazione e l’accesso,” 124.

103. Valacchi, *L’archivio aumentato*, 80.

re can reasonably be expected for archives and especially for hybrid or digital archives. When asked about this issue, ChatGPT4.5 replies that “the future of archives lies at the intersection of technology, memory, access, and ethics. As society becomes increasingly digital, archives are evolving from static repositories of documents into dynamic, interconnected ecosystems of data, narrative, and memory”. The AI continues: “the future of archives is not just about preservation, but about purpose: what should we remember, and how? Who decides? And for whom is the memory being preserved? Archives will survive by being adaptive, inclusive, interdisciplinary - and above all, human-centered, even in a digital world” [Fig. 3.10].

Artificial intelligence raises a fundamental issue that ultimately requires serious consideration: the legacy we wish to leave for future generations. This concerns the deliberate selection of what should be preserved and what should consciously be allowed to fade into oblivion - if such oblivion remains possible in the digital realm¹⁰⁴. What experiences do we deem worthy of preservation, and how do we intend to select them? To which social phenomenon, group, or institution do we delegate the responsibility of deciding what is suitable to transmit to posterity? Moreover, what role can technology play in this process? Just “as writing has done for centuries, alongside monumental art, the characteristics of instruments used to record and evoke experiences shape memory. However, compared to the past, today’s tools exhibit a significant peculiarity: unless intentionally preserved, both art and documents were traditionally created to endure, whereas contemporary technologies primarily serve present purposes.

Fig. 3.10 Screenshot of the query to artificial intelligence ChatGPT4.5.



104. Umberto Ambrosoli, and Massimo Sideri, *Diritto all'oblio, dovere della memoria. L'etica nella società interconnessa* (Bompiani, 2017).

Thus, memory and technology share a far more ambiguous relationship than commonly perceived, one that we approach with limited awareness”¹⁰⁵. Indeed, as Ambrosoli and Sideri have emphasized, digital technologies paradoxically function as ‘memory accelerators’, capable of storing immense volumes of information, yet simultaneously vulnerable to instantaneous data loss, exemplified by events such as computer viruses swiftly erasing stored data. This ambiguity carries profound implications for our cultural responsibility towards future generations¹⁰⁶. Furthermore, the illusion of digitally archiving everything - information, sounds, images, texts, etc. - must ultimately be dispelled. In fact, “if everything is an archive, then nothing remains an archive in the historical sense. The syndrome of totality undermines the quality of information because memory represents a refined process of selection, not simply a desire for accumulation up to inconceivable capacities”¹⁰⁷. Thus, “selection”¹⁰⁸ emerges as necessary, not only to prevent the accumulation of vast quantities of ephemeral documentation - both paper-based and digital - but also as a meaningful cultural practice through which future historical sources are identified and valued, enabling future generations to understand and interpret our present”¹⁰⁹.

In conclusion, the digital transformation of archives profoundly challenges traditional archival theories and practices, prompting significant reconsideration regarding authenticity, memory selection, and long-term preservation. The transition from analog to digital has reshaped archives not merely as passive repositories but as active, complex systems of information management, intrinsically tied to their sociocultural contexts.

Therefore, the future of archives requires a balanced integration of analog heritage with digital advancements, guided by ethical considerations, robust technical standards, and informed policy-making. Italy’s initiatives, such as the *Digital Library*¹¹⁰ established by the Ministero

105. Ambrosoli and Sideri, *Diritto all’oblio, dovere della memoria*, 49-53.

106. Ambrosoli and Sideri, *Diritto all’oblio, dovere della memoria*, 49-53.

107. Valacchi, *L’archivio aumentato*, 43-44.

108. In archival science, the term ‘selection’ refers to the “activity that determines the retention period of records in order to decide their final disposition (long-term preservation or destruction), based on the identification and evaluation of criteria related to archival functionality” (Linda Giuva and Maria Guercio (ed.), *La selezione in Archivistica. Teorie, metodi, pratiche*, Carocci, 2014, 79).

109. Nicola Carofiglio, “Selezione e scarto in ambiente digitale: spunti di riflessione,” in *Reti di archivi per gli archivi in rete. Conservazione e accesso ai patrimoni digitali*, ed. G. Crupi and M. Guercio (Edizioni ANAI, 2017), 75-77.

110. Istituto centrale per la digitalizzazione del patrimonio culturale – Digital Library, accessed

della Cultura and the *Piano Nazionale di Digitalizzazione* (PND)¹¹¹, exemplify structured attempts to navigate this complex digital transformation, fostering interoperability, transparency, and sustainable preservation practices for the cultural heritage of future generations¹¹².

May 1, 2026, <https://digitallibrary.cultura.gov.it/>.

111. “Il Piano,” Istituto centrale per la digitalizzazione del patrimonio culturale – Digital Library, accessed May 1, 2026, <https://digitallibrary.cultura.gov.it/il-piano/>.

112. See chapter 05 of the present thesis.

03.2 Historical-documentary research in the web era

Archival research has long been recognized as a complex and often unpredictable endeavor, more akin to an intellectual expedition than a linear process of data retrieval¹. As Zanni Rosiello observes, “the course of archival research is never straightforward; more often than not, it is winding, uneven, and arduous. At the same time, however, it is captivating, replete with surprises, enticements, and intellectual appeal. Each archival undertaking poses distinct challenges and demands equally diverse preparation, knowledge, and cultural-historical competencies in order to be successfully brought to completion”². Unlike libraries or museums, which present discrete, clearly defined objects, archives are complex networks of documents, relationships, and cross-references that resist linear navigation. The answers researchers seek are frequently hidden in unexpected places, and sometimes they are simply not there to be found. As a result, archival investigation proceeds almost always through successive approximations, requiring not only methodological rigor but also patience, creativity, and occasionally, serendipity³ [Fig. 3.11].

Traditionally, this complexity has necessitated a high degree of mediation - both human and instrumental. Archivists have played a vital role in bridging the gap between users and collections, offering physical reference services and crafting the research tools (inventories, guides, etc.) that enable scholars to decode fragmentary or unintelligible sources. These instruments, far from being mere lists or databases, function as ‘portals’ to the informational depths of archival holdings⁴.

In recent decades, the landscape of archival research has been significantly reshaped by the emergence of digital technologies. These are no longer experimental or peripheral tools, but a central and unavoidable component of archival practice and research. On one hand, we have digital archives - documentary systems composed of electronic records managed throughout their entire lifecycle using digital tools. On the other, we find technological applications to traditional archives, where digital resources are employed to preserve and enhance access to re-

1. Federico Valacchi, *Diventare archivisti. Competenze tecniche di un mestiere sul confine* (Editrice Bibliografica, 2015), 126.

2. Isabella Zanni Rosiello, *Andare in archivio* (Società editrice il Mulino, 1996), 7.

3. Valacchi, *Diventare archivisti*, 126.

4. Valacchi, *Diventare archivisti*, 127.

Fig. 3.11 Holland House library after an air raid, London, 23 October 1940.

[https://commons.wikimedia.org/wiki/File:Holland_House_library_after_an_air_raid.jpg]



cords originally created outside the digital environment⁵.

Since the mid-1990s, the emergence of the World Wide Web has profoundly influenced not only the nature of the information managed by cultural heritage institutions, but also the agents who are able to produce, access and disseminate it, leading to the development of innovative and far-reaching systems for the communication of archival resources⁶. The internet is now routinely used to enhance work on individual archival collections and to support the dissemination of integrated information systems. Online archival research represents the natural evolution of traditional practices, prompting a critical reassessment of which methods remain relevant and which must adapt, particularly in terms of how this transition is to be effectively managed⁷.

The complexity of this phenomenon, along with the vast and varied range of resources it brings together, is often mirrored in the language used to describe it. In this field, one frequently encounters a certain degree of terminological uncertainty, an issue that is often ignored or left

5. Federico Valacchi, "Archivi storici e risorse tecnologiche," in *Archivi e informatica*, ed. A. Romiti, M. Guercio, S. Pigliapoco, and F. Valacchi (Civita editoriale, 2010), 93.

6. Elisabetta Caterina Giovannini, Massimiliano Lo Turco, and Noemi Mafri, "Documenting historical research for a collection information modelling. A proposal for a digital asset management system," *ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* 2, no. 42 (2019): 519, <https://doi.org/10.5194/isprs-archives-XLII-2-W15-519-2019>.

7. Valacchi, *Diventare archivisti*, 159.

unresolved, whether out of superficiality or hesitation. In this regard, the reflections of Daniela Giglio on the concept of the ‘digital library’ are particularly relevant, as they can also be extended to the idea of the archive in the digital age. Giglio observes that “the term digital library is commonly used to refer to computerized systems that provide, in various ways, access to digital or digitized resources. The same term is also often applied to library websites, or parts thereof, as well as to online content portals, collections of electronic journals, and databases. Consequently, the expression is employed to describe systems that differ widely in purpose, structure, and functionality. [...] At first, the emergence of digital libraries was associated with the idea of the traditional library, of which they were considered the digital counterpart; later, their potential was extended, transforming them into complex, interconnected infrastructures capable of supporting communication and collaboration across distributed online communities”⁸.

The first step towards gaining a deeper understanding of such an elusive field lies in a more articulated identification of the types and purposes of the set of tools and resources generally referred to as technological applications to historical archives. In the past, when the use of information technology in archival studies was still in its early stages, understanding and assessing the available technological tools was relatively straightforward. Today, however, the situation has become far more complex due to the rapid pace of both cultural and technological change. The drive toward technological innovation has produced uneven results: alongside projects of great value, there have also emerged many uncoordinated and fragmented initiatives⁹.

According to Valacchi, technological applications in the archival domain can essentially be grouped into three main categories. The boundaries between these categories are, in fact, quite fluid, as they tend to overlap and integrate with one another in various ways. The three principal types can therefore be identified as follows [Tab. 3.2]:

1. Archival description software;
2. Archival information systems (SIA);
3. Telematic or web-based resources serving as complementary tools that enhance the visibility and accessibility of archival materials

8. Daniela Giglio, *Per una storia della Biblioteca digitale: prototipi, definizioni, esperienze e modelli*, (PhD diss., Università degli Studi di Firenze and Università degli Studi di Siena, 2017), 58.

9. Valacchi, “Archivi storici e risorse tecnologiche,” 95.

(the so-called archival web).

A cross-cutting element common to all these categories is digitization, understood as the conversion of primary sources and research tools from paper-based to digital formats. The challenge in this respect is not limited to the costs or technical feasibility of such a transformation, but rather concerns the need for a conscious and informed use of digital opportunities¹⁰.

Tab. 3.2 Main typologies of technological applications and tools in archiving.

Technological applications and tools in archiving			
	Archival description software	Archival information systems (SIA)	Archival web
Definition	Tools supporting the processes of arrangement and inventorying that reproduce traditional archival practices in a digital environment.	Research orientation tools. Unlike simple databases, they mediate access to archival sources in a digital environment. The Archival Information System integrates and harmonizes information on both content and context, enabling flexible and in-depth research paths.	A tool for enhancing and promoting the work carried out on individual collections or documentary complexes preserved in various institutions, as well as a potential means for disseminating and integrating information systems. It often takes the form of an institutional website managed by a cultural organization to communicate its mission, facilitate access to archival holdings, and promote its documentary heritage.
Main purpose	Constructing digital resources.	Providing access to digital resources.	Valorization and communication of digital resources.
Users	Archivists	Archivists and external users	External users
Examples	• Arianna (https://arianna4.it/arianna4/); • Archimista (https://archivodistatobrescia.cultura.gov.it/archimista).	• SAN (http://san.beniculturali.it/); • SIUSA (https://siusa-archivi.cultura.gov.it/); • Guida Generale (https://icar.cultura.gov.it/guida-generale).	• Archivio Storico Istituto Luce (https://www.archivioluce.com/); • Archivio di Stato di Trento (https://archivodistatotrento.cultura.gov.it/).

10. Valacchi, "Archivi storici e risorse tecnologiche," 104-105.

While setting aside description software, which is more relevant for archivists than for external users and not central to the objectives of this thesis, it is possible to provide a concise overview of the main Italian archival information systems, beginning with the SAN (*Sistema Archivistico Nazionale*). SAN represents the ‘system of systems’ of the national archival web, developed to rationalize a previously fragmented offering that, although valid in many cases, was often incoherent from the user’s perspective. SAN’s commitment to synthesis is evident in the CAT (*Catalogo delle risorse archivistiche*)¹¹, which aggregates information from the various participating systems, as well as in its thematic portals, covering topics from architecture to fashion and including more specialized projects. These portals do not constitute direct archival descriptions but rather thematic selections from CAT’s resources, serving as invitations to consult the collections associated with specific topics. Among the most significant participating systems are the *Guida Generale degli Archivi di Stato italiani*¹², the SIAS (*Sistema Informativo degli Archivi di Stato*), and the *Sistema Guida Generale*¹³, and the SIUSA (*Sistema Informativo Unificato delle Soprintendenze Archivistiche*), still under development to manage a large and complex heritage¹⁴.

Despite the generous availability of resources in Italy, the network of information systems remains neither exhaustive nor capable of providing deep content analysis. Search functionalities often remain tied to analog models and suffer from data dispersion across multiple contain-

11. “The CAT functions as a centralized repository of essential information relating to Italy’s archival heritage, as described in both national and local systems. Its purpose is to enable users to identify archival resources capable of meeting their research needs and to guide them toward the system - or systems - that hold the relevant descriptions. CAT allows users to search descriptive records imported from archival systems participating in the Sistema Archivistico Nazionale (SAN). Searches can be conducted starting from several entry points: archival holding institutions (including public and private bodies, as well as individuals and families that preserve and make archives accessible); archival creators (institutions, organizations, individuals, and families that have produced, accumulated, preserved, and used the archival documentation in the course of their activities); and archival groupings, such as fonds, aggregated fonds, and though to a lesser extent - series and sub-series” (“Il Catalogo delle Risorse Archivistiche,” SAN, accessed May 1, 2026, <http://san.beniculturali.it/web/san/ricerca-negli-archivi>).

12. “The *Guida generale degli Archivi di Stato italiani* provides a systematic and coherent description, based on uniform criteria, of all archival fonds preserved at the *Archivio centrale dello Stato* and the *Archivi di Stato* established in each provincial capital, including any dependent sections where applicable” (“Sistema Guida generale degli Archivi di Stato italiani,” Direzione Generale per gli Archivi, accessed May 1, 2026, <http://www.guidageneralearchivistato.beniculturali.it/>).

13. “Within the Sistema Guida generale, in addition to the analytical description of individual archival creators to whom the fonds are attributed, a general institutional profile is also provided for those creators governed by a common regulatory framework or belonging to the same typological category” (“Sistema Guida generale degli Archivi di Stato italiani”).

14. Valacchi, *Diventare archivisti*, 155-158.

ners, due both to the richness and complexity of the documentary heritage and to approaches that have so far been insufficiently systematic. However, the *ICAR Archivio Digitale* project [Fig. 3.12], still in progress, offers prospects for improvement by proposing a single platform through which users can access, from a single entry point, the digitized holdings of the State Archives and participating archival and bibliographic superintendencies, thereby overcoming the limitations of existing systems¹⁵.

Fig. 3.12 *ICAR Archivio Digitale* website.

[Archivio Digitale, accessed May 1, 2026, <https://archiviodigitale-icar.cultura.gov.it/>]



At the local level, the significant initiative of the *Sistema informativo degli archivi storici del Trentino* (AST) is noteworthy. AST is the result of a project promoted and coordinated by the *Provincia autonoma di Trento*, involving the main public and private archival institutions of the region. The AST system, which provides separate interfaces for professionals and general users, integrates inventories of archives from municipal, parish, educational, and private entities, as well as family and personal archives, all preserved within the Trentino territory. Archival information is organized into detailed records, complemented by contextual data - including institutional, archival, and legal information - and technical and administrative details concerning arrangement and inventory work, collected in dedicated Project records. Since 2016,

15. Maddalena Valacchi, "La speranza della ricerca," in *L'archivio aumentato. Tempi e modi di una digitalizzazione critica*, ed. F. Valacchi (Editrice Bibliografica, 2024), 138.

following an agreement between the *Ministero dei beni e delle attività culturali e del turismo* and the *Provincia autonoma di Trento*, the AST system has been integrated into the *Sistema archivistico nazionale* (SAN)¹⁶ [Fig. 3.13].

The software for archival description and the information systems, each with its own features and objectives, represent two components of decisive importance in the construction and presentation of coherent and effective descriptive systems. However, they constitute only two pieces of a much larger mosaic - that of the archival web - within which they can fully develop their potential¹⁷. The term archival web refers to the wide range of archival resources available online: a sort of collection of tools of different nature and depth, capable of guiding and supporting archival research¹⁸.

Archival web have brought about significant changes and challenges for both users and archivists. From the users' perspective, conducting research through online platforms and tools has significantly improved access to archival documents and materials, which are now increasingly diverse and heterogeneous.

Fig. 3.13 Search interface of the *Sistema informativo degli archivi storici del Trentino* website.

[“Ricerca nel sistema AST,” Trentino Cultura, accessed May 1, 2026, <https://www.cultura.trentino.it/archivistorici/sistema/semplice>]

The screenshot shows the search interface of the AST website. At the top, there is a navigation bar with links: Homepage, Consulta gli inventari, Ricerca nel sistema (highlighted), Progetto archivi Thun, and Studi e ricerche. Below the navigation bar, the title "Ricerca nel sistema AST" is displayed. The main search area is divided into two sections: "CERCA" and "FILTRO SULLE SEGUENTI LISTE". The "CERCA" section contains a search bar. The "FILTRO SULLE SEGUENTI LISTE" section contains two columns of checkboxes for filtering results. The first column includes: Ambiti territoriali, Contesti storico-istituz., Fonti, Profili documentari, and Profili istituzionali. The second column includes: Soggetti titolari, Soggetti produttori, Strumenti di ricerca, Complessi archivistici, and Unità archivistiche. Below the filters, there is a section for "Filtro per disponibilità immagini online" with a checkbox. Further down, there are two input fields for "Filtro per data inizio" and "Filtro per data fine", both with a date format "(gg/mm/aaaa)". At the bottom, there is a yellow button labeled "Trova" with a magnifying glass icon.

16. “Il Sistema informativo degli archivi storici del Trentino - AST,” Trentino Cultura, accessed May 1, 2026, <https://www.cultura.trentino.it/archivistorici/home>.

17. Valacchi, *Diventare archivisti*, 158-159.

18. Valacchi, “Archivi storici e risorse tecnologiche,” 133.

Today, for example, it is possible to access - and sometimes download - digitized photographs, drawings, and historical documents directly from a personal computer, alongside born-digital content such as audio recordings, videos, text files, design files, and more. These developments have not only introduced new tools, but also reshaped researchers' approaches, affecting both their strategies and expectations. Regardless of format or platform, users can often be distinguished as either 'seekers', who pursue specific information with little concern for archival structure, or 'navigators', who engage more patiently with archival systems, refining their search through successive approximations. These differing approaches inevitably shape the selection of research tools. Many users now initiate archival inquiries through general-purpose search engines such as Google or Yahoo - a practice that may be considered acceptable, provided that the information obtained is ultimately contextualized within its appropriate archival framework¹⁹. As a result, interaction with archivists has diminished, leading to greater independence and a higher level of responsibility on the part of the researcher in conducting their work²⁰.

It becomes increasingly clear that behind the many new opportunities the web offers to historical research lie also a number of risks, limitations, and challenges. These risks can be broadly summarized and categorized as economic, technical, and qualitative constraints.

Initially regarded as an unprecedented opportunity to democratize access to historical sources and broaden research horizons, the digitization of archival resources and their online storage and dissemination held the promise of a comprehensive and universally accessible repository of human knowledge. This vision greatly elevated public expectations, giving rise to what might be described as an 'archival mania', characterized by a proliferation of digitization initiatives driven by the illusion of limitless storage capacity and instant accessibility²¹. Digitizing archival documents and providing online access evokes the empowering vision of transcending traditional institutional boundaries, enabling unrestricted circulation of knowledge and overcoming the physical constraints that previously hindered access to cultural herita-

19. Valacchi, "Archivi storici e risorse tecnologiche," 115.

20. Valacchi, *Diventare archivisti*, 149-150.

21. Federico Valacchi, *L'archivio aumentato. Tempi e modi di una digitalizzazione critica* (Editrice Bibliografica, 2024), 43-44.

ge²². This situation is exacerbated by the deceptive ease and apparent low cost of digital storage, leading to an indiscriminate accumulation of data. Within this context, it is essential to acknowledge that the digital realm possesses a physical dimension: it occupies specific space and time, carries environmental implications, incurs costs, and produces tangible consequences²³. From an economic perspective, digitization and long-term digital storage represent substantial investments, posing significant challenges, particularly for institutions operating with limited budgets. High costs are associated not only with the initial phases of digitization but also with the ongoing maintenance of digital data²⁴. Technical limitations further compound these economic constraints. As digital technologies continue to evolve, online archival resources must constantly adapt to prevent data loss or inaccessibility caused by obsolete formats or hardware. This instability has given rise to two paradoxically opposed views within public opinion: on the one hand, “for the public, there is a belief (and a worry) that if something is on the Internet, it will be around forever”; on the other, there are those who fear an imminent “digital dark age”, in which recent historical records may become inaccessible or entirely lost²⁵.

Moreover, the way the Internet functions as an archive diverges significantly from traditional archival principles. A traditional archive is, by its very nature, designed to ensure the transmission of documents and the information they contain across time. In contrast, the web has primarily served as a medium for the rapid dissemination of information, prioritizing immediacy and novelty over permanence and stability. This is evident in the short lifespan and ever-evolving nature of web pages, which frequently change in structure, presentation, and content²⁶. Preserving the historical record of websites is therefore essential, as they reflect the activity of their creators. Each significant update should not

22. Valacchi, *L'archivio aumentato*, 94-99.

23. Valacchi, *L'archivio aumentato*, 20.

24. The illusion of being able to archive everything at minimal cost emerged as early as the 1990s, just a few years after the advent of the World Wide Web. Brewster Kahle launched the Internet Archive in 1996, arguing that “the dropping costs of digital storage mean that a permanent record of the Web and the rest of the Internet can be preserved by a small group of technical professionals equipped with a modest complement of computer workstations and data storage devices. A year ago I and few others set out to realize this vision as part of a venture known as the Internet Archive” (Brewster Kahle, “Preserving the internet,” *Scientific American* 3, no. 276, 1997: 82-83).

25. Trevor Owens, *The Theory and Craft of Digital Preservation* (Johns Hopkins University Press, 2018), 1-2.

26. Stefano Vitali, *Passato digitale. Le fonti dello storico nell'era del computer* (Bruno Mondadori, 2004), 208.

result in the erasure of the site's digital memory²⁷.

Finally, the profound transformation of online resources and tools for historical and archival research has raised significant concerns - not only with respect to the sheer volume of available materials, but, more importantly, with regard to their quality. On the one hand, in an era increasingly characterized by a shift from providing research instruments to offering entire documentary collections through digital archival libraries, there is a growing risk that superficial digitization initiatives may neglect the indispensable role of curatorial mediation. The so-called 'syndrome of totality' risks diluting the informational value of online resources. As Valacchi warns, "if everything is an archive, then nothing is an archive anymore, at least in the historical sense of the term", thus challenging the foundations of archival practice, which rely on selective and deliberate memory processes²⁸. Addressing this challenge requires critical reflection on the motivations underpinning digitization projects, the criteria employed in the selection of sources²⁹, and the challenges and opportunities posed by digital access - ranging from technical and legal considerations to questions of intellectual property, data security, and institutional strategies. Equally crucial is the meaningful presentation and contextualization of digital resources³⁰ [Fig. 3.14].

On the other hand, the lack of standardized evaluation criteria for online archival tools has made it difficult to distinguish truly valuable platforms - those that can be considered 'genuine archives' - from the overwhelming number of sites that, despite hosting archival content, offer little actual utility for scholarly research³¹.

Fig. 3.14 Some of the main opportunities and limitations of digitizing archival documents and sharing them online.

Impacts of digitization and the World Wide Web on historical research			
Potential		Limits	
Greater quantity and variety of materials available	Increased accessibility to materials	Digitization costs	Technological obsolescence
New advanced research tools	Increased autonomy in conducting research	Web instability	Quality of online resources

27. Julien Masanès, *Web Archiving* (Springer, 2007), 153; Valacchi, "Archivi storici e risorse tecnologiche," 144.

28. Valacchi, *L'archivio aumentato*, 43-44.

29. For further discussion on the role of selection in digitization processes, see Umberto Ambrosoli, Massimo Sideri, *Diritto all'oblio, dovere della memoria. L'etica nella società interconnessa* (Bompiani, 2017), 9-10; Vitali, *Passato digitale*, 101-104.

30. Valacchi, *Diventare archivisti*, 159-165.

31. Valacchi, *Diventare archivisti*, 159-165.

Beyond the strictly technical limitations - matters that fall primarily within the competence of archival IT specialists - from the perspective of the user, that is, of those engaged in historical and documentary research increasingly supported by digital resources, the primary concern lies in assessing and analysing the quality and navigability of the materials available online.

It may therefore be useful to develop provisional classifications or taxonomies that help define the main features of the online archival landscape. This effort, however, is made without any claim to exhaustiveness and with full awareness that it would be neither possible nor credible to systematize a reality so inherently complex and fluid by nature³².

A preliminary distinction can thus be drawn between online archives, archival websites, and web repositories (or ‘invented archives’) [Tab. 3.3].

Tab. 3.3 Classification of archival resources available online.

Online archival resources		
Online archives	Archival website	Web repositories
Archives composed of born-digital or digitized documents, managed according to models that ensure authenticity, integrity, long-term preservation, accessibility, and transparency. Supported by technical and organizational infrastructures, standards, and regulations, and designed across the entire lifecycle of digital documents.	Meta-search tools, that is, tools capable of providing guidance on both the containers (archives) and their contents (fonds and documents).	Also called ‘invented archives,’ they are thematic aggregations of digital documents, created by assembling archival units originating from distinct archival contexts and documentary systems.

The online archive is a complex phenomenon, whether viewed as the digitization of existing collections or the creation of born-digital collections on the web. In these cases, the web amplifies both opportunities and challenges associated with digitization and electronic documents, including fundamental issues such as the concept of the archive, authenticity, and access rights³³.

Archival websites can be defined as meta-research tools, providing guidance at multiple levels regarding archives and their collections, for

32. Federico Valacchi, “Contentitori e contenuti. L’offerta archivistica nel web,” *Archivi* IV, no.1 (2009): 35.

33. Valacchi, *Diventare archivisti*, 160.

example, the procedures for accessing an archive, the availability of online inventories, or even the possibility of consulting individual documents directly over the web.

Regarding archival websites, Valacchi suggests a more detailed categorization based on the type of information they provide access to. He identifies two main categories: meta-informational and informational resources³⁴ [Fig. 3.15].

The former - such as institutional portals and government websites - serve primarily as reference tools, offering general guidance on archival access (e.g., addresses, opening hours, regulations) and providing an overview of the archival landscape³⁵. Meta-informational resources allow, or should allow, users to take an initial step toward identifying their areas of interest while also offering the opportunity to understand how the institutional and cultural system in which they operate is organized³⁶. These include general-interest portals like the *Ministero italiano della cultura* website, *CulturaItalia*, *Archivi*, della *Direzione Generale*, and dedicated portals like ICAR (*Istituto Centrale degli Archivi*), which, while not always suited for in-depth research, offer valuable regulatory, bibliographic, and standardization information.

Fig. 3.15 Classification of archival websites based on the level of detail of the information provided.

Online archival resources		
Online archives	Archival website	
	meta-informational “There is this archive”	informational “This archive holds”
	general-interest portals	simple informational websites
	dedicated portals	summary websites
		static descriptive websites
		dynamic descriptive websites
		complete websites

34. This classification focuses primarily on the content provided by websites, without considering the canonical and legal criteria used for scholarly evaluation, that is how it is organized, maintained, or delivered (Valacchi, *Diventare archivisti*, 160-161).

35. Valacchi, *Diventare archivisti*, 161-162.

36. Valacchi, “Archivi storici e risorse tecnologiche,” 135.

By contrast, informational resources are those that delve into the substance of archival collections. Rather than simply identifying the existence of an archive, they provide insight into its actual contents. This category is diverse, encompassing both centralized systems and smaller institutional sites, each offering varying levels of detail and functionality. For this second category, Valacchi proposes a further classification based on the effectiveness of the search function and the structure of navigation. He identifies five principal types: informational, summary, static descriptive, dynamic descriptive, and comprehensive websites. These classifications reflect differing levels of archival description and user interaction, from basic overviews to full-text searchable databases, and are essential for evaluating the research value of digital archival platforms.

The following section presents an evaluation of various informational resources based on the services offered, carried out according to a set of parameters rated on a scale from 0 (inadequate) to 5 (excellent). The qualitative parameters used to evaluate the informational resources are:

- A. The extent and specificity of the information presented on the website concerning the archive or the preservation institution that holds the digital or digitized collections. The rating scale ranges from 0, indicating a minimal amount of information sufficient only to access and identify the preservation institution, to 5, representing a comprehensive and detailed informational overview of the archive.
- B. The details of the information provided regarding the archive's collections. Ratings range from 0, indicating only basic, general information about the archive's contents, to 5, representing comprehensive and contextually detailed information on individual archival units.
- C. The opportunities for conducting simple or advanced searches directly online, a parameter closely related to the volume of archival documents accessible on the website. The rating scale ranges from 0, indicating minimal online search capability due to only general information being available about the archived materials, to 5, where the availability of entire archival collections online allows research to be conducted fully from one's workstation.
- D. The educational and dissemination function of the website, that is, its role as a resource capable of conveying the rich cultural content that characterizes archival institutions. The evaluation scale ranges from 0, indicating resources serving strictly scientific and archival

research purposes, to 5, representing a resource accessible not only for scholarly research but also for dissemination and educational activities.

Although this taxonomy is subjective, certainly not exhaustive, and in some respects outdated, it still offers a valuable framework for assessing the evolving role of digital platforms in archival access. Below is a table presenting the description and qualitative evaluation of the various types of information resources [Tab. 3.4].

Tab. 3.3 Qualitative comparison of the main types of informational resources.

Informational resources		
Simple informational websites		
Definition and characteristics Informational websites serve as basic web presences for archival institutions. Their function is largely declarative, providing minimal data such as institutional location, contact details, and general archival holdings. These sites are often limited in their research utility.	A. Information on the archive	●●○○○
	B. Information on archival fonds	●○○○○
	C. Search capabilities	○○○○○
	D. Educational and dissemination functions	○○○○○

Example

Archivio Diocesano Tridentino
<https://www.diocesitn.it/area-cultura/category/servizio-archivio/>



← Torna a Chiesa di TRENTO

CHIESA DI TRENTO

Area Cultura

Home

Chi siamo

Archivio Diocesano Tridentino

Biblioteca Diocesana Vigilantium

Formazione

Didattica

Testimonianza e Impegno sociale

Annuncio e Sacramenti

Cultura

Amministrazione

Patrimonio

I principali fondi che costituiscono l'Archivio Diocesano Tridentino sono Archivio della Curia vescovile, composto dalla documentazione dell'Ordinariato vescovile e dagli Atti dei vescovi, e l'Archivio del Capitolo della Cattedrale. Accanto a questi trovano collocazione anche gli archivi degli enti ecclesiastici dipendenti dall'autorità diocesana e archivi di enti e persone a vario titolo legate al mondo cattolico trentino. Presso l'Archivio Diocesano Tridentino sono depositati anche alcuni archivi parrocchiali che erano privi di una collocazione adeguata.

1. Archivio della Curia vescovile (1307-1989)

2. Archivio della Mensa vescovile (1375-1961)

3. Archivio del Capitolo della Cattedrale (1060-1989)

4. Archivio famiglia conti Alberti Poia (sec. XV-XX)

5. Azione Cattolica Italiana ' sezione di Trento (1898-1979)

6. Sezione provinciale delle ACLI trentine (1940-1998)

7. Archivio Partito Democrazia Cristiana ' Comitato regionale del Trentino Alto Adige (1948-1992)

8. Archivio Partito Democrazia Cristiana ' Comitato provinciale di Trento (1945-1992)

Dal 1996 presso l'Archivio Diocesano Tridentino è conservata anche la biblioteca del Capitolo della Cattedrale di Trento.

119

Summary websites

Definition and characteristics

Summary websites represent a modest improvement, offering logistical information alongside basic descriptions of archival holdings. They often include fund names, dates, and extents, sometimes reaching the series level, though they typically lack contextual metadata or advanced search capabilities.

- A. Information on the archive ●●●●○
- B. Information on archival fonds ●●●○○
- C. Search capabilities ●○○○○
- D. Educational and dissemination functions ○○○○○

Example

Archivio fotografico storico provinciale

<https://www.cultura.trentino.it/Luoghi/Tutti-i-luoghi-della-cultura/Archivi/Archivio-fotografico-storico-provinciale>



Static descriptive websites

Definition and characteristics

Static descriptive websites mark a turning point, functioning as genuine research tools. They often replicate paper-based finding aids in digital form, such as downloadable PDFs or navigable HTML pages. Despite their limited interactivity, they allow detailed consultation of archival units.

- A. Information on the archive ●●●●●
- B. Information on archival fonds ●●●●○
- C. Search capabilities ●●●○○
- D. Educational and dissemination functions ●○○○○

Example

Archivio del MuSe (Museo delle Scienze di Trento)

<https://www.muse.it/la-biblioteca/archivi/>**Dynamic descriptive websites****Definition and characteristics**

Dynamic descriptive websites integrate interactive tools and enable multidimensional navigation through archival systems. They function as genuine archival information systems for users, yet within familiar frameworks and interfaces. In this context, the website acts as a true digital simulation of the archival institution, allowing users to explore independently while following a carefully structured pathway.

A. Information on the archive



B. Information on archival fonds



C. Search capabilities



D. Educational and dissemination functions

**Example**

CIM (Catalogo Integrato del Mart)

<https://cim.mart.tn.it/cim/pages/>

Complete websites

Definition and characteristics

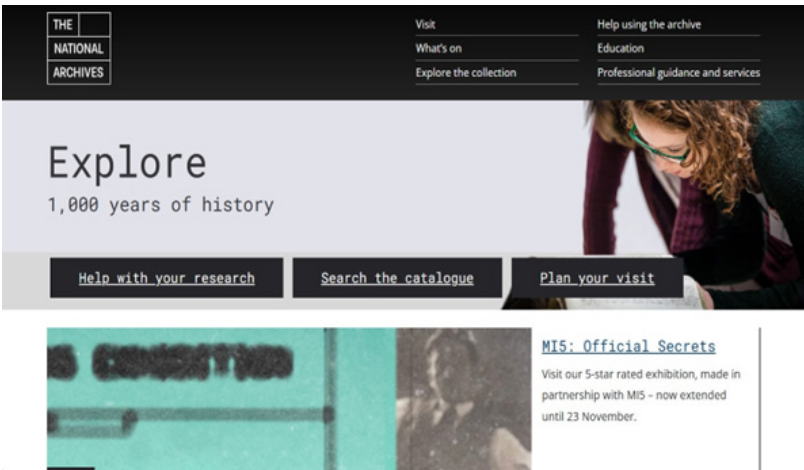
Complete websites go beyond facilitating research - they deliver entire digital collections, enabling users to perform full-scale research remotely. A complete archival website should provide online access to documents, ensure coherence and reliability, offer advanced digital tools, and present documentary collections within a consistent and contextualized framework for consultation and interpretation. It should be a tool that recreates the archive in a digital environment, enabling the full transmission of the rich cultural content inherent in archival institutions, and opening up not only to scholarly research but also to dissemination and education.

- A. Information on the archive ●●●●●
- B. Information on archival fonds ●●●●●
- C. Search capabilities ●●●●●
- D. Educational and dissemination functions ●●●●○

Example

The National Archives (UK)

<https://www.nationalarchives.gov.uk/>



Finally, a web repository can be defined as an aggregation of digital objects, of various formats and types, generally detached from their original creators and reassembled through a distinctly subjective process. Its structure is shaped by relationships that arise from representational intentions rather than from the archival bond. For these reasons, it takes the name ‘invented archive’.

Information is organized according to a collection tree model, but instead of traditional hierarchical models, it adopts alternative forms such as typological structures (art, video, audio, and so on). While the bond

traditionally arises from the necessary and often unconscious sequence of documentary production, in this emerging type of bottom-up archives, the perspective actively forges connections among documents to support a deliberate reflection on actions and their consequences. Contextualization, in this sense, entails accounting for the profile and motivations of the aggregating subject, thereby clarifying the intellectual and creative rationale behind the act of invention itself. Ultimately, the invented archive never fully becomes a historical archive: it circulates within the web, remains perpetually open to further contributions, and resists any attempt at definitive crystallization³⁷.

Within the broad domain of web repositories, two main categories can be identified, distinguished by their approach to managing digital archival resources and by their objectives: collections, whose primary purpose is to collect, preserve, and disseminate digital resources; and tools, which go beyond the mere collection of historical information by re-elaborating it to create online instruments that support and guide historical research [Fig. 3.16].

The *September 11 Digital Archive* is one of the most emblematic examples of ‘collection’ repository, a web repository that took shape from the emotional wave triggered by the attacks on New York’s Twin Towers in 2001³⁸.

Fig. 3.16 Classification of web repositories according to their strategies for managing and organizing digital archival resources.

Online archival resources			
Online archives	Archival website	Web repositories	
		Collections Organizing information	Tools Process information
		simple collection	
		participatory archives	
		living archives	

37. Federico Valacchi, “Se l’archivio è artificiale. Verso uno ius archivi partecipativo?,” *AIDAinformazioni. Rivista semestrale di scienze dell’informazione* 41, no. 1-2 (Cacucci editore, 2023): 159, <https://doi.org/10.57574/596529288>.

38. The September 11 Digital Archive. Saving the histories of September 11, 2001, accessed May 1, 2026, <https://911digitalarchive.org/>.

“The *September 11 Digital Archive* uses electronic media to collect, preserve, and present the history of the September 11, 2001 attacks in New York, Virginia, and Pennsylvania and the public responses to them. Initially funded by a major grant from the Alfred P. Sloan Foundation [...], the Archive is contributing to the on-going effort by historians and archivists to record and preserve the record of 9/11 by collecting and archiving first-hand accounts, emails and other electronic communications, digital photographs and artworks, and a range of other digital materials related to the attacks. The Archive is also using these events as a way of assessing how history is being recorded and preserved in the twenty-first century and as an opportunity to develop free software tools to help historians to do a better job of collecting, preserving, and writing history in the new century”. The goal is “to create a permanent record of the events of September 11, 2001. To these ends the Archive has partnered with the Library of Congress, which in September 2003 accepted a copy of the Archive into its permanent collections - an event that both ensured the Archive’s long-term preservation and marked the Library’s first major digital acquisition”³⁹. Regarding the rights management of materials in the archive, the site administrators advise users to “be aware that the original contributors maintain copyright over all objects”⁴⁰, as they are no longer able to provide a referral service to secure these rights.

Among the so-called ‘invented archives’ are also participatory archives such as the *Ukraine War Archive*⁴¹, which emerged in response to the emotional impact of the war to collect testimonies of crimes attributed to Russian forces. Beyond any political stance, this marks the rise of a new archival movement, distinguished by the immediacy and richness of the data being gathered. This heterogeneous body of information turns the archive into a tool of real-time testimony, overcoming the traditional asynchronicity of historical archives⁴². “Although the concept of a ‘participatory archive’ is related to the concept of ‘community archives’, a key distinction is that more than one community (for example, one or more source communities, a judicial community, an academic community, the professional archival community) are si-

39. “About,” The September 11 Digital Archive. Saving the histories of September 11, 2001, accessed May 1, 2026, <https://911digitalarchive.org/about>.

40. “About”.

41. Ukraine War Archive. The largest independent multi-media archive of Russia’s war in Ukraine, accessed May 1, 2026, <https://ukrainewararchive.org/eng/>.

42. Valacchi, *L’archivio aumentato*, 108-109.

multaneously and explicitly involved in and responsible for the creation, management and use of a participatory archive. In other words, the concept of a participatory archive acknowledges that multiple parties have rights, responsibilities, needs and perspectives with regard to the archives. Participatory archives consequently become a negotiated space built around critical reflection in which these different communities share stewardship and expertise - they are created by, for and with multiple communities, according to and respectful of community values, practices, beliefs and needs”⁴³.

In recent years, within the broader category of ‘collection’, the concept of the living archive has become increasingly relevant in the fields of contemporary art, digital humanities, and participatory memory practices. As defined by Sabiescu, “living archives refer to practices and environments that connect the organisation, curation and transmission of memory with present-bound creative, performative, and participatory processes”⁴⁴. The components of a living archive are dynamic and continuously updated, thanks to the involvement of the community that inhabits it and sustains its existence. “The term Living Archive refers to an inclusive and never complete set, in which the archivist is an active participant in the construction of the collective history present in the archive itself. The term ‘living’ means present, incessant, continuous, unfinished, and open, it is closely linked to the concept of tradition”⁴⁵. This evolving archive exemplifies an active and participatory approach to documentary practice, reflecting a widespread imperative for information sharing. It critically engages with professional ethics, challenging and redefining its boundaries and objectives, and is underpinned by a pronounced collaborative ethos⁴⁶.

A notable example is *Interference Archive*⁴⁷, whose mission is “to explore the relationship between cultural production and social movements. This work manifests in an open stacks archival collection, publications,

43. Anne J. Gilliland, and Sue McKemmish, “The Role of Participatory Archives in Furthering Human Rights, Reconciliation and Recovery,” *Atlanti: Review for Modern Archival Theory and Practice*, no. 24 (2014): 78-88.

44. Amalia G. Sabiescu, “Living Archives and The Social Transmission of Memory,” *Curator*, no. 63 (2020): 497-510, <https://doi.org/10.1111/cura.12384>.

45. Giulia Cardoni, Francesca Fabbri, and Alessandro Iannucci, “The Digital Living Archive and the construction of a participatory cultural memory in the DARE-UIA project (Digital Environment for collaborative Alliances to Regenerate urban Ecosystems in middle-sized cities),” *Archives* 11, no. 2 (2022): 351-380, <https://doi.org/10.6092/issn.2283-9364/16278>.

46. Federico Valacchi, “The Season of Living Archives: a Generative Provenance,” *JLIS* 15, no. 2 (2024): 52-60, <https://doi.org/10.36253/jlis.it-597>.

47. Interference Archive, accessed May 1, 2026, <https://interferencearchive.org/>.

a study center, and public programs including exhibitions, workshops, talks, and screenings, all of which encourage critical and creative engagement with the rich history of social movements”⁴⁸.

To date, a wide range of web repository initiatives has been developed, assuming diverse forms, particularly when the simple collection and dissemination of documents is complemented by advanced technological applications. Such developments have given rise to fully-fledged online tools that, by collecting and processing archival information, facilitate the creation of innovative and meaningful research pathways. These initiatives frequently emerge from grassroots efforts, are supported by various institutions, encompass a broad spectrum of historical themes, and operate across different scales.

With regard to the built historical heritage, at the local level, for instance, the *TOTEM. 4D Trento Time Machine* project⁴⁹, developed by Fondazione Bruno Kessler, represents a noteworthy example. The *TOTEM* project, funded by Fondazione Cassa di Risparmio di Trento e Rovereto, focuses on the city of Trento (Italy) and “aims to use and valorize historical data (especially maps and photos) preserved in the local archives and make them explorable through advanced ICT solutions. *TOTEM* proposes a multi-temporal exploration of historical data, testing and developing several AI-based solutions to enhance the historical value of archives sources”⁵⁰. It is therefore not merely a web repository, but rather an online platform that interprets and utilizes archival documents to promote a series of research-support services, including those based on the application of artificial intelligence. More specifically, the project develops and deploys “advanced ICT solutions for using, valorizing, visualizing, studying, analysing and communicating historical data, such as: machine learning methods to predict building heights in historical maps; deep learning methods to colorize historical images; re-photographing solutions to geo-reference historical photos and overlay them with actual images; deep learning techniques for creating 3D effects on historical images; AR visualization on smartphones and tablets. *TOTEM* [...] offers the opportunity to visit the city of Trento (Italy) of the last 150 years, reading the urban transformations in the reconstructive 3D cities and visualizing and comparing historical photos

48. Interference Archive.

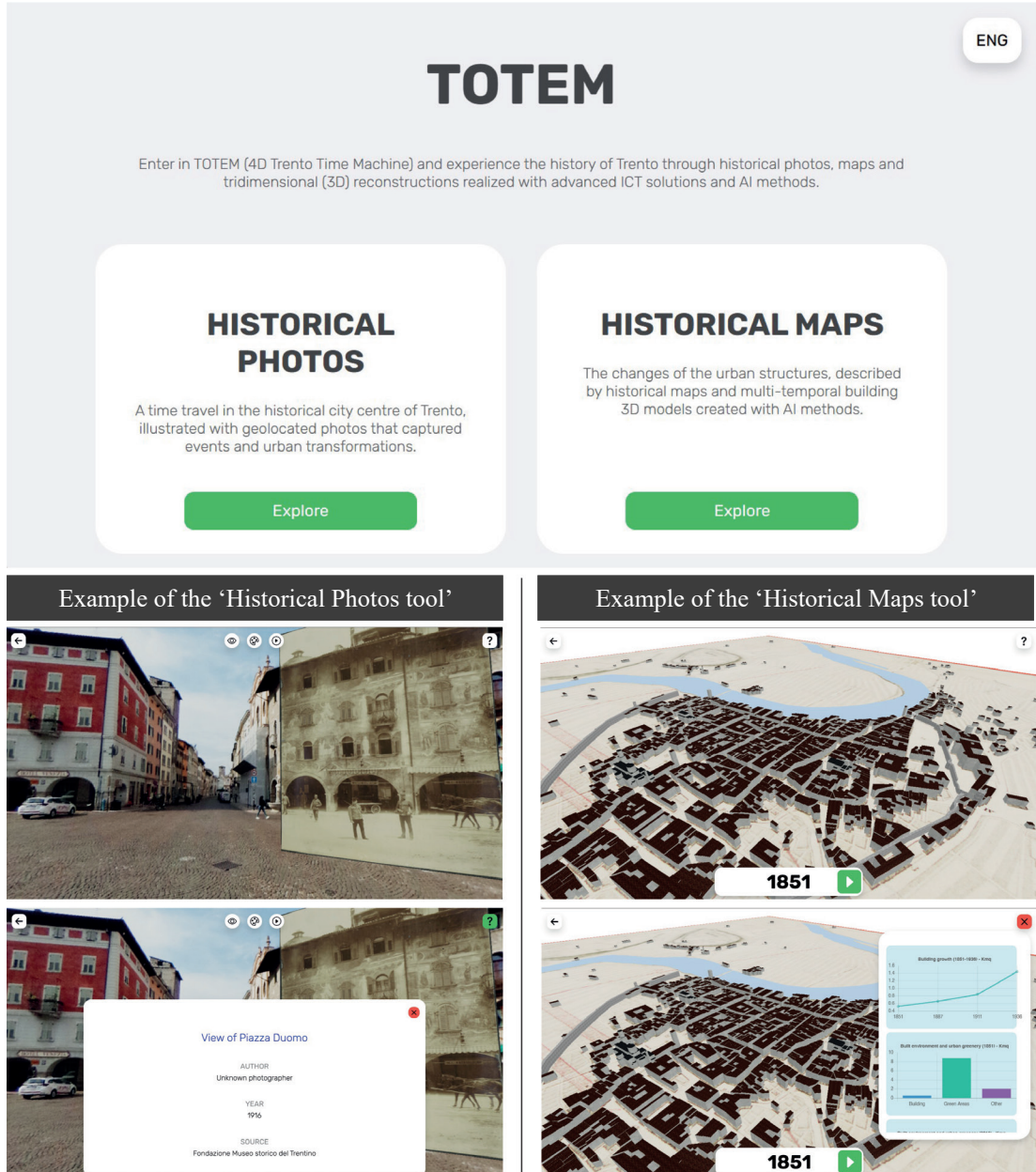
49. TOTEM. 4D Trento Time Machine, accessed May 1, 2026, <https://totem.fbk.eu/>.

50. TOTEM. 4D Trento Time Machine.

Fig. 3.17 Main interface of the TOTEM 4D portal. On the left: example of the Historical Photos function; on the right: example of the Historical Maps function.

with actual situations”⁵¹.

Although the project demonstrates an interesting and engaging approach to the dissemination of archival materials - particularly iconographic ones - through user-friendly navigation and an innovative application of artificial intelligence, the tool remains of limited utility for conducting archival research. This limitation stems from several factors [Fig. 3.17].



51. TOTEM. 4D Trento Time Machine.

First, the strong subjectivity that characterizes both the pronounced thematic selection of archival materials and their interpretation reduces the research potential. Second, the emphasis on simple navigation and public outreach may have taken precedence over the proper contextualization of the documents. Indeed, the archival references provided are often summary and general, lacking adequate description and interoperability with the relevant archives. Finally, although the historical documents are displayed, their use is constrained by the pre-defined presentation modes offered by the website; it is therefore not possible to download or engage with the materials independently.

In conclusion, the *TOTEM* project proves to be a highly effective tool for dissemination purposes, yet it remains limited in terms of its usefulness for historical and documentary research.

At the national level, two other significant examples of web repositories stand out for their approach and innovation: *Treviso Urbs Picta* and the *Naples Digital Archive*.

The *Treviso Urbs Picta* project is a collective and multidisciplinary research initiative launched by Fondazione Benetton in 2011. It focuses on Treviso as a ‘painted city’, aiming to identify and study the iconographic and stylistic features of frescoed façades and other decorated buildings within the city walls from the 13th to the 21st century.

Based on bibliographic and archival sources, as well as extensive field surveys, the research led to a new dating and cataloguing of existing and lost frescoed buildings, and to the creation of a synchronic and diachronic topographic map of the city’s painted heritage. The project also advances proposals for the preservation and enhancement of this cultural legacy [Fig. 3.18].

A major outcome of this work is the collective book *Treviso urbs picta. Facciate affrescate della città dal XIII al XXI secolo: conoscenza e futuro di un bene comune*⁵². Complementing the publication is the online database⁵³, which documents 614 frescoed buildings - both extant and lost - through images, historical and stylistic data, and information on their conservation status. The database integrates research data with historical and contemporary maps (from the 1811 Napoleonic cadastre to current orthophotos), enabling users to generate thematic maps and

52. Rossella Riscica, and Chiara Voltarel, ed., *Treviso urbs picta. Facciate affrescate della città dal XIII al XXI secolo: conoscenza e futuro di un bene comune* (Fondazione Benetton Studi Ricerche - Antiga, 2017).

53. Treviso Urbs Picta, accessed May 1, 2026, <https://trevisourbspicta.fbsr.it/>.

conduct complex queries through 20 searchable filters. Each record is geolocated, allowing the identification of every façade and the exploration of the historical and collective memory embedded in Treviso's painted heritage.

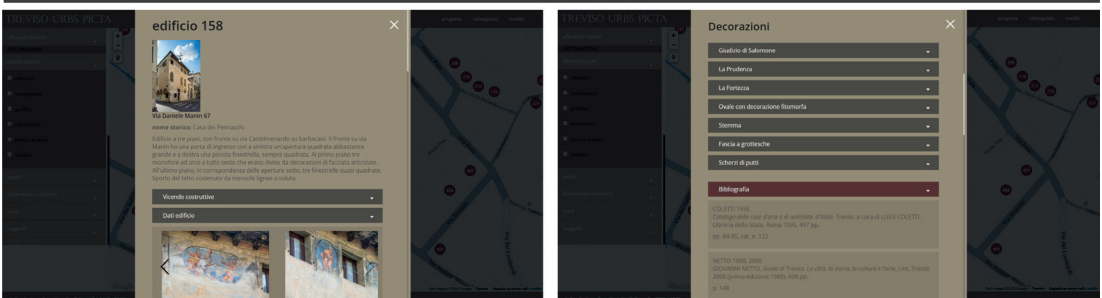
The *Treviso Urbs Picta* database is a highly intuitive tool which, although thematically limited, can serve as an initial aid for guiding historical and documentary research, especially thanks to the extensive bibliography provided for each building. However, the archival documents available on the portal are limited to buildings that no longer exist and, when present, only a photograph of the document is provided along with general information about its place of preservation.

Another significant example of a web repository for the study of built heritage and the city is the *Naples Digital Archive. Moving Through*

Fig. 3.18 Main interface of the *Treviso Urbs Picta* portal. At the bottom: typical record of a building catalogued and mapped in the system.



Example of a mapped building record



*Time and Space*⁵⁴, a project developed by the Centro Interdipartimentale di Ricerca sull'Iconografia della Città Europea (CIRICE) at the Università degli Studi di Napoli Federico II, in collaboration with the Bibliotheca Hertziana.

The project focuses on the Naples' historical iconography from the early modern to the contemporary period, integrating urban imagery, historical maps, and guidebooks into a multilayered digital platform. Drawing on a rich corpus of cartographic sources - from the sixteenth to the twentieth centuries - georeferenced and linked to archival documents, it offers a critical and digital reinterpretation of the city's history. A key contribution is the reconstruction of the *Viceroyal Map*, representing Naples' urban fabric between the mid-sixteenth and early eighteenth centuries. Based on pre-cadastral maps produced under Spanish and Austrian rule, this map is digitized and georeferenced to create an expandable historical survey enriched with graphic, textual, and hyper-textual data. The resulting open-access digital platform serves as an evolving archive, connecting urban and architectural scales⁵⁵. "This enables the user to grasp the urban development of Naples from a new perspective. At the same time, this analysis is used as a basis for a critical examination of historical representation methods and their digital processing"⁵⁶.

More than a simple web repository, the platform functions as a research tool supporting historical inquiry. Despite its occasionally complex navigation, due to the abundance of content and features, it offers multiple functions such as searches on georeferenced maps or through toponym lists, and detailed viewing of archival documents [Fig. 3.19]. The platform's most significant strength lies in its multilayered digital system, which integrates cartographic, iconographic, archival, and textual sources within a structured and interoperable framework. Historical maps are georeferenced, enabling each element to be associated with precise spatial coordinates. Buildings and architectural complexes are described through structured records with standardized fields such as name, period, source, location, and bibliographic references. Moreover, archival documents and historical guidebooks are semantically linked to the

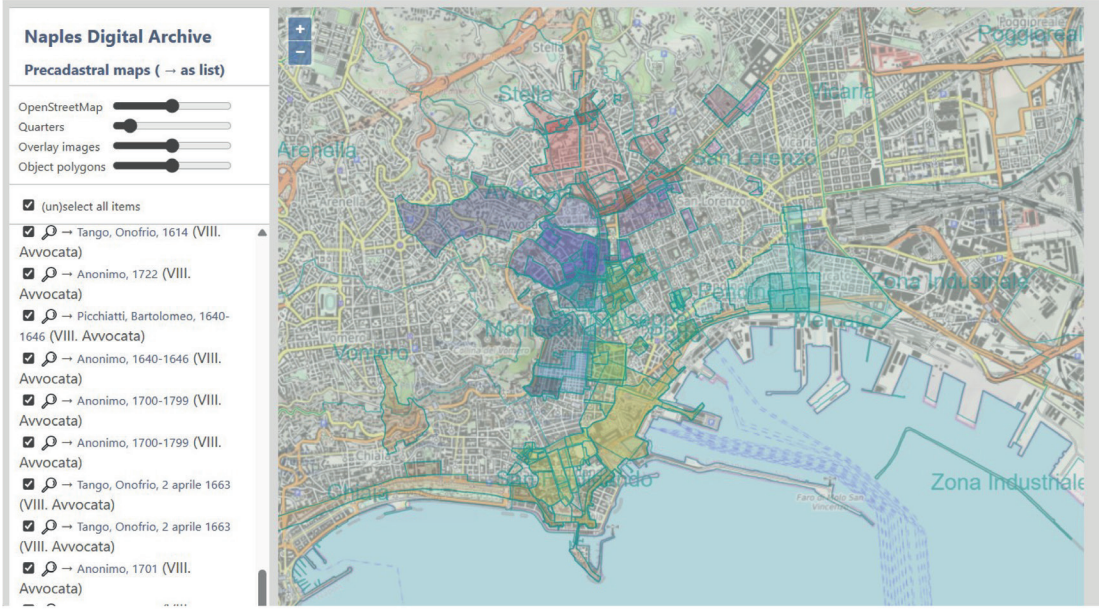
Fig. 3.19 Main interface of the *Naples Digital Archive*. At the bottom, some of the portal's principal research functionalities: searching for a building directly on the map (i) or through a list (ii); the building record with archival and bibliographic information (iii); and dynamic visualisation of digitized archival documents.

54. "Naples Digital Archive. Moving Through Time and Space," CIRICE, accessed May 1, 2026, <https://www.iconografiacitta europea.unina.it/cms/naples-digital-archive-2/>.

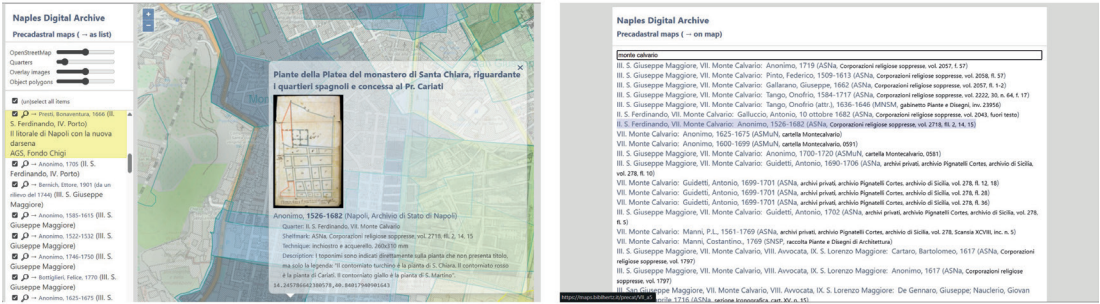
55. "Naples Digital Archive. Moving Through Time and Space," CIRICE; "Naples Digital Archive. Moving Through Time and Space," Bibliotheca Hertziana, accessed May 1, 2026, <https://www.bibl hertz.it/en/dept-michalsky/naples-digital-archive>.

56. "Naples Digital Archive. Moving Through Time and Space," Bibliotheca Hertziana.

relevant buildings and urban areas through an internal gazetteer. This structured approach enables users to cross-search maps, buildings, and texts, visualise urban development across historical layers, and supports interoperability with other digital archives and GIS, offering an extensive tool for studying Naples' urban and documentary history.

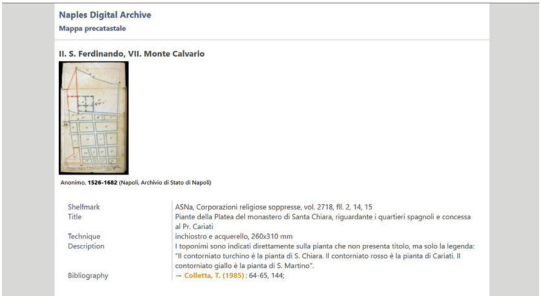


Website's key features concerning architectural complexes



i) Search on the georeferenced map.

ii) Search through the list of mapped architectural complexes.



iii) Record of the architectural complex.

iiii) Detailed display of archival documents.

03.2.1 In-depth study & experiences

Information Technology for historical research: exploring

Trento's public works through static and interactive maps

Project title	<i>Geopandas</i> and <i>Folium</i> for historical research: explorable maps.
Course	Information Technology for Planning, Architectural Design and Built Environment Management (a.y. 2021/2022), Politecnico di Milano.
Professors	prof. Luciano Baresi, prof. Giovanni E. Quattrocchi.
SSD Code	ING-INF/05
Link to the course	<u>050760</u>

Introduction

The course “Information Technology for Planning, Architectural Design and Built Environment Management” at the Politecnico di Milano, coordinated by Luciano Baresi and Giovanni Ennio Quattrocchi, aims to provide fundamental concepts of computer science, with a particular focus on programming and data modelling, and to demonstrate their application in the field of Building Information Modelling (BIM). Specifically, the course introduces the core principles of programming and data management, with emphasis on Python¹, an interpreted, object-oriented, high-level programming language widely used in scientific research and spatial analysis.

The integration of computational methods into humanistic disciplines offers powerful tools for digitizing, analyzing, and visualizing historical data. This section presents the project entitled ‘Geopandas and Folium for historical research: explorable maps’, conceived to employ Python for the investigation of urban transformations in the city of Trento during the nineteenth century.

The research originates from traditional archival analysis of public works - including the construction and renovation of streets, squares, and buildings - and aims to translate this historical data into digital, explorable cartographic representations. Starting from the heterogeneous cartographic and iconographic materials collected during the documentary research on the city of Trento² [Fig. 3.20], the objective is to pro-

1. Python, accessed May 1, 2026, <https://www.python.org/>.

2. See chapter 06 of the present thesis.



Fig. 3.20 Some examples of archival documents used for research and for the project. From the top left, moving to the right: (i) Vincenzo Zucchelli, *Piano di situazione degli stabili Sizzo e Gruber, via di San Bernardino e relativo progetto di strade*, November 22, 1890 (ASCTn, 3.8 – VII.73.1890); (ii) Giuseppe P. Dal Bosco, *Pianta della piazza Maggiore con idea di lastricatura in pietra* (ASCTn, 3.8 – XI.363.1843); (iii) Annibale Apollonio, *Progetto di massima delle Caserme militari da erigersi a Trento*, May 23, 1881 (ASCTn, 3.8 – X.40.1880); (iiii) *Il Tribunale*, 1893 (BDTn, TI1f137).

duce both static and interactive maps capable of visualising the spatial distribution of urban transformations across different historical periods, along with the digitized archival documents related to these works.

Method

The project was implemented using Python as the core programming language, with Anaconda³ serving as the package manager and Visual Studio Code⁴ as the development environment. The methodological approach was divided into two distinct, yet complementary, stages to achieve different levels of map exportability and interactivity: the creation of a static map for data plotting (A) and the development of an interactive map for deep data exploration (B).

Python’s structure, composed of modules, statements, and expressions, facilitates modular programming. Dynamic typing and built-in data structures (lists, dictionaries, tuples) enable efficient manipulation of large datasets such as CSV archives used in this project. The functionality of the system is entirely dependent on the specific roles played by a stack of specialized Python libraries, as detailed below.

3. Anaconda, accessed May 1, 2026, <https://www.anaconda.com/>.
 4. “The open source AI code editor,” Visual Studio Code, accessed May 1, 2026, <https://code.visualstudio.com/>.

A. Static map implementation

The first phase of the project focused on the development of static maps aimed at visualizing the nineteenth-century public works in the city of Trento. This part was implemented through the combined use of several Python libraries, primarily GeoPandas⁵, PyProj⁶, Shapely⁷, Pandas⁸, and Matplotlib⁹ [Fig. 3.21]. Each of these played a specific and complementary role in the construction of a spatially accurate and visually coherent representation of the urban fabric.



A.1 Creation of the base map

The process began with the creation of a base map derived from the official technical cartography of the Municipality of Trento, downloaded in the form of a shapefile. The shapefile format, commonly used in geographic information systems (GIS), allows for the storage of both geometric features and attribute data, providing a suitable foundation for spatial analysis. The file was imported into the Python environment using GeoPandas, a library that extends the capabilities of Pandas to handle geometric data.

Once imported, it was essential to define a consistent coordinate reference system to ensure that all subsequent geospatial data could be correctly aligned. This was accomplished through the PyProj library, which enabled the specification of the EPSG:25832 coordinate system, a standard projection widely used for mapping in Northern Italy. This step ensured that both the base map and the additional da-

Fig. 3.21 The main steps in developing the base map and the Python libraries employed at each stage.

5. GeoPandas, accessed May 1, 2026, <https://geopandas.org/en/stable/>.
6. PyProj, accessed May 1, 2026, <https://pyproj.org/project/pyproj/>.
7. Shapely, accessed May 1, 2026, <https://pypi.org/project/shapely/>.
8. Pandas, accessed May 1, 2026, <https://pandas.pydata.org/>.
9. Matplotlib, accessed May 1, 2026, <https://matplotlib.org/>.

Importing the Geopandas library for reading the shapefile

```
2 import geopandas as gpd
10 CTshp = './Shape file/CartaTecnicaTrento.shp'
21 basemap = gpd.read_file(CTshp)
```

Setting the coordinate system with PyProj (EPSG=25832)

```
6 from pyproj import CRS
22 basemap_geo = basemap.to_crs(epsg=25832)
```

Import of Matplotlib and setting plotting parameters

```
4 import matplotlib.pyplot as plt
24 fig, ax = plt.subplots(figsize = (17, 17))
25 ax.axis('off')
26 basemap_geo.plot(ax=ax, column='tipo', cmap="GnBu", legend=True)
```

Plotting the map...

```
46 plt.show()
```



Fig. 3.22 The main steps in developing the base map using Geopandas.

tasetts would share a common spatial framework, allowing accurate overlay and distance computation.

The visualization of the map was handled with Matplotlib, which allowed for the customization of graphical parameters such as colors, labels, and legend visibility. Through a series of adjustments in plotting style, a clear and aesthetically balanced static representation of the city was produced, serving as the foundation for further spatial operations [Fig. 3.22].

A.2 Historical data preparation

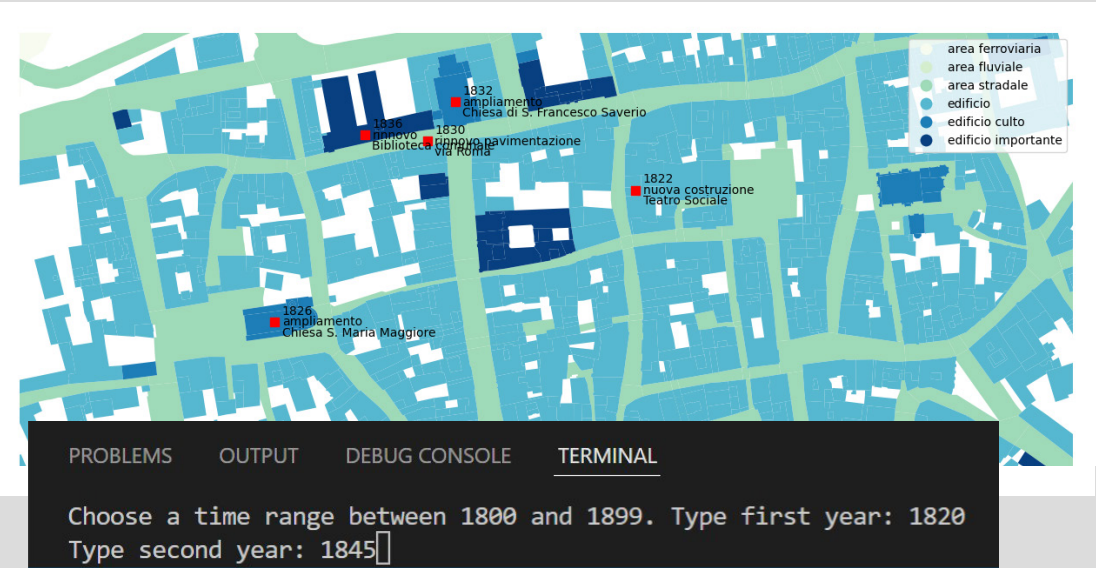
The second stage of the static mapping process involved the georeferencing of the main public works undertaken in Trento during

the nineteenth century. A CSV file was prepared containing essential information for each project, including the name of the work, its typology (such as street, square, or building), its geographical coordinates, and the year of intervention. The dataset was imported into Python as a ‘DataFrame’ using Pandas, then transformed into a ‘GeoDataFrame’ through GeoPandas and Shapely. The latter library played a key role in defining the geometric properties of the dataset by converting numerical coordinate pairs into geometric points located precisely on the map.

A.3 Static rendering

The integration of this dataset with the previously generated base map enabled the plotting of the public works directly on the city’s layout. To enhance the analytical dimension of the map, a custom Python function named ‘geo_year’ was developed. This function allows users to specify a temporal range, defined by a starting and an ending year, and automatically filters and visualizes only those works completed within that interval. The resulting tool not only improved the interpretative depth of the visualization but also facilitated a comparative reading of urban evolution across different historical phases. The outcome of this phase was a series of static maps capable of representing, with both geographical precision and temporal specificity, the major infrastructural transformations that shaped the city of Trento during the nineteenth century [Fig. 3.23].

Fig. 3.23 The function allows the user to choose the desired time period.



B. Interactive map implementation

While static maps provided a clear and rigorous representation of spatial data, the project also aimed to create a more engaging and dynamic tool capable of fostering user interaction and exploration. This objective led to the second phase of the work: the development of an interactive map based on Folium¹⁰, a Python library that serves as a bridge between Python’s data-processing capabilities and the JavaScript-based Leaflet.js¹¹ mapping framework [Fig. 3.24].

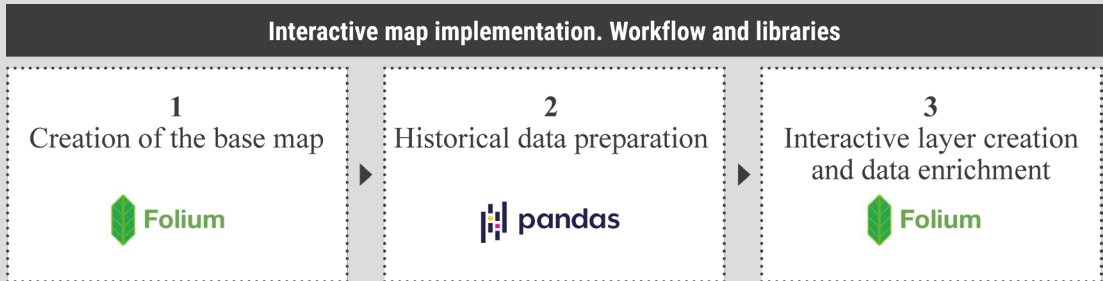


Fig. 3.24 The main steps in developing the interactive map and the Python libraries employed at each stage.

B.1 Creation of the base map

The interactive map was conceived as an evolution of the static version, enabling users to access and explore spatial information directly through a web browser. The first step consisted of defining a customized base map using Mapbox¹², a web-based cartographic platform that allows users to design and export map styles. By integrating the Mapbox API within Folium, a digital map centered on the city of Trento was generated, with an appropriate zoom level and visual style that enhanced the legibility of urban structures.

B.2 Historical data preparation

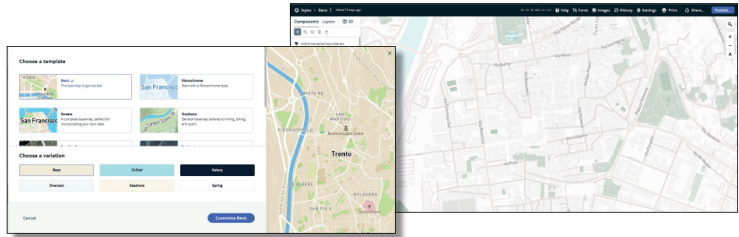
Once the base map was established, the georeferencing of public works was performed again using data from a CSV file, this time structured to support interactivity. The file was read into a Pandas ‘DataFrame’, and a Python for loop was used to iterate through each row of the dataset [Fig. 3.25].

10. Folium, accessed May 1, 2026, <https://python-visualization.github.io/folium/latest/>.

11. Leaflet, accessed May 1, 2026, <https://leafletjs.com/>.

12. “Maps that do more,” Mapbox, accessed May 1, 2026, <https://www.mapbox.com/>.

Editing the style of the base map using Mapbox



Importing Folium and creation of the map (m)

```
8 import folium
51 m = folium.Map(location=[46.06726, 11.12144],
52                 zoom_start=15,
53                 tiles='https://api.mapbox.com/styles/v1/annamagragno/c131vcb26002t14mw6943sf3c/tiles/256/{z}/{x}/{y}@2x?access_token=pk.eyJ1Ijo1YW5uYW1hcmFnbm8iLCJhIjo1Y2wzbnQ5OGhkMGg2dDNrbThzc3ljdw53MyJ9.18Gf6CIPiY03H0MwGC0MzA',
54                 attr='pk.eyJ1Ijo1YW5uYW1hcmFnbm8iLCJhIjo1Y2wzbnQ5OGhkMGg2dDNrbThzc3ljdw53MyJ9.18Gf6CIPiY03H0MwGC0MzA',
55                 control_scale=True)
56
```

From a csv file, creation of a DataFrame (df2) with Pandas

```
1 import pandas as pd
12 LP2csv = './CSV/LavoriPubblici2.csv'
58 df2 = pd.read_csv(LP2csv)
```

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Nome	Tipologia	Longitudine	Latitudine	Anno1	Text1	Anno2	Text2	Anno3	Text3							
2	Castello del Buonconsiglio,edificio,46.07166336458977,11.12703511964667,1809,Costruzione bastione meridionale,1820,Sopraelevazione ala ovest,1857,Alzamento cinta muraria																
3	Chiesa S.M. Maggiore,edificio culto,46.06865052942783,11.119645640814433,1826,Rinnovo volta,1846,Ampliamento cappella meridionale,1881,Nuova pala d'altare																

For loop to assign markers to all rows in the DataFrame (df2)

```
61 for i,row in df2.iterrows():
62     lat = df2.at[i, 'Latitudine']
63     lng = df2.at[i, 'Longitudine']
64     nome = df2.at[i, 'Nome']
65     tipo = df2.at[i, 'Tipologia']
81
82     folium.Marker([lng, lat],
83                   popup=nome,
84                   tooltip=tipo,
85                   icon=folium.Icon(icon='file', color='red')).add_to(m)
```

Saving the map and opening it in the browser

```
91 m.save("map.html")
```



B.3 Interactive layer creation and data enrichment

For every record, a marker was placed on the map corresponding to the coordinates of the public work. Each marker was designed to include a tooltip that briefly indicated the typology of the object (such as street, square, or building) and a popup window displaying more detailed information, including the name of the site and, where available, historical images extracted from archival sources.

A key aspect of this implementation was the visual differentiation of markers according to the type of object they represented. Conditional statements within the script allowed the program to assign distinct colors to each typology: civic buildings, for example, were displayed in blue, while religious structures appeared in dark blue, and public spaces in green. This chromatic distinction enhanced the interpretability of the map and contributed to a more intuitive visual reading of the city's urban components.

To further enrich the user experience, a system was designed to automatically associate each marker with relevant archival images. This was achieved by creating a directory containing photographs of historical documents named according to the 'name' field in the dataset (for instance, 'Castello del Buonconsiglio.png'). The program matched each data entry with the corresponding image, ensuring that when a marker was selected, the appropriate visual material appeared in the popup.

Finally, the completed map was exported as an HTML file, enabling it to be opened in any web browser without additional software. The resulting interactive visualization provided a dynamic, multilayered tool through which the historical transformations of Trento could be explored spatially and visually. By integrating textual, geographic, and iconographic information within a single digital environment, the project offered a new mode of engagement with urban history, bridging traditional archival research and contemporary information technology [Fig. 3.26].

Results

The project generated two distinct cartographic outputs. First, a high-resolution, publication-ready map depicting the main nineteenth-century public works in Trento, filterable by time period. This static visualization serves as a powerful analytical tool to study the city's spatial evolution over time. Second, an n HTML-based, explorable map with

Fig. 3.25 The main steps in developing the base map and the historical data.

interactive markers, tooltips, and popups containing archival documents and information. The use of Folium ensured accessibility via standard web browsers, facilitating the dissemination of research results to both academic and public audiences.

The project successfully demonstrated Python’s potential as an instrument for integrating historical research, data science, and spatial visualization.



Discussion and Conclusion

The integration of computational methods into architectural and urban history marks an innovative shift in humanities research. The project ‘Geopandas and Folium for historical research: explorable maps’ demonstrates how digital mapping technologies can enrich historical-documentary studies. By leveraging Python and its extensive ecosystem of libraries, static archival data are transformed into dynamic, interactive environments that allow patterns of urban transformation to emerge visually.

This approach highlights the effectiveness of open-source Python libraries such as GeoPandas and Folium in converting traditional, text-based research into an interactive, visual data model. Researchers can now explore the spatial and temporal density of urban interventions, immediately identifying patterns, clustering construction activities, and correlating them with administrative decisions or socio-economic events, thus gaining a deeper understanding of urban dynamics.

Embedding primary source materials (archival documents and images) directly into the geospatial interface further transforms the map

Fig. 3.26 The final interactive map.

into a digital repository of built heritage. This eliminates the need to cross-reference static maps with physical documents, making the research process more efficient and transparent.

The framework is highly scalable and opens numerous avenues for future development. One key direction involves converting the dataset into Linked Open Data, assigning unique persistent identifiers (URIs) to each public work and connecting them to external resources such as Wikidata or GeoNames. This would enrich the dataset with contextual information - historical figures, related buildings, or broader events - turning the local map into a node within a global, interconnected graph of historical knowledge. Web deployment could then transform the project into an open-access digital atlas, making it widely available to the public and the academic community. Furthermore, incorporating machine learning tools could facilitate the automatic classification of historical cartographic features, adding an extra layer of analytical depth.

03.3 Toward open and AI-enhanced research

The global space of the web, where information is accessed, processed, and used by both humans and machines, has transformed the approach of information producers. Whereas decisions in the past focused on local needs or specialized communities, today they must consider a global context of sharing. Data produced may be used by anyone, in any community or context, making interoperability a key value. Structured and rich data maximize efficiency and reuse, while isolated or local approaches risk wasting resources, limiting data reuse, and reducing overall utility. Cultural institutions and libraries must avoid marginalization in a space that is publicly visible but not truly integrated or shareable¹.

In this context, the adoption of structured data - information organized in predefined fields, tables, or databases - becomes essential². Structured data enable efficient querying, comparison, and retrieval, while «metadata, or data about data, provides basic information about data which makes it easier to find and use. Common elements of metadata include title, creator, date, subject or keyword, type of resource, and the rights and use»³. Ultimately, metadata provides meaning, context, and interoperability, allowing systems to connect collections, institutions, and disciplines.

«There are times, however, when additional contextual information would be helpful to users about the process and practices surrounding the creation of data. ‘Paradata’ is an important concept that incorporates these ideas and provides the necessary contextual detail. Paradata derives from the Greek prefix ‘para’ meaning alongside or beyond and refers to auxiliary data that surrounds a dataset. It can encompass a wide array of information, including timestamps, survey data such as response patterns and user interactions, and type of respondent that ensures the survey is reaching the target population»⁴.

In archival science, metadata are structured and formalized data about

1. Mauro Guerrini, and Tiziana Possemato, *Linked data per biblioteche, archivi e musei* (Editrice bibliografica, 2015), 99-102.

2. Maurizio Caminito, *La biblioteca nella nuvola. Utenti e servizi al tempo degli smartphone* (Editrice bibliografica, 2018) 18-19.

3. Lisa Andersson, Isto Huvila, and Olle Sköld, “Foreword,” in *Perspectives on Paradata. Research and Practice of Documenting Process Knowledge*, ed. L. Andersson, I. Huvila, and O. Sköld (Springer, 2024), V, <https://doi.org/10.1007/978-3-031-53946-6>.

4. Andersson, Huvila, and Sköld, “Foreword,” V.

archival records, essential for their retrieval, identification, visualization, analysis, appraisal, and long-term management. In contrast, paradata are structured data that document the methods, processes (including technological ones), and agents (both human and institutional) associated with the creation and management of those records. Paradata differ from metadata not only qualitatively, as they aim to capture the context of production and management rather than the identity and integrity of records, but also quantitatively, as they encompass broader and less detailed information⁵ [Tab. 3.4].

Together, structured data and metadata form the foundation for maximizing the utility, accessibility, and integration of information in a globally shared digital environment.

Tab. 3.4 Comparison of structured data, metadata, and paradata in the context of built heritage documentation.

Structured data		Metadata		Paradata	
Represents content (tell what the data is)		Provide context (tell what the data means, where it comes from, and how to use it)		Paradata explain procedures and tools (tells how, why and by whom the data was produced)	
Example					
Structured data for a building		Metadata for a 3D digital model of a building		Paradata for documenting the 3D digital model workflow	
Building record (Unique identifier of the building within the database)	Building_ID = 00245	Descriptive (Identifies and describes the digital object or record)	Title: Palazzo Pretorio, Trento; Author: Anna Maragno; Date of creation: 2026	Documentation of the reconstruction project and team	Project: “Digital Reconstruction of Palazzo Pretorio”; Team: University of Trento, LAMARC
Location (Geographical coordinates of the building)	Latitude: 45.4642; Longitude: 9.19	Technical (Technical characteristics of the 3D model or scan)	File format: OBJ; Software: Agisoft Metashape 2.0; Resolution: 0.5 mm/pixel	Paradata about spatial data acquisition process	Method: TLS (Terrestrial Laser Scanning); Date of survey: May 2026
Chronology (Construction and restoration dates)	Construction_Year = 1570; Restoration_Year = 1998	Structural / Semantic (Defines the semantic relationships or conceptual models adopted)	Linked ontology: CIDOC CRM (<i>E22_Man-Made_Object</i> → <i>P108_has_produced</i> → <i>E12_Production</i>)	Documentation of modeling and interpretation choices	Texture mapping process: derived from photogrammetry; Color calibration: D65 light standard.

5. Pierluigi Feliciati, and Luciana Duranti, “The responsible use of Artificial Intelligence in archives through the use of paradata,” *JLIS* 16, no. 2 (2025), <https://doi.org/10.36253/jlis.it-636>.

Essentially, metadata adds meaning and context to raw data, facilitating its organization, discovery, and reuse. When enriched with semantic information through ontologies⁶ such as the CIDOC Conceptual Reference Model (CIDOC CRM)⁷ - a high-level ontology enabling information integration in Cultural Heritage - metadata⁸ not only describe and contextualize data but also establish formal relationships among entities and concepts. This semantic enrichment allows researchers to move beyond isolated datasets toward complex, interoperable analyses of digitized heritage⁹.

This process forms the foundation of the Semantic Web, which represents the natural evolution of the World Wide Web from a 'web of documents' to a 'web of data'. In its original conception, the web was primarily a network of interlinked documents written in HTML (HyperText Markup Language). HTML provided a way to structure and visually format information through tags, but these tags only indicated how content should be displayed - they carried no intrinsic meaning that computers could interpret. Machines could read the structure of a web page but could not understand what the information actually represented. The Semantic Web aims to overcome this limitation by adding a new layer of meaning to the web. It introduces ontologies, formal models that define concepts and the relationships among them, and controlled vocabularies, which ensure consistent naming and categorization of entities. These semantic frameworks enable data to be described not

6. "A formal model that allows knowledge to be represented for a specific domain. An ontology describes the types of things that exist (classes), the relationships between them (properties) and the logical ways those classes and properties can be used together (axioms)" ("Linked Data Glossary," W3C Working Group Note, accessed May 1, 2026, <https://www.w3.org/TR/ld-glossary/#linked-open-data>).

7. "In cultural heritage domain, the international standard ISO 21127:2006 also known as CIDOC Conceptual Reference Model (CRM) provides definitions and a formal structure for describing the implicit and explicit concepts and their relations. Nowadays the needs to show the relationships between content management both collections and digital asset management is crucial to develop systems with data that can be re-usable and implemented over future years, by people of different disciplines, with a special attention on possible narratives outcomes for education and communication purposes" (Elisabetta Caterina Giovannini, Massimiliano Lo Turco, and Noemi Mafrić, "Documenting historical research for a collection information modelling. A proposal for a digital asset management system," *ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* 2, no. 42, 2019: 519-525, <https://doi.org/10.5194/isprs-archives-XLII-2-W15-519-2019>).

8. "Information used to administer, describe, preserve, present, use or link other information held in resources, especially knowledge resources, be they physical or virtual. Metadata may be further subcategorized into several types (including general, access and structural metadata). Linked Data incorporates human and machine readable metadata along with it, making it self describing" ("Linked Data Glossary").

9. Martin Doer, "The CIDOC CRM: an ontological approach to semantic interoperability of metadata," *AI Magazine* 24, no. 3 (2003): 75-92.

merely by its structure or appearance, but by its meaning and its relationships to other pieces of information.

“The Semantic Web is not a separate Web but an extension of the current one, in which information is given well-defined meaning, better enabling computers and people to work in cooperation”¹⁰. In other words, rather than treating web pages as static documents, the Semantic Web treats them as collections of linked data elements that can be queried, connected, and interpreted by machines. Through this transformation, the web evolves into a ‘web of data’, where the connections between resources are not just hyperlinks but semantic relationships - explicitly defined and interpretable both by humans and computers¹¹. This makes it possible for machines to understand, reason about, and reuse the information published online, enabling a far more intelligent and interconnected digital ecosystem.

The concept of the Semantic Web is thus inseparable from Linked Data¹², a set of methods and technologies that ensure data interoperability and unique identification across heterogeneous systems. Using shared vocabularies, Linked Data enables non-human agents to interpret content on the web, turning it into a semantically structured environment where each resource is contextualized for machine understanding. In essence, Linked Data constitutes both a technology and a best-practice framework for publishing information online in a machine-readable, interpretable, and reusable form¹³.

The core idea is that each digital resource on the Semantic Web is assigned a unique identifier, usually in the form of a Uniform Resource Identifier (URI), which functions much like an address on the internet. This identifier allows every piece of information to be precisely referenced and connected to other data through explicitly defined semantic relationships. In this way, individual data elements - whether they describe people, places, buildings, or historical events - can be linked together to form a coherent and interoperable web of knowledge. This interconnected network is made possible by standard web technologies such as URIs, HTTP (the protocol that enables data exchange on the

10. Tim Berners-Lee, James Hendler, and Ora Lassila, “The semantic web,” *Scientific American* 284, no. 5 (2001); 34-43.

11. Guerrini and Possemato, *Linked data*, 26-27.

12. “Linked data is essential to actually connect the semantic web. It is quite easy to do with a little thought, and becomes second nature” (Tim Berners-Lee, “Linked Open Data,” accessed May 1, 2026, <https://www.w3.org/DesignIssues/LinkedData.html>).

13. Guerrini and Possemato, *Linked data*, 26-27.

web), and the Resource Description Framework (RDF), a model for representing information as structured statements. Together, these technologies allow data stored in different repositories or institutions to be interlinked and accessed as part of a global information space¹⁴.

When this data is made open and freely accessible, it is referred to as Linked Open Data (LOD). As stated by Tim Berners-Lee, the inventor of the WWW, “Linked Open Data (LOD) is Linked Data which is released under an open licence, which does not impede its reuse for free”¹⁵. LOD extends the potential of structured, semantically enriched metadata by enabling datasets to be shared in open, standardized, and interconnected formats. It embodies the Semantic Web’s principle of a common framework that allows data to be “shared and reused across application, enterprise, and community boundaries”¹⁶.

By linking data across repositories and employing standards such as RDF, LOD allows machines to interpret statements like “Palladio designed Villa Capra” as a triple: ‘subject’ (Palladio), ‘predicate’ (designed), and ‘object’ (Villa_Capra), each identified by a unique URI. This logic underlies systems such as Google’s Knowledge Graph, which distinguishes between entities (persons, places, organizations) and provides contextual information, as well as Wikidata, DBpedia, and GeoNames, now essential sources for historical and heritage research.

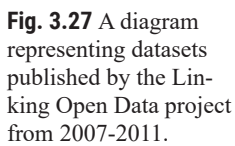
Together, these interconnected data form a vast semantic network: the Linked Data Cloud [Fig. 3.27].

In 2010, Tim Berners-Lee introduced a five-star rating system to assess

14. Tim Berners-Lee, “Linked Open Data”.

15. Tim Berners-Lee, “Linked Open Data”.

16. “I have a dream for the Web... and it has two parts. In the first part, the Web becomes a much more powerful means for collaboration between people. I have always imagined the information space as something to which everyone has immediate and intuitive access, and not just to browse, but to create. The initial WorldWideWeb program opened with an almost blank page, ready for the jottings of the user. Robert Cailliau and I had a great time with it, not because we were looking at a lot of stuff, but because we were writing and sharing our ideas. Furthermore, the dream of people-to-people communication through shared knowledge must be possible for groups of all sizes, interacting electronically with as much ease as they do now in person. In the second part of the dream, collaborations extend to computers. Machines become capable of analyzing all the data on the Web - the content, links, and transactions between people and computers. A ‘Semantic Web’, which should make this possible, has yet to emerge, but when it does, the day-to-day mechanisms of trade, bureaucracy, and our daily lives will be handled by machines talking to machines, leaving humans to provide the inspiration and intuition. The intelligent “agents” people have touted for ages will finally materialize. This machine-understandable Web will come about through the implementation of a series of technical advances and social agreements that are now beginning (and which I describe in the next chapter). Once the two-part dream is reached, the Web will be a place where the whim of a human being and the reasoning of a machine coexist in an ideal, powerful mixture” (Tim Berners-Lee, *Weaving the Web: the past, present and future of the World Wide Web by its inventor Tim Berners-Lee with Mark Fischetti*, HarperBusiness, 2000, 157-158).



18. “L’Agenzia,” Agenzia per l’Italia Digitale, accessed May 1, 2026, <https://www.agid.gov.it/it/agenzia>.

standable, and reusable on the Web¹⁹:

One star



Data is made available on the web under an open license²⁰, regardless of format. Licensing remains a crucial issue in data sharing, with Creative Commons (CC)²¹ licenses among the most widely used solutions.

Two stars



Data is provided in a machine-readable format (e.g., an Excel table rather than an image of a table).

Three stars



Data is distributed in non-proprietary formats such as CSV (Comma Separated Values) instead of Excel. Open formats ensure lower production costs, higher interoperability, better long-term preservation, and reduced dependence on commercial software providers.

Four stars



Data adopt ‘W3C-recommended standards’²² (such as RDF or SPARQL) for identifying and linking resources in a consistent and machine-interpretable way.

Five stars



Data is interlinked with other datasets, both internally and externally, creating meaningful connections that extend the context of a local dataset into a global network of knowledge.

“LOD is also important to historical scholarship as it is seen as the gold standard for maximising the reuse of data. The 5-star Linked Data rating system [Fig. 3.28] encourages people to publish data on the web in an increasingly open, structured and linked manner; where the fifth

19. Guerrini, and Possemato, *Linked data*, 99-102.

20. Licensing is a crucial aspect of data use and distribution. In the field of open data, the most widely adopted licenses are those developed by Creative Commons (CC), now a de facto international standard. The Creative Commons framework is maintained by a global network of more than 70 affiliate groups, which adapt, update, and translate license sets within their respective national jurisdictions. CC licenses are intentionally designed to be simple and user-friendly for anyone creating or publishing data online. Through an online tool, users answer a few questions (such as whether the resource may be modified or used for commercial purposes) and the system automatically generates the appropriate license to be attached to the resource. (Guerrini, and Possemato, *Linked data*, 117-118).

21. Creative Commons, accessed May 1, 2026, <https://creativecommons.org/>.

22. “Best Practices for Publishing Linked Data,” W3C Working Group Note, accessed May 1, 2026, <https://www.w3.org/TR/ld-bp/>.

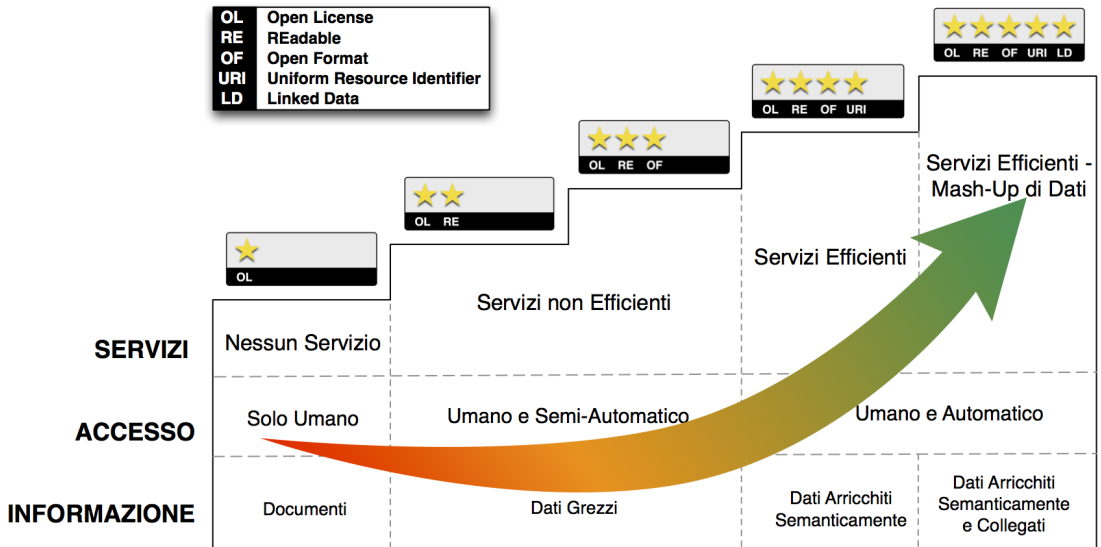


Fig. 3.28 Five-star rating system to assess the quality and openness of public data on the Web

[Agenzia per l'Italia Digitale, *Linee guida nazionali per la valorizzazione del patrimonio informativo pubblico* (2020), 10, <https://www.dati.gov.it/linee-guida-valorizzazione-patrimonio-informativo-pubblico>]

star is only given if data is linked by cross-datasets through URIs. This cross-dataset linkage encourages data reuse, preventing repetitive information; but also enables other URIs representing the same entity or concept to be published elsewhere and to be linked together. Linking all possible sorts of data has led to a massive amount of data which is the linked open data cloud. For historical scholarship, this means that statements about a single entity can be taken from a large amount of sources spread over many archives in order to gain a bigger picture or to identify opposing views”²³.

The Semantic Web is deeply connected to another technological field that has seen rapid development in recent years, even within the archival context: Artificial Intelligence and, more specifically, AI agents. The relationship between the two has deep historical roots. In the early 2000s, parallel to Tim Berners-Lee’s vision of a ‘Web of Data’, an internet where information carries well-defined meaning to enable more effective collaboration between humans and machines, researchers began to envision personal software agents capable of performing tasks such as automatically scheduling meetings through the exchange of semantically rich information across websites. Around the same time, the field of Multi-Agent Systems (MAS) was emerging, exploring how

23. Annemieke C. Romein, Max Kemman, Julie M. Birkholz, James Baker, Michel De Gruijter, Albert Meroño-Peñuela, Thorsten Ries, Ruben Ros, and Stefania Scagliola, “State of the field: Digital history,” *History* 105, no. 365 (2020): 291-312, <https://doi.org/10.1111/1468-229X.12969>.

decentralized, autonomous entities could cooperate through negotiation and coordination to achieve both shared and individual goals.

“Although Semantic Web technologies (namely RDF (Resource Description Framework) and OWL (Web Ontology Language)) provided a framework for agent interoperability, real-world adoption was hindered by the difficulty of large-scale ontology agreement and the high cost of semantic annotation. As a result, agentic functionality remained largely confined to research prototypes and closed systems. The advent of LLMs changed this trajectory: by implicitly learning rich world representations, modern agents can bypass the need for extensive manual annotation, instead leveraging web-scale text data to reason about meaning and perform web-based actions”²⁴.

“The growth of Large Language Models (LLMs) such as ChatGPT has field of Natural Language Processing (NLP), offering unprecedented capabilities in text generation and understanding”²⁵. Through exposure to vast textual data (including books, articles, and web pages) these models learn complex linguistic representations in an auto-supervised manner, predicting the next word in a sequence. Once trained, LLMs can interpret text, respond to prompts, and interact with databases using keyword-based searches on behalf of users. Their development typically involves three stages: pre-training, instruction tuning, and deployment²⁶. “However, a significant challenge faced by these models is their tendency to produce ‘hallucinated’ content entirely fabricated. This phenomenon not only impacts the reliability of LLM outputs but also limits their application in critical domains requiring high accuracy, such as medical advice or scientific research. With the development of methods to enhance the reliability of LLMs and minimize the occurrence of hallucinations, a promising solution has emerged in the form of retrieval augmented generation (RAG). This technique enhances LLMs by equipping them with a way to pull in relevant and timely information from various external databases as they work. By doing so, RAG grounds the models’ responses in reality, enabling them to produce

24. Tatiana Petrova, Boris Bliznioukov, Aleksandr Puzikov, and Radu State, “From Semantic Web and MAS to Agentic AI: A Unified Narrative of the Web of Agents,” ArXiv, no. 2507 (2025), <https://doi.org/10.48550/arXiv.2507.10644>.

25. El Moatez Billah Nagoudi, Alcides Alcoba Inciarte, and Abdul-Mageed Muhammad, “Improving Archives-Focused LLMs with Retrieval Augmented Generation,” in *Artificial Intelligence and Documentary Heritage*, ed. L. Duranti, and C. Rogers (SCEaR, 2024), 21.

26. Pierluigi Feliciati, *Archivi e intelligenza artificiale: sfide, rischi e opportunità per la ricerca storica*, oral presentation, Archivio di Stato di Taranto, September 19, 2025, <https://anai.org/eventi/archivi-e-intelligenza-artificiale-sfide-rischi-e-opportunita-per-la-ricerca-storica/>.

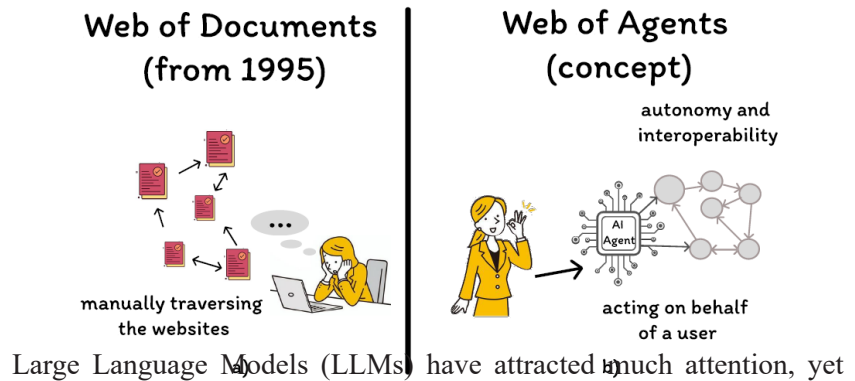
more accurate and reliable text that is supported by actual data. This approach represents a useful step towards improving the trustworthiness and performance of LLMs, by ensuring that their outputs are based on information that can be fact-checked”²⁷.

The vision of a global digital ecosystem populated by autonomous software agents - capable of discovering, communicating, and collaborating to perform complex tasks on behalf of users - is one of AI’s most enduring ambitions. “This concept, often termed the ‘Web of Agents’, envisions a fundamental evolution of the internet from a repository of human-readable information into a dynamic environment for machine-to-machine cooperation. Early proponents imagined distributed programs that could traverse a machine-readable web, providing novel capabilities with minimal human intervention”.

Basically, in the Web of Agents, “the user delegates a high-level goal to an autonomous AI agent. This agent offloads the cognitive load by dynamically finding and coordinating with a heterogeneous ecosystem, comprising other agents, external tools via APIs (Application Programming Interface), and data sources, to accomplish the task”²⁸ [Fig. 3.29].

Fig. 3.29 The difference between the Web of Documents and the Web of Agents.

[Tatiana Petrova, Boris Bliznioukov, Aleksandr Puzikov, and Radu State, “From Semantic Web and MAS to Agentic AI: A Unified Narrative of the Web of Agents,” ArXiv, 2507 (2025), <https://doi.org/10.48550/arXiv.2507.10644>]



27. Billah Nagoudi, Alcoba Inciarte, and Muhammad, “Improving Archives-Focused LLMs,” 21. “The functioning of RAG systems is based on a two-stage process. In the first stage, the information retrieval engine searches for relevant data within a predefined database in response to a user query. In the second stage, the retrieved results are used as input for the generative model, which formulates a response based both on its internal knowledge and on the retrieved information. This approach helps reduce the risk of hallucinations and enables more accurate and contextually relevant responses. The resource database from which RAG systems draw information can be curated and updated by domain professionals, allowing for the rapid correction of potential errors. In this sense, control over the resources - before the LLM generates a response - is not left solely to the model’s training, but is instead managed by those who have designed the digital environment through which the information is delivered” (Giorgia Di Marcantonio, “Verso una descrizione artificiale?,” in *L’archivio aumentato. Tempi e modi di una digitalizzazione critica*, ed. Federico Valacchi, Editrice Bibliografica, 2024, 152-156).

28. Petrova, Bliznioukov, Puzikov, and State, “From Semantic Web and MAS to Agentic AI”.

they comprise only one facet of AI capabilities. In archival science, and professional contexts more broadly, it is possible to identify at least three distinct classes of AI agents, each defined by the modality of data they process or generate: (1) agents that process multimedia information; (2) agents that process text; and (3) generative AI agents²⁹.

1. Multimedia-processing AI agents

These agents process non-textual inputs (such as images, video, and audio) or multimodal combinations (e.g., image and text, audio and text). Their main functions include:

- *Face recognition*: detecting and identifying individuals in photographs/video;
- *Object detection*: identifying items, features, or elements in images and video³⁰;
- *Image-text analysis*: extracting textual information from images via optical character recognition (OCR) or handwriting text recognition (HTR)³¹;
- *Speech and voice recognition*: converting spoken audio into text, performing speaker identification, and conducting speech analysis;
- *Recommendation systems*³²: suggesting images, documents, or videos based on user behaviour, similarity, tags, or content features.

In archival context, they can support automated description of photographs or video footage, enable image-based search, facilitate voice-to-text conversion in oral history archives, and link user queries to relevant multimedia items through recommender systems.

Among the most widely used applications in the archival field are Optical Character Recognition (OCR) and Handwriting Text Recognition (HTR), techniques that convert printed and handwritten texts into machine-readable data, thereby enabling text search, automatic content

29. Feliciati, *Archivi e intelligenza artificiale*.

30. Thea Pedone, "Sistemi informativi (archivi) digitali iconografici," in *Metodi, applicazioni, tecnologie. Colloqui del dottorato di ricerca in Storia, Disegno e Restauro dell'Architettura*, ed. A. Carannante, S. Lucchetti, S. Menconero, A. Ponzetta (Sapienza Università Editrice, 2022), 75-85.

31. James Philips, and Nasseh Tabrizi, "Historical Document Processing: A Survey of Techniques, Tools, and Trends," in *Proceedings of the 12th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management*, v. 1 (KDIR, 2020): 341-349, [10.5220/0010177403410349](https://doi.org/10.5220/0010177403410349); Silvio Imboden, Antonella Guidazzoli, Giorgia Cardano, Luca Mattei, Federico Andrucci, Deanna Shemek, Rossella Pansini, Fauzia Albertin, and Maria C. Liguori, "An Open-Source Workflow for Handwritten Character Recognition," in *Digital Heritage*, ed. S. Campana, D. Ferdani, H. Graf, G. Guidi, Z. Hegarty, S. Pescarin, and F. Remondino (2025) [10.2312/dh.20253069](https://doi.org/10.2312/dh.20253069).

32. Giorgia Di Marcantonio, "Intelligenza artificiale, Large Language Models (LLMs) e Retrieval-Augmented Generation (RAG). Nuovi strumenti per l'accesso alle risorse archivistiche e bibliografiche," *Bibliothecae.it* 13, no. 1 (2024), 147, <https://doi.org/10.6092/issn.2283-9364/19982>.

Fig. 3.30 Example of Handwriting Text Recognition (HTR) applied to historical sources using Transkribus (<https://www.transkribus.org/it>). Left: (i) an image of a handwritten document from 1833 preserved in the Archivio Storico del Comune di Trento (ASCTn 3.8, XI.65.1833). Right: (ii) the text automatically extracted from the image using the software.

extraction, and indexation. Written documentation lies at the heart of historical research, yet neither printed nor handwritten text is inherently readable by computers. “A computer can only recognise these images as text if it is trained to do so. [...] Whereas OCR is applied to standard fonts and a finite number of characters and texts printed on a bright background, Handwriting Text Recognition (HTR) has to overcome the extensive variation in handwriting. To be able to decipher handwriting, several techniques needed to be combined: the statistical analysis of language patterns, artificial intelligence combined with deep learning and human training. Although individual hands can be trained through OCR-programs, the results generated, for example, by the READ-Coop’s HTR tool Transkribus³³ are promising”³⁴. “Transkribus is a tool that integrates image and text recognition models to facilitate Handwritten and Optical Character Recognition. The tool, accessible via a graphical interface or programmatically through APIs, is designed to “fit neatly in the archival workflow, making direct use of growing repositories of digitised images of historical texts.” Transkribus is increasingly being adopted by archives and other institutions, playing a crucial role in expanding the use of AI to extract records’ contents and make them searchable. Access to records’ contents, in particular texts, in turn, allows using them for indexation”³⁵ [Fig. 3.30].



i) Image of a document from 1833. ii) Text extraction from the image using Transkribus.

33. “Transkribus enables you to automatically recognise text easily, edit seamlessly, collaborate effortlessly, and even train your custom AI for digitizing and interpreting historical documents of any form” (Transkribus, c. 2026, <https://www.transkribus.org/it>).

34. Romein et al., “State of the field: Digital History,” 295.

35. Giovanni Colavizza, Tobias Blanke, Charles Jeurgens, and Julia Noordegraaf, “Archives and AI: An Overview of Current Debates and Future Perspectives,” *Journal on Computing and Cultural Heritage* 15, no. 1 (2021), <https://doi.org/10.1145/3479010>.

“While text has been central to the identity of the digital humanities, historical scholarship is not limited to the study of text. The ability of machines to comprehend digital images has made remarkable strides in recent years, and it is in the context of these developments that computer vision has been used in the service of historical scholarship”³⁶. For iconographic archives, image recognition systems, emulating human neural networks and vision through Artificial Neural Networks (ANNs), are particularly useful. ANNs replicate human learning by integrating memory (via connections) and computation across multiple processing units. Standard ANNs, however, are not optimized for image recognition, which is why Convolutional Neural Networks (CNNs) are employed. CNNs process local pixel correlations hierarchically: initial layers detect edges and brightness changes, intermediate layers identify simple shapes, and deeper layers recognize complex objects. Outputs are iteratively compared with training targets, and errors are corrected through repeated forward and backward passes until satisfactory results are achieved³⁷. “This offers the prospect of a digital history and uses machines to analyse the information content of images rather than textual proxies for those images”³⁸.

2. Text-processing AI agents

This class of AI agents focuses on textual data, performing tasks such as read, understand, generate, or transform text. They take text as input, analyze it using Natural Language Processing (NLP) techniques, often powered by Large Language Models (LLMs), and produce meaningful output or perform actions based on it. Core functions include:

- *Named-Entity Recognition (NER), topic modelling, semantic classification of text*: identifying entities (like people, places, or dates), extracting main topics, and categorizing content based on meaning;
- *Automatic summarisation of long text bodies*: condensing documents while preserving key information, enabling faster comprehension;
- *Machine translation and multilingual text processing*: translating text between languages and handling multilingual data efficiently;
- *Conversational agents or chatbots to assist users*³⁹: assisting users

36. Romein et al., “State of the field: Digital History,” 298.

37. Pedone, “Sistemi informativi (archivi) digitali iconografici,” 75-85.

38. Romein et al., “State of the field: Digital History,” 299.

39. “The term ‘Chatter Bot’ was coined by Michael Mauldin in 1994 to describe the program he was working on. Once again, the metaphor of language emerges, although expressed in an everyday and informal sense: chat, meaning a light, casual conversation, like a friendly exchange. The second part of the term, bot, is instead a shortened form of robot. The result is the idea of a ‘robot

in tasks such as query answering or interacting with information systems, powered by LLMs that generate human-like responses;

- *Sentiment analysis or pattern detection*: detecting opinions, emotions, or recurring trends in user feedback, complaints, or historical correspondence.

In archival practice, one of the most useful features is Quantitative Text Analysis. The digitisation of millions of books, newspapers, and letters has made textual analysis central to historical research. At its core lies the study of linguistic patterns - particularly shifts in keyword frequency over time. Tools such as Google Books Ngram Viewer (launched in 2011) popularised this approach by enabling rapid visualisation of word-frequency trends, offering historians new ways to interpret cultural and historical phenomena. However, frequency-based methods possess inherent limitations, such as their inability to capture semantic nuance or contextual meaning⁴⁰.

Another interesting tool that can read, understand, generate, and transform text, especially useful for students and researchers, is NapkinAI. It is an AI-powered tool that transforms text into visual representations. Using Natural Language Processing (NLP), it analyzes user-provided text (such as paragraphs, lists, or outlines) to identify key concepts, relationships, and structure. Based on this NLP analysis, NapkinAI automatically generates visuals like flowcharts, mind maps, diagrams, or charts, selecting the most suitable format depending on the text type. Users can then customize layouts, colors, icons, and connections. Essentially, NapkinAI leverages NLP to convert textual information into clear, organized visuals, making complex ideas easier to understand and communicate⁴¹ [Fig. 3.31].

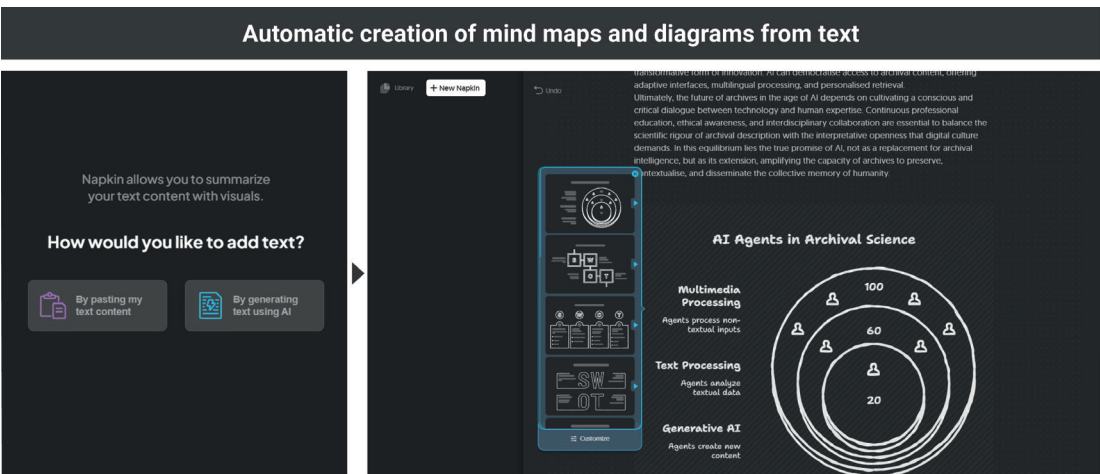
3. Generative AI agents

“The term Generative AI, as it is currently understood, primarily describes machine learning models and methodologies adept at generating content in response to user prompts. This encompasses a broad range of outputs, including audio, images, text, and video. The high fidelity of

that chats’ with us” (Paola Castellucci, and Elisabetta Gomelino, “Chatbot. Un giorno, al museo,” in *DigItalia* 2 (1): 9-24, [10.36181/digitalia-00034](https://doi.org/10.36181/digitalia-00034)).

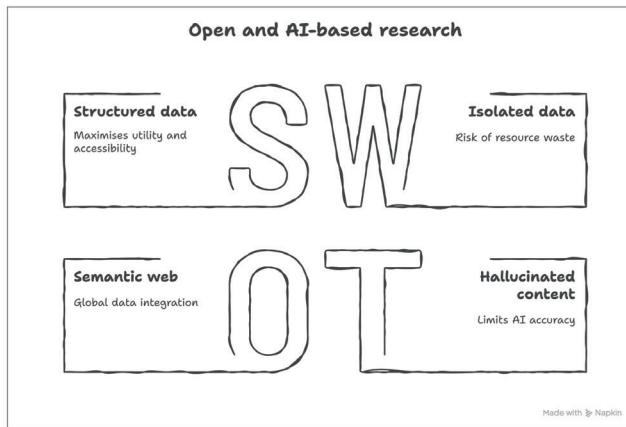
40. Word frequency in historical texts can vary for many reasons, including spelling changes, idiomatic shifts, and data inconsistencies, making abrupt fluctuations difficult to interpret. Moreover, words often change meaning over time, so frequency alone cannot capture semantic evolution. To address these issues, recent approaches in digital history move beyond single-word analysis toward broader semantic fields (Romein et al., “State of the field: Digital History,” 304-306).

41. NapkinAI, accessed May 1, 2026, <https://www.napkin.ai/about-us/>.



i) Text input.

ii) Generation of a set of maps/diagrams from text.



iii) Map selection and download.

Fig. 3.31 Visualizing the thesis chapter ‘Toward open and AI-enhanced research’ using Napkin. The tool automatically generates diagrams, including a concept map on AI Agents in Archival Science. The workflow begins with Text Input (i), where the user provides the source material by pasting the relevant text. Then, AI analyzes the content to extract key concepts and logical relationships, consequently producing multiple visualization options (ii). Finally, the user completes the process with map selection, customisation and download (iii).

this AI-generated content has recently captivated users, with machines capable of producing content that is often indistinguishable from that created by humans”⁴². Principal functions include:

- *Generation of synthetic images, video, or 3D models*: creating realistic or stylized visual content from scratch or from prompts;
- *Drafting of textual documents*: creating coherent and context-aware text, such as summaries, translations, metadata, or stories, by using Large Language Models (LLMs);
- *Synthetic audio production*: generating speech, music, or sound effects, including voice cloning and audio enhancement;
- *Enhancement of user experiences through interactive simulations*

42. Billah Nagoudi, Alcoba Inciarte, and Muhammad, “Improving Archives-Focused LLMs,” 9.

and virtual-reality reconstructions.

The emergence of Generative AI (GenAI) is transforming heritage and archival research and practice. For example, GenAI can support archival functions by enhancing user engagement, reconstructing lost visual or textual contexts, or generating metadata suggestions. Also «galleries and museums have integrated GenAI into the structure of their exhibits to tailor the interpretation of collections for various audiences, such as visitors with disabilities. In these contexts, GenAI systems guide visitors through exhibits, tell stories, and even provide recommendations. In libraries, AI-powered chatbots have been developed to assist with obtaining relevant information and increasing the accessibility of collections . GenAI has also been used for restoring and reconstructing heritage objects»⁴³. Despite these promising developments, the overall impact of GenAI on the heritage sector is still insufficiently understood. Given past issues related to data privacy and AI ethics, researchers emphasize the need to identify both the opportunities and risks associated with integrating GenAI into heritage management and policy development [Fig. 3.32].

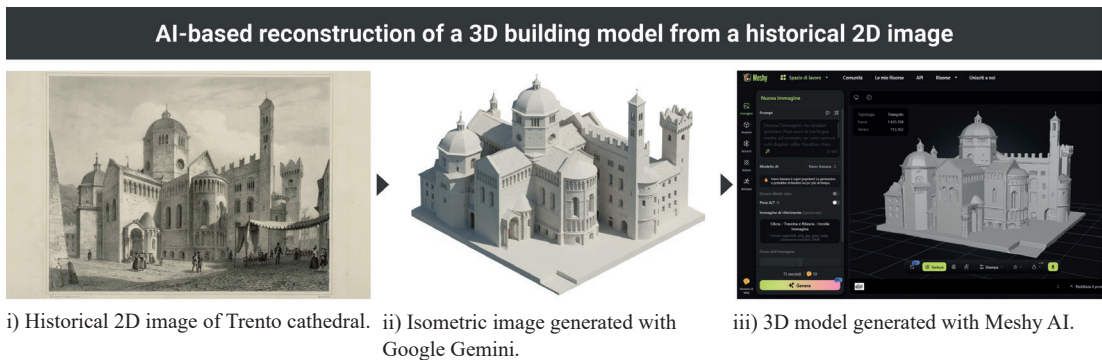


Fig. 3.32 Workflow for generating a 3D model from a historical image using GenAI agents.

First the selection of an archival image (i), which is uploaded to Google Gemini to generate an isometric visualization of the building (ii). The resulting image is then processed through Meshy AI (iii), which automatically reconstructs a 3D model.

From an archival science perspective, this range of technological capabilities could have significant impacts on various aspects related to the production, management, and preservation of information resources⁴⁴. A growing body of research highlights the applicability of AI in supporting archival functions. This development is driven by large-scale digitisation and the proliferation of born-digital records, which have tran-

43. Jessica Witte, Edmund Lee, Lisa Brausem, Verity Shillabeer, and Chiara Bonacchi, "Generative AI in Heritage Practice: Improving the Accessibility of Heritage Guidance," *arXiv*, no. 2510 (2025), <https://doi.org/10.48550/arXiv.2510.13811>.

44. Di Marcantonio, "Intelligenza artificiale," 147.

sformed vast quantities of archival materials into data. Initially, archival processes such as appraisal and selection were performed manually; however, as the volume of digital materials continues to expand, manual processing has become increasingly unfeasible. Archives are thus evolving into big-data organisations, requiring archivists to collaborate with machine reasoning and assess algorithmic decision-making. Over the past decade, the use of AI in archival work has shifted from isolated experimentation to integrated applications embedded across recordkeeping workflows⁴⁵.

Although the idea of using AI to support archival functions is not new⁴⁶, «established organizations, especially larger ones, are being crushed by this onslaught of Big Data»⁴⁷, and the challenge persists even with the emergence of new forms of documentary resources⁴⁸. The same issue applies to metadata: to manage the massive quantities required, archivists and records managers will almost certainly need AI systems capable of analysing the form, content, and context of archival objects and automatically populating descriptive systems⁴⁹.

In this context, a key contribution comes from the InterPARES Trust AI project (2021–2026). “Since 1998, InterPARES (International Research on the Preservation of Authentic Records in Electronic Systems), a multinational and multidisciplinary collaborative research project funded by the Social Sciences and Humanities Research Council of Canada and the University of British Columbia (UBC), has [...] shown, through five phases of research, that archival principles and concepts can support the trustworthiness of records regardless of the technology used to create, manage, and preserve them. Today Artificial Intelligence (AI) is changing the way we live and work, sparking either great enthusiasm for its capabilities or great fear for its unintended consequences. While AI poses significant challenges to documentary heritage, these

45. Colavizza, Blanke, Jeurgens, and Noordegraaf, “Archives and AI”.

46. Rhoads, in 1969, writing about the concept of the cybernetic archivist, stated that “we would not use the computer merely as an archivist or typist, but rather as a cybernetic extension of research itself”. Hirtle discussed “Artificial Intelligence, Expert Systems, and Archival Automation” in 1987. In 1991, Stielow compared the development of archival theory to the avant-garde of artificial intelligence, describing both as “the search for the obvious”. Later, in 2009, Benson examined the use of artificial intelligence to represent archival photographs (Pierluigi Feliciati, “Archival users and AI tools for reference and access: a study within the InterPARES Trust AI project,” *JLIS* 14, no. 3, 2023, [10.36253/jlis.it-558](https://doi.org/10.36253/jlis.it-558)).

47. Robert Smallwood, *Information Governance: Concepts Strategies and Best Practices* (Wiley, 2015), 5.

48. Feliciati, “Archival users and AI tools”.

49. Geoffrey Yeo, “Trust and context in cyberspace,” *Archives and Records*, no. 34 (2013): 214–234, <https://doi.org/10.1080/23257962.2013.825207>.

challenges can be met with the same grounding in foundational archival knowledge when approached through collaborative, interdisciplinary effort”⁵⁰. The project⁵¹ aims to design, develop, and leverage AI to ensure the ongoing accessibility and trustworthiness of public records. Its strategy involves creating a sustainable partnership that produces original research, trains students and professionals, and fosters a continuous exchange between academia, archival institutions, government professionals, and industry. The objectives include identifying AI technologies capable of addressing critical challenges in records and archives management, evaluating the benefits and risks of their application, and ensuring that archival principles guide the responsible development of AI systems. These goals are validated through case studies and practical demonstrations⁵².

InterPARES Trust AI is structured around six working groups corresponding to archival functions: (1) Creation and Use; (2) Appraisal and Acquisition; (3) Arrangement and Description; (4) Retention and Preservation; (5) Management and Administration; and (6) Reference and Access⁵³.

The project explores a variety of machine-learning methods. Natural Language Processing (NLP) is particularly valuable for archival applications. “For example, named entity recognition (NER) systems can enable classifying records and arrange and describe archival fonds based on the names of people, places, and organizations, thus improving description of these materials and facilitating access to them. Some technologies can be used to summarize records or archival fonds content, translate it from one language to another, and/or enable users to ask questions about content and receive tailored answers. These technologies can thus significantly enhance engagement of users with the archival content and reduce human effort needed to locate particular types

50. Luciana Duranti, and Corinne Rogers, “Introduction,” in *Artificial Intelligence and Documentary Heritage*, ed. L. Duranti, and C. Rogers (SCEaR, 2024).

51. “I Trust AI includes almost 100 partner organizations in North, Central, and South America, Europe, Africa and Asia, representing academia, industry, archives, government agencies, and international organizations. Researchers from the archives and records fields, cybersecurity, data science, information science, computer science, computational linguistics, economics, law, electrical engineering and more are engaged in more than 40 studies investigating the current and potential uses of AI in records and archival work, focusing attention on the challenges to trustworthiness of documentary heritage arising from rapid and ill-considered adoption of AI” (Duranti and Rogers, “Introduction”).

52. InterPARES Trust AI, accessed May 1, 2026, <https://interparestrustai.org/>.

53. Feliciati, “Archival users and AI tools”.

of information”⁵⁴.

Deep learning techniques, both traditional and advanced, are also being studied to address new archival challenges. For instance, improving Optical Character Recognition (OCR) tools to enhance accessibility and usability⁵⁵. Research on Deep Convolutional Neural Networks (DCNNs) focuses on image classification and the automated description of digital documents⁵⁶. “Although earlier research examined traditional machine-learning methods, recent advances in deep learning, including DCNNs, show promising results. For instance, attention-based Faster R-CNN models could be employed to describe digitised records lacking metadata. Similarly, multitask learning can enhance translation quality, object detection, and image classification, in combination with NLP techniques for text generation, classification, and machine translation”⁵⁷.

Each class of AI agent offers significant potential to support archival functions, yet each also presents distinct risks, including hallucinations, biased or offensive outputs, and a range of ethical, legal, and technical challenges⁵⁸. “The quality of input data is crucial. No matter how computationally capable AI may be, it cannot ‘magically’ correct or interpret flawed information. Moreover, it is important to distinguish between access to and use of resources. Allowing AI unrestricted reuse of archival data carries the risk of problematic recontextualisations. For this reason, InterPARES Trust AI is developing a conceptual model to differentiate access and use functions, ensuring responsible implementation of AI in archival systems. LLMs may also reproduce biases embedded in training data, perpetuating stereotypes and prejudices. It

54. Muhammad Abdul-Mageed, “AI in the I Trust AI Partnership,” in *Artificial Intelligence and Documentary Heritage*, ed. L. Duranti, and C. Rogers (SCEaR, 2024), 12.

55. David Smith, and Ryan Cordell, “A research agenda for historical and multilingual optical character recognition,” in *NULab* (Northeastern University Report, 2018), <https://ocr.northeastern.edu/report>.

56. Sanskruti Patel, “A Comprehensive Analysis of Convolutional Neural Network Models,” *International Journal of Advanced Science and Technology* 29, no.4 (2020): 771-777.

57. Feliciati, “Archival users and AI tools”.

58. Regarding the responsible use of AI agents, in 2019 the European Union published the Ethics Guidelines for Trustworthy AI, the first comprehensive ethical framework for artificial intelligence. «According to the Guidelines, trustworthy AI should be: (1) lawful - respecting all applicable laws and regulations; (2) ethical - respecting ethical principles and values; (3) robust - both from a technical perspective while taking into account its social environment» (“Ethics guidelines for trustworthy AI,” European Commission, accessed May 1, 2026, <https://digital-strategy.ec.europa.eu/en/library/ethics-guidelines-trustworthy-ai>). On 17 September 2025, Italy also definitively approved its national law on the anthropocentric use of artificial intelligence, emphasising the need for oversight of economic and social risks as well as the potential impact on fundamental rights (Disposizioni e deleghe al Governo in materia di intelligenza artificiale, Legge n. 132/25 del 23 settembre 2025, GU n. 223 del 25 settembre 2025).

is therefore essential to adopt strategies that identify and mitigate such biases, promoting fair and inclusive use of technology. Finally, the opacity of AI algorithms can make it difficult to understand how responses are generated. Transparency must be promoted by providing clear information on how systems operate and by complementing AI outputs with reliable tools such as inventories and catalogues, which support deeper contextualisation and exploration of resources. LLMs, Retrieval-Augmented Generation (RAG), and AI more broadly can open new horizons for access to archival resources, but their effective use requires continuous professional training and interdisciplinary collaboration to balance the scientific rigour of archival description with the approximations inherent in current AI technologies”⁵⁹.

Thus, the question remains open as to whether AI truly represents the most appropriate solution for archival practice, and how this technology might develop if the balance of power were reversed: if archival theory, rather than technological innovation, were to guide the design and development of AI tools. In this perspective, technological challenges should be addressed through the lens of archival theory, ensuring that technical methods are integrated into complex, human-oriented systems that respond to the real needs of users⁶⁰. The importance of user centrality in designing information systems was also emphasised by Chiara Veninata, Director of the ICAR, during the conference “AI servizio degli utenti: Archivi e Sala Studio” (12 November 2024). ICAR manages a vast and heterogeneous set of archival information systems - often developed according to territorial, thematic, or institutional logics - which, despite attracting around one million annual visitors, see that 70% of users remain on the site for less than 30 seconds. As Veninata observed, “something is not working”⁶¹.

If a user has access to multiple research archival information systems (SAN, SIUSA, SIAS, etc.), each with different navigation paths for various reasons, a careful and informed use of Artificial Intelligence could help simplify access systems to these resource platforms, or at least make the initial exploration of archival and bibliographic holdings more intuitive for users⁶².

59. Di Marcantonio, “Verso una descrizione artificiale?,” 152-156.

60. Feliciati, “Archival users and AI tools”.

61. Chiara Veninata, *Al servizio degli utenti: Archivi e Sala Studio*, oral presentation, Archivio di Stato di Taranto, November 12, 2024, <https://www.youtube.com/watch?v=-mV2LWK7Sxs>.

62. Di Marcantonio, “Intelligenza artificiale,” 154.

A potential shift may come with I.PaC⁶³, the technological engine of *Ecomic – Digital Ecosystem for Culture*, promoted by the Istituto centrale per la digitalizzazione del patrimonio culturale (Digital Library) within Italy's National Recovery and Resilience Plan (PNRR). This initial version of the I.PaC public portal serves as the first operational access point for public and private entities wishing to participate [Fig. 3.33]. Aligned with the vision of the National Digitalisation Plan (PND), which seeks to create an integrated system of services to host, semantically enrich, and ensure interoperability of digital cultural heritage, I.PaC aims to overcome existing fragmentation and provide new opportunities for access, reuse, and enhancement of digital heritage. Through advanced technological tools and services, often inaccessible to individual institutions, I.PaC democratises innovation, enabling every cultural organisation to enhance its collections according to shared, high-quality standards. Among its core services are AI-driven services capable of analysing metadata and content to extract information, suggest correlations, and generate new insights⁶⁴.

Fig. 3.33 Homepage of I.PaC (*Infrastruttura digitale per il patrimonio informativo culturale*).

[<https://ecomic.cultura.gov.it/ipac/>]



63. Infrastruttura digitale per il patrimonio informativo culturale, accessed May 1, 2026, <https://ecomic.cultura.gov.it/ipac/>.

64. "Online il nuovo sito di I.PaC – Infrastruttura e servizi per il Patrimonio Culturale. Il primo punto di accesso all'infrastruttura tecnologica di Ecomic," Digital Library, August 18, 2025, <https://digitallibrary.cultura.gov.it/notizie/online-il-nuovo-sito-di-i-pac-infrastruttura-e-servizi-per-il-patrimonio-culturale/>.

Without sustained attention, a deep divide may emerge between these two domains - a “black hole” in collective memory, where analogue records risk being forgotten due to a lack of digitisation, expertise, or resources⁶⁵. Addressing this requires the collaboration of archivists, computer scientists, legal scholars, and cultural professionals to develop sustainable strategies for preservation, interoperability, and ethical access. Accessibility, in this sense, becomes the most radical and transformative form of innovation. AI can democratise access to archival content, offering adaptive interfaces, multilingual processing, and personalised retrieval⁶⁶.

Ultimately, the future of archives in the age of AI depends on cultivating a conscious and critical dialogue between technology and human expertise. Continuous professional education, ethical awareness, and interdisciplinary collaboration are essential to balance the scientific rigour of archival description with the interpretative openness that digital culture demands⁶⁷. In this equilibrium lies the true promise of AI, not as a replacement for archival intelligence, but as its extension, amplifying the capacity of archives to preserve, contextualise, and disseminate the collective memory of humanity.

65. Maddalena Valacchi, “La speranza della ricerca,” in *L'archivio aumentato. Tempi e modi di una digitalizzazione critica*, ed. F. Valacchi (Editrice Bibliografica, 2024), 139-140.

66. Pedone, “Sistemi informativi (archivi) digitali iconografici,” 87-88.

67. Di Marcantonio, “Verso una descrizione artificiale?,” 152-156.

04

From physical object to digital resource. Creating the memory of the built heritage through digital technologies



Chapter 04 • From physical object to digital resource. Creating the memory of the built heritage through digital technologies

As both a cultural and technical activity, survey today must confront the impact of the digital revolution, which has transformed the ways information is acquired, processed, and communicated, within a broader context often described as a contemporary ‘archival impulse’.

Building on these considerations, the chapter examines the principal processes of data acquisition and processing in 3D digital surveying, with particular attention to the most widely used range-based and image-based techniques, including low-cost solutions. It also addresses the potential outputs of reality-based digital models, namely the digital resources that, if properly managed, may become new forms of “historical sources” related to the built heritage.

As the focus shifts from physical models to digital ones (CAD, BIM, HBIM, Digital Twin, Memory Twin), the ways in which these resources are experienced also evolve, notably through the various forms of Extended Reality (VR, AR, MR). In this context, the chapter revisits a number of significant experiments and case studies in architectural and urban surveying conducted within the framework of doctoral research, evaluating their outcomes and exploring their potential future developments.

04.1 Surveying as a means of preserving and understanding built heritage in the era of 'archival mania' and new visual culture

Article 1 of the “Convention Concerning the Protection of the World Cultural and Natural Heritage”¹, in its most comprehensive and updated version, defines cultural heritage as the ensemble of artefacts, monuments, groups of buildings, sites, and museums that express a variety of symbolic, historical, artistic, aesthetic, ethnological or anthropological, scientific, and social values of universal significance. Cultural heritage (CH) includes both tangible heritage (movable, immovable, and underwater) and intangible cultural heritage (ICH), as embodied in artefacts, sites, or monuments of cultural and natural heritage².

Within the framework of this definition, built heritage³ (or architectural heritage) may be defined as a form of tangible and immovable cultural heritage, consisting of all buildings and structures, both existing and past, that make up the built environment⁴. Architecture, as an event and activity that transforms the environmental setting at different scales - from that of the building to that of the landscape - therefore represents “a historical fact, embedded within the culture of a given era, interacting with it, and reaching us inextricably bound to it”⁵.

According to Vittorio Ugo, the nature of architecture - comprising constructed works, the marks inscribed upon the territory, and the uses and discourses they generate - essentially takes shape in “two distinct and heterogeneous ‘universes’: the material, physical, and spatial one of built works, which takes form in construction and use; and the discursive one of intellectual elaborations that develop around the building and, within the realm of language, take shape in theoretical, historical, and

1. UNESCO, *Convention Concerning the Protection of the World Cultural and Natural Heritage* (1972), 2, <https://whc.unesco.org/archive/convention-en.pdf>.

2. UNESCO, *The 2009 UNESCO framework for Cultural Statistics (FCS)* (UNESCO Institute for Statistics, 2009), iii, <https://unesdoc.unesco.org/ark:/48223/pf0000191061>.

3. “The built heritage is an expression of techniques and knowledge to be considered as a unique and irreplaceable source of aesthetic, historical, and cultural values, and therefore must be studied and documented in order to prevent any loss or damage, also ensuring that any restoration, maintenance, and reuse activities are undertaken consciously. Loss of data means loss of the link between past, present and future; loss of memory and loss of knowledge” (Stefano Cursi, Michele Calvano, Letizia Martinelli, Luciano Cessari, Filippo Calcerano, and Elena Gigliarelli, “Digital processes for the conservation and valorisation of built heritage,” in *Digital Humanities & Heritage*, ed. K. Kuzman Šlogar, and A. Žugčić Borić, Institute of Ethnology and Folklore Research, University of Zadar, 2024, 34, <https://hdl.handle.net/11573/1729148>.

4. “Architectural heritage,” Wikipedia, accessed May 1, 2026, https://en.wikipedia.org/wiki/Architectural_heritage#cite_note-3.

5. Vittorio Ugo, *Fondamenti della rappresentazione architettonica* (Progetto Leonardo, 1994), 9.

critical discourse. These universes [...] are evidently not independent, but complementary, and they integrate with one another to form that synthetic idea and concept of architecture to which we normally refer when describing our experience of dwelling in a place that construction has structured and profoundly transformed”⁶.

In the relationship that human beings establish with their surrounding environment, it becomes evident that the common (albeit subjective) experience of architecture tends to pay less attention to the theories and history it embodies, and is more influenced by the conditions of visual, tactile, and functional experience of buildings. Moreover, the everyday direct experience of architecture is overlapped and complemented by “the experience mediated by representation: from photographic images to literary descriptions, from cinema to television, from painting to drawing, ... which tend to provide us with knowledge of works that we may never have experienced directly⁷ and perhaps never will [...]. The challenge, the main problem of representation in architecture, lies precisely in this: in being able to account for all its statuses, all its metric, material, and qualitative determinations by means of a simulacrum; to allow its experience and understanding while it is not present, while it remains at a perceptual distance or within the virtuality of the project [...]. Like history, theory, and technique, representation must also have a truth-bearing function: not only is it not permitted to betray the ‘truth’ of the work, but it must reveal it, demonstrate it, construct it, placing itself in relation to history, theory, and technique; and its truth must unfold on a double level: with respect to the work, as the fidelity of the produced ‘copy’ to the currently existing ‘original’; and with respect to representation itself, as the internal coherence of the reproductive

6. Ugo, *Fondamenti della rappresentazione*, 9-11. According to Margherita De Simone, “the ‘artefact’ has always been configured in two distinct ways: one with an idealist connotation (artefact = value); the other with a materialist connotation (artefact = function), to employ two recognizable and historically definable categories” (Margherita De Simone, *Disegno, rilievo, progetto. Il disegno delle idee, il progetto delle cose*, La Nuova Italia Scientifica, 1990, 219-220).

7. According to Vittorio Ugo, “architecture is not a visual art, although it possesses an image; indeed, it may have many, depending on the point from which it is observed, the way it is illuminated, photographed, or represented on a drawing sheet or on the pages of a journal. Architecture has an image, but it is not an image; it is a ‘thing’ and a place; it does not primarily consist in its images, but in its status as a built entity in relation to dwelling. And, as Martin Heidegger states, ‘Building is properly dwelling’ because ‘only if we have the capacity to dwell can we build’. With reference to architecture, form is therefore something quite different from image; and it is so precisely because of its inseparable connection, on the one hand, with statics (the Vitruvian *firmitas*), and on the other, with dwelling and its related culture. An analysis of the etymology of the terms leads to a surprising conceptual circuit that precisely links the notion of form to that of dwelling (Vittorio Ugo, *Architettura e temporalità* (Edizioni Unicopli, 2008), 27).

process”⁸.

Recalling the words of Michel Foucault, representation, in the technical form of surveying, is therefore called upon to document the “monuments”⁹ that surround us, that is, “to fix in drawing and measurement the state of affairs at a given moment, to disseminate its knowledge, to preserve its memory, and to transmit it to posterity”¹⁰.

According to the architect Marco Fasolo, “surveying should be understood as a cognitive model of the object under analysis, in which, through two complementary actions (one of scientific investigation aimed at recording information in order to organise data into a synthetic language, and a second aimed at evaluating and ordering the information obtained according to logical criteria based on acquired knowledge), a vast amount of historical, artistic, humanistic, and technical data is processed”¹¹ [Fig. 4.1].

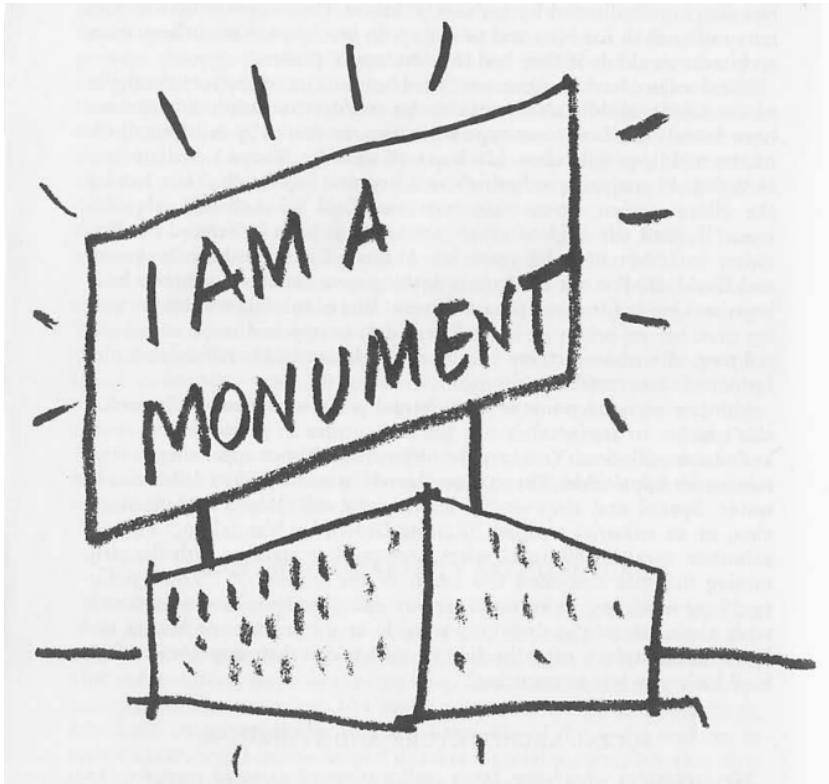


Fig. 4.1 Recommendation for a monument.

[Robert Venturi, Denise Scott Brown, and Steven Izenour, *Learning from Las Vegas* (The MIT Press, 1977), 156]

8. Ugo, *Fondamenti della rappresentazione*, 9-11.

9. Michel Foucault, *L'archeologia del sapere. Una metodologia per la storia della cultura* (BUR Rizzoli, 2020), 11.

10. Ugo, *Fondamenti della rappresentazione*, 32-36.

11. Marco Fasolo, “Il rilievo come modello conoscitivo,” *XY. Dimensioni del disegno* IX, no. 23-24-25 (Officina Edizioni, 1995): 103.

In these terms, representation “can assume a role closely analogous to that of the ‘new’ history described by Michel Foucault: it is concerned with ‘isolating, grouping, establishing relevance, relating, and constituting into sets’ the mass of elements that architecture offers to analysis. In essence, it operates critically - that is, selectively - constructs an archaeology understood as a system of principles, and ‘monumentalizes’ the document by preserving its memory and revealing its historicity. In doing so, it conceptually repositions the document, inserting it into a new historical context and into a dimension distinct from that of direct empirical experience. As such, representation never coincides with mere copying, just as the historian’s narration and documentation, as well as the painter’s portrait, never amount to the simple duplication of an ‘original’ or of its image”¹².

On the other hand, each of us “is at every moment confronted with the fact that the world is, in itself, unknowable in its entirety: it appears to us filtered through the interpretative tools that Nature has provided, tools that necessarily offer a partial and distorted description. Any form of reading or representation of reality therefore inevitably entails a choice: we are unable to fully comprehend the world, but only parts of it, and thus we must each time decide where to begin, influenced by contingent interests or by the automatisms of our cognitive functions. Those who engage scientifically in the description of reality must therefore consciously make a selection, choosing one or more of the possible modes of knowledge available to us and one of their specific degrees of precision, thereby implementing a true project of knowledge in which objectives, timeframes, costs, and available resources are evaluated and correlated within a coherent whole”¹³. It is therefore appropriate to dispel once and for all the ‘subtle ambiguity’ according to which the surveyor is expected to carry out his operations passively, merely tasked with providing objective measurements, acquired and returned with the utmost neutrality. The surveyor, on the contrary, designs and plans the survey according to his own cultural framework; it is already at this stage of data acquisition that the act of surveying assumes the form of a critical and cognitive activity¹⁴. The data obtained through the investigation of the analysed reality, and sto-

12. Ugo, *Fondamenti della rappresentazione*, 32-36.

13. Maurizio Boriani, “Rilievo, tutela e conservazione del paesaggio antropico,” *XY Dimensioni del disegno* XII, no. 32-33 (Officina Edizioni, 1998): 40.

14. De Simone, *Disegno, rilievo, progetto*, 219-220.

red - for example - in a computer's memory, come to constitute the model [...]. These data can subsequently be retrieved in various forms of representation by the user of the survey, who may then determine the appropriate mode of interpretation according to their own cultural framework, pursuing further analysis in line with specific interests and objectives"¹⁵.

If every representation is therefore marked by the imprint of its author, in what way do the outputs of architectural surveying acquire documentary value as accurate records and truthful testimonies of the specific reality to which they refer? According to Vittorio Ugo, surveying as the measurement and representation of what exists is a "document of a document", potentially endowed with historical value. "However, in order for it to be a historical document, it is not sufficient that it be truthful and dated: it must display its own historicity and the 'way' in which it tells the truth. Beyond *mimesis*, it is required to produce analysis, critique, hermeneutics - a model that interprets form in all its spatial, historical, material, and qualitative determinations [...]. This is why surveying is also a form of design, a form of knowledge, a documentation that, once again recalling Foucault, 'tends to become monument.' [...] If the survey-document, as its etymology requires, must *docere*, that is, possess a didactic character rather than mere figuration; if it must tend toward the monument, to memorise and admonish (*mimnésko*, *moneo*), and not remain an inert graphic fixation of a state of affairs; then the representation constructed by the survey must produce *mimesis* in its deepest sense"¹⁶.

The operations of surveying must be directed both toward the "visible" and the "non-visible." "The 'visible' essentially concerns the metric determinations of perceptual data and their graphic restitution, thus relying on a *mimesis* of a figurative order, appropriately quantified. The 'non-visible' may concern either the synthetic graphic restitution of ensembles that are overall invisible but composed of individually visible elements (a plan, a section, a territorial fragment, ...), or the representation of realities not directly perceptible through sight alone (structural equilibria and stresses of materials, land-use regimes, historical components and references, ...). In this second case, *mimesis* clearly concerns deeper structures, and the corresponding modelling assumes a more

15. Fasolo, "Il rilievo come modello," 103.

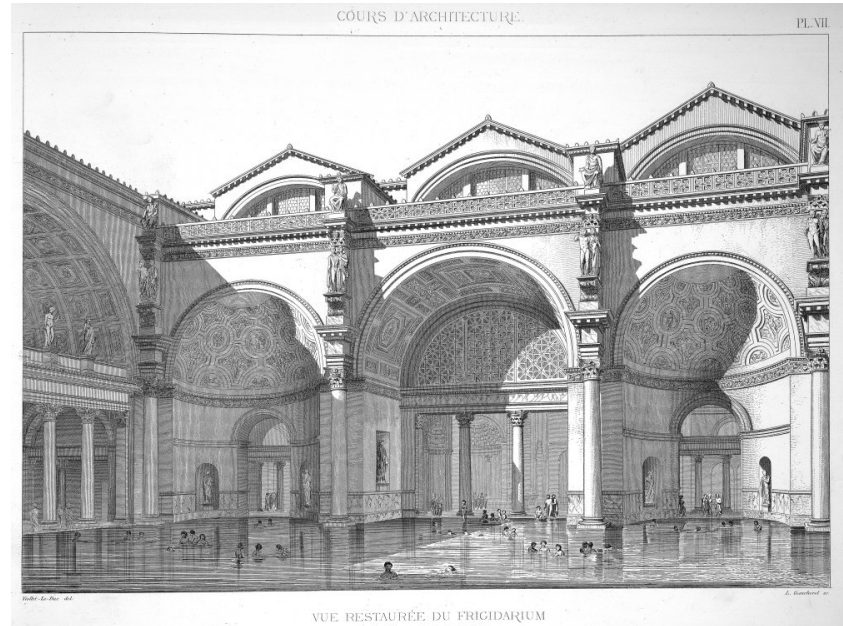
16. Ugo, *Fondamenti della rappresentazione*, 137-138.

markedly critical character”¹⁷ [Fig. 4.2].

All this, however, will not exempt the document from future “charges of ‘falsehood’ in an implacable ‘trial of the document’ conducted by future historians, but it will at least earn it ‘extenuating circumstances’, even in the face of such astute inquisitors as to invert the well-known saying ‘translator-traitor’ into its reverse, ‘traitor-translator’”¹⁸.

Fig. 4.2 E.E. Viollet-le-Duc, *Bath of Caracalla, Rome: conjectural reconstruction of the Frigidarium*, 1864.

[https://www.ribapix.com/baths-of-caracalla-rome-conjectural-reconstruction-of-the-frigidarium_riba17728]



Within this framework, we may ultimately conclude that “the primary aim of surveying, as a specific process within the discipline of architectural survey, is the attainment of critical and scientific knowledge (that is, oriented, evaluative, verifiable, and transmissible) and the systematic documentation of the quantitative and qualitative consistency (physical-spatial, metric, historical, related to use and state of conservation, etc.) of archaeological, architectural, and landscape heritage - heritage that surveying itself contributes to defining. It follows that any illusion of a purely technicist neutrality in surveying must be abandoned, although the practical uses of its results may, of course, be multiple, and even unforeseen or unexpected. [As already noted in the

17. Ugo, *Fondamenti della rappresentazione*, 118-123.

18. Giuseppe Fusco, “Rilievo e memoria,” *XY. Dimensioni del disegno* V, no. 11-12 (Officina Edizioni, 1991): 128-129.

preceding paragraphs,] the outcome of surveying is the construction of 'models', thematically grounded within the discipline, as critical and scientific representations of physical reality and its metric, historical, and aesthetic components; and thus the formation of an 'archive' as the place in which knowledge is deposited, organised, and elaborated"¹⁹. Surveying, therefore, proceeds through models²⁰, which may be "metric", "descriptive-figurative", "element-based" and "descriptive-perceptual" "thematic", and "interpretative-relational", as well as "critical-relational" and "synthetic". Each of these models produces "representations" of reality that possess a paradoxical quality: on the one hand, the model "is precisely dissimilar from the way things actually are in nature"; on the other, it is a facsimile of reality, even if "the correspondence between the model's operation and the behaviour of the things it represents will likely be imperfect [...]. A model is a device, an expedient, a kind of 'imaginary machine' that human beings construct artificially, yet which can be related to the sector of reality under investigation insofar as the successive configurations of the represented system [...] are imitated by those of the corresponding parts of this machine. The concept of 'model', therefore, does not refer solely to *maquettes* or physical models, but above all to theoretical, mental, and representational ones"²¹.

"As a cultural and technical activity deeply rooted in its own time, surveying, like most other disciplines, has had [for several years now] to contend with the digital revolution in the fields of representation, in-

19. Ugo, *Fondamenti della rappresentazione*, 118-123.

20. On the concept of a model, see: Elisa Guagenti, "Modello, ovvero conoscere per decidere," in *Tempo forma immagine dell'architettura. Scritti in onore di Vittorio Ugo con due suoi testi inediti*, ed. G.A. Massari (Officina Edizioni, 2010), 99-108; Roberto de Rubertis, "Riflessioni sulle nuove tendenze," *XY Dimensioni del disegno* IX, no. 23-24-25 (Officina Edizioni, 1995): 12-13; Ugo, *Fondamenti della rappresentazione*; Uliva Velo, "Alcune considerazioni sul significato di modello d'architettura," in *Metodologie integrate per il rilievo, il disegno, la modellazione dell'architettura e della città*, ed. E. Chiavoni, M. Filippa (Gangemi editore, 2011): 120-123.

21. Giovanna A. Massari, "Riferimenti teorici e ambiti operativi," in *Rilievo urbano e ambientale. Appunti, repertorio iconografico, antologia critica*, ed. G.A. Massari, C. Pellegatta, and E. Bonaria (Libreria Clup, 2006), 30-31. From an epistemological perspective, one may argue that a model is the product of a process of selection whereby a subject operates on an object in order to extract some of the infinitely many pieces of information it contains. The selected data, however, are not the result of arbitrary readings; rather, they are governed by rules that the subject establishes in advance, more or less consciously and rigorously, in order to create a stable relationship between the object and its model. At this stage, however, the model remains accessible only to the subject who constructed it: it is in the subsequent phase of representation that the data are encoded and translated into a form that can be communicated to other subjects capable of interpreting the representational code (Carlo Bianchini, "Modelli discreti e modelli continui nel rilievo e rappresentazione informatizzata dell'architettura," *Disegnare. Idee immagini* XII, no. 22, Gangemi editore, 2001: 51-52).

formation management, and communication”²². In general, among the main consequences of technological advancement observed in recent decades, one may note, on the one hand, as mentioned in the previous chapter, the indefinite expansion of the boundaries of both historical document and memory, which opens new horizons for the production of these “document-monuments”²³; on the other hand, the promotion of “a cultural phenomenon that strongly characterizes our time, a sort of ‘archival mania’ that permeates our lives and our cultural and scientific activities at various levels”²⁴.

In the field of surveying, these tendencies in fact have deep roots. As early as 1998, Roberto de Rubertis opened the magazine “XY. Dimensioni del disegno”, launching a provocation, still topical today, about the need for a new type of survey beyond measurement, that goes further than geometric cast which we have often believed could substitute for architecture and the environment in the illusion of capturing its quality²⁵. That invitation is more relevant today than ever, given the ease of acquiring large amounts of data to create that ‘geometric cast’ of reality through 3D (image-based, range-based) digital survey tools²⁶.

“The theme of the ‘excess’ of data that can be acquired”²⁷ is part of the broader and more complex phenomenon of digitalisation²⁸, reflecting a society that daily, in various spheres of private and public life, produ-

22. Alberto Melucci and Flavio Nider, “Fotografia, infografica e rilievo d’architettura,” in *Gli archivi per la storia dell’architettura*, Atti del convegno internazionale di studi, Reggio Emilia, 4-8 ottobre 1993 (1999), 544. See also: Jean Paul Saint Aubin, “Nuove tendenze del disegno di sintesi,” *XY. Dimensioni del disegno* IX, no. 23-24-25 (Officina Edizioni, 1995), 75.

23. Fusco, “Rilievo e memoria,” 128-129.

24. Melucci and Nider, “Fotografia, infografica e rilievo d’architettura,” 544.

25. Roberto De Rubertis, “Editoriale,” *XY. Dimensioni del disegno. Rappresentazione e verità*, no. 32-33, (Officina Edizioni, 1998), 3.

26. Violette Abergel, Kevin Jacquot, Livio De Luca, and Philippe Veron, “Combining on-site and off-site analysis: towards a new paradigm for cultural heritage surveys,” *Disegnarecon* 14, no. 26 (2021), <https://doi.org/10.20365/disegnarecon.26.2021.13>. «The processes underlying the acquisition and processing of 3D data from active and passive sensors are well known, as the result of experimentation and refinement gained in the research field over the last fifteen years. The necessity to apply these systems for the acquisition of extensive areas of territory or complex shapes focuses on the issue of massive acquisition of three-dimensional data. Massive survey activity is intended as a very large multiresolution and/or multi-instrumental approach devoted to representing huge objects at variable scale, which still today highlights a series of limits and methodological aspects. These latter require attention to improve control on the entire process and getting results useful for Cultural Heritage understanding» (Carlo Bianchini and Michele Russo, “Massive 3D acquisition of CH,” in *3rd Digital Heritage International Congress (DigitalHERITAGE)*, 24th International Conference on Virtual Systems & Multimedia (2018), 1).

27. Giovanna A. Massari, “Del rigore della misura,” *XY. Dimensioni del disegno. Rappresentazione e verità* 9, no. 47 (Officina Edizioni, 2005): 105-116.

28. European Commission, *Bussola per il digitale 2030: il modello europeo per il decennio digitale* (2021), <https://digital-strategy.ec.europa.eu/en/news/commission-proposes-common-european-data-space-cultural-heritage>.

ces, exchanges, and consumes a ‘huge’ amount of data²⁹. In the field of urban and architectural surveying, as in many other fields and disciplines³⁰, the plethora of data collection leads to significant data management problems in various phases of the work: selection, which is often carried out *ex post* depending on the survey’s objective³¹; processing, which needs high-performance computers; archiving, which requires sufficiently large storage media and must account for technological obsolescence; and fruition, which struggles with format compatibility and often involves significant selection of information to suit device performance or web sharing. The accessibility (in terms of cost and ease of use) of low-cost digital survey tools (e.g., spherical cameras, smartphones, and tablets with LIDAR sensors) that, although with less precision, allow for the acquisition of large amounts of data in a short time³², suggests hypothetical scenarios of extensive survey campaigns. The increasing popularity of these procedures shifts the discussion to the usefulness of the data, meaning the functionality of the information acquired in relation to the purpose of the survey³³ [Fig. 4.3].

Indeed, the functionality of a datum is not an intrinsic property, but depends on certain of its characteristics which, if properly defined, can

29. Federico Valacchi, *La verità di carta. A cosa servono gli archivi?* (Graphe.it, 2023); Federico Valacchi, *La memoria integrata nell’era digitale. Continuità archivistica e innovazione tecnologica* (Archilab, 2006).

30. Mariella Guercio, *Conservare il digitale. Principi, metodi e procedure per la conservazione a lungo termine di documenti digitali* (Laterza, 2013); Paul G. Weston, “Digital curation. Nuove opportunità per bibliotecari e archivisti,” in *Il libro, gli archivi e la memoria digitale*, ed. P.G. Weston (Unicopli, 2013).

31. «For centuries the limited amount of measurable points required a preliminary accurate design of the survey operations in order to capture the really significant ones (selection before acquisition). In the last decades, instead, this order has been somehow inverted thanks to new massive measurement technologies in which selection follows acquisition» (Carlo Bianchini, “Survey, modeling, interpretation as multidisciplinary components of a Knowledge System,” *SCientific REsearch and Information Technology Ricerca Scientifica e Tecnologie dell’Informazione* 4, i. 1(2014): 15-24, <http://dx.doi.org/10.2423/i22394303v4n1p15>).

32. Chiara Chioni, Anna Maragno, Angelica Pianegonda, Marco Ciolli, Sara Favargiotti, and Giovanna A. Massari, “Low-Cost 3D Virtual and Dynamic Reconstruction Approach for Urban Forests: The Mesiano University Park,” *Sustainability* 15, no. 19 (2023), <https://doi.org/10.3390/su151914072>; Mateusz Janiszewski, Masoud Torkan, Lauri Uotinen, and Mikael Rinne, “Rapid Photogrammetry with a 360-Degree Camera for Tunnel Mapping,” *Remote Sensing* 2022 14, no. 21 (2022), <https://doi.org/10.3390/rs14215494>; Giuseppina Vacca, “3D Survey with Apple LiDAR Sensor - Test and Assessment for Architectural and Cultural Heritage,” *Heritage*, no. 6 (2023): 1476-1501, <https://doi.org/10.3390/heritage6020080>.

33. Anna Maragno, Ambra Barbini, Elena Bernardini, Chiara Chioni, and Giovanna A. Massari, “La misura per la dismisura dei dati da rilievo digitale 3D. Il caso del centro storico di Trento = The Measure for Uncountable data from 3D Digital Survey. The Case of the Historical Centre of Trento,” in *Misura / Dismisura. Atti del 45° Convegno Internazionale dei Docenti delle Discipline della Rappresentazione = Measure / Out of Measure. Transitions. Proceedings of the 45th International Conference of Representation Disciplines Teachers*, ed. F. Bergamo, A. Calandriello, M. Ciammaichella, I. Friso, F. Gay, G. Liva, and C. Monteleone (FrancoAngeli, 2024), 1679-1698, [10.3280/oa-1180-c554](https://doi.org/10.3280/oa-1180-c554).



Fig. 4.3 An evocative image showing the amount of data acquired using different 3D digital survey technologies. From left to right: mobile laser scanner, spherical camera, camera on a telescopic rod, terrestrial laser scanner, tablet with a LIDAR sensor, and drone.

[Maragno, Barbini, Bernardini, Chioni, and Massari, “La misura per la dismisura dei dati da rilievo digitale 3D,” 2024]

be measured and evaluated both before and after acquisition according to a specific objective. To this end, it is worth recalling once again that the act of “measuring”, “in order to acquire meaning, must imply [...] a capacity for critique, and thus for selection and attribution of value according to a clearly defined intentionality”³⁴, and that it is neither possible nor useful to document and represent “everything” without form dissolving into an indistinct neutrality³⁵. Ultimately, as the architect Livio de Luca argues, “in the enthusiastic embrace of this new era, it is imperative to maintain a critical perspective. One must weigh not only the enormous possibilities offered by digital data but also understand and acknowledge the methodological limitations inherent in their generation within the scientific landscape [...]. Constructive critique and the continuous revision of digital practices are essential to ensure that research is not merely driven by technological solutions, but is also grounded in a profound humanistic understanding”³⁶.

The ‘archival mania’ can therefore be regarded as a deviation, an extreme consequence of the contemporary process of digitization of cultural heritage. This is a practice widely promoted and funded by the European Union in recent years³⁷ with the aim of preserving the memory of

34. Vittorio Ugo, “Misura-interpretazione-conoscenza-interpretazione-misura: circolo vizioso, o virtuoso?”, *XY. Dimensioni del disegno. Rappresentazione e verità*, no. 32-33 (Officina Edizioni, 1998): 19-24.

35. Ugo, *Fondamenti della rappresentazione*, 32-36.

36. Livio De Luca, “Un ecosistema digitale per lo studio interdisciplinare di Notre-Dame de Paris,” *Disegnare. Idee immagini* XXXIV, no. 66 (Gangemi Editore, 2023), 18.

37. “Commission proposes a common European data space for cultural heritage,” European Commission, last modified January 30, 2023, <https://digital-strategy.ec.europa.eu/en/news/commission-proposes-common-european-data-space-cultural-heritage>. “Over the last 20 years, the European Union (EU) has invested more than €1 billion in supporting cultural heritage (CH) in-

material assets exposed to the risks of natural or war-related events and, at the same time, of expanding knowledge, conservation, and accessibility of heritage in an era in which collections and cultural sites are still often confined to areas that are difficult to access or not open to visitors³⁸.

In the field of built heritage in particular, models produced through advanced 3D digital surveying techniques play a fundamental role - now more than ever - in making historic buildings (and beyond) an integral part of contemporary life, fostering the convergence of past and present knowledge in order to facilitate their interpretation and conservation, while also supporting the envisioning of their possible future use³⁹.

Alongside public investments in digitization, the past fifteen years have witnessed the emergence of large- and medium-scale 2D and 3D digitization programs led by commercial enterprises such as Google, as well as by NGOs such as CyArk⁴⁰ and Global Heritage Fund⁴¹, and by initiatives including the Smithsonian Institution⁴², the Zamani Project in Africa⁴³, and many others. Information and Communication Technologies (ICT), by drastically facilitating the creation and distribution of content, have generated exponential growth in the production of infor-

stitutions and stakeholders (museums, sites, monuments, archives and libraries) to digitise their assets, archive, protect, preserve and make them available for use and re-use in research, innovation and education. The instruments used for this purpose comprised Limited liability company (d.o.o.) the Research Framework Programmes (FP) including FP61 (2002-2006), FP71 (2007-2013) and H20202 (2014-2020), eContent and ContentPlus, the European regional development fund (ERDF), European social fund (ESF) and other programmes. This investment has driven a unique period for research, innovation, education and intersectorial development across the European CH area, in which organisations of all scales have developed models and methodologies for digitisation. In the global education sector, more than 97% of the BA, BSc, MSc and MA courses in digital humanities, digital social sciences and cultural informatics have been developed during the last 20 years, a large number of them offered by tertiary education institutions in the EU. Europeana, Europe's digital library for CH has become a successful reality, promoting the creation of a strong network of EU national and thematic aggregators and bringing together a multidisciplinary professional and technical CH community to increase innovation, collaboration and the creation of new digital multimedia content" (European Commission, *Study on quality in 3D digitisation of tangible cultural heritage: mapping parameters, formats, standards, benchmarks, methodologies, and guidelines*, VIGIE 2020/645, 2022, 4-5).

38. Cecilia Bolognesi, "From heritage to massive future fruition," in *Digital & Documentation. Digital strategies for Cultural Heritage*, ed. M. Lo Turco, E.C. Giovannini, and N. Mafri, v. 2 (Pavia University Press, 2020), 189.

39. Fabio Remondino, "Il rilievo 3D fotogrammetrico," in *Teorie e tecniche della rappresentazione contemporanea*, ed. R. Salerno (Maggioli Editore, 2011), 195-196; Fabio Remondino, "Heritage Recording and 3D Modeling with Photogrammetry and 3D Scanning," *Remote Sensing* 6, no. 3 (2011): 1104-1138, <https://doi.org/10.3390/rs3061104>.

40. CyArk, accessed May 1, 2026, <https://www.cyark.org/>.

41. Global Digital Heritage, accessed May 1, 2026, <https://globaldigitalheritage.org/>.

42. The Smithsonian Institution is the world's largest museum, education, and research complex (Smithsonian, accessed May 1, 2026, <https://www.si.edu/>).

43. Zamani Project, accessed May 1, 2026, <https://www.zamaniproject.org/>.

mation and digital data, to the point that the size of the digital universe has been observed to double every two years⁴⁴.

Advances in 3D digitization have significantly improved access to cultural heritage for purposes related to research, innovation, education, and entertainment. In the EAC (Engineering, Architecture, and Construction) sector, one of the main ambitions of digitization lies in the creation of information systems capable of integrating the 3D representation of a building with the evolutionary data produced throughout its life cycle, thus creating a kind of centralized, structured, coherent, and non-redundant archive capable of supporting building management. These information systems can optimize and integrate processes of conservation, intervention, and enhancement at different scales of built heritage⁴⁵, ranging from the territorial level (GIS - Geographic Information System) to the architectural level (BIM - Building Information Model⁴⁶)⁴⁷.

In particular, with regard to historic built heritage, the spread of Historic (or Heritage) Building Information Modeling (HBIM)⁴⁸ enables advanced management of complex scenarios such as historic buildings, archaeological sites, ancient infrastructures, and monuments. Unlike the early digital era, in which computer-aided 2D and 3D drawing (CAD) consisted of purely geometric elements, HBIM assists architects, engineers, and archaeologists in adding new layers of information (metadata) to the architectural and structural components of surveyed artefacts, which are conceived as parametric objects - that is, virtual components

44. European Commission, *Study on quality in 3D digitisation*, 4-5.

45. Cursi et al., "Digital processes for the conservation," 34-35.

46. "Born in the building design context for parametric modelling, BIM platforms developed his algorithms and software over the last years in Architecture Engineering and Construction (AEC) industry management for new buildings. Nowadays BIM is largely settled and useful in the context of Facility Management (FM) activities on existing buildings, the so-called "as-built BIM". BIM on real objects enables the monitoring of all design and life cycle assessment, maintenance, refurbishment, deconstruction, end-of-life considerations and side-analysis (contact-less or invasive analysis: energetic efficiency, structural, material...) [...]. In early XXI the first HBIM was developed like a new prototype-system of BIM, a modelling of historic structures as parametric objects in a database "library". These objects can be collected and moulded in the reverse engineering process, creating full 2D and 3D models including details behind the object's surface, concerning its methods of construction and material makeup. Information are taken on the base of 3D reality-based data from point clouds, by automatic or semi-automatic recognition" (Filiberto Chiabrand, Giulia Sammartano, and Antonia Spanò, "Historical Buildings Models and Their Handling Via 3D Survey: From Points Clouds To User-Oriented Hbim," *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci.* XLI-B5, 2016: 633-640, <https://doi.org/10.5194/isprs-archives-XLI-B5-633-2016>).

47. Marco Gaiani, "Metodi di fruizione di modelli 3D digitali dalla scala dell'oggetto a quella della città con dispositivi a differente livello di iconicità e facilità di interazione," in *Metodologie integrate per il rilievo, il disegno, la modellazione dell'architettura e della città*, ed. E. Chiavoni, and M. Filippa (Gangemi editore, 2011), 127.

48.

of a building defined by modifiable parameters⁴⁹ [Fig. 4.4]. The transition from CAD representations to reality-based 3D information models (scan-to-BIM processes) has also enabled EAC professionals to improve their analyses, thanks to the possibility of condensing and sharing large amounts of data within a single ‘intelligent’⁵⁰ model, thereby supporting collaborative management of the built environment⁵¹.

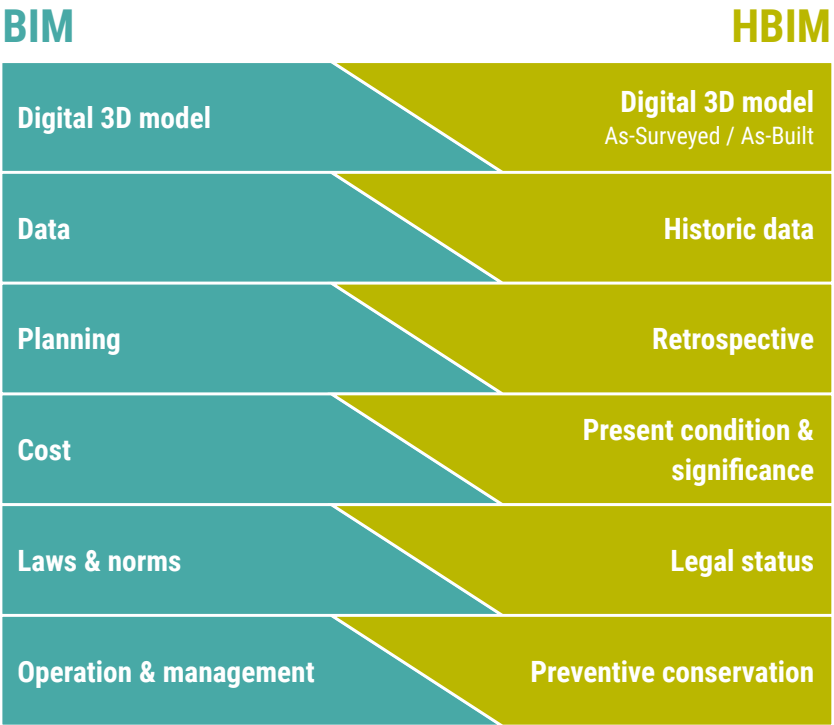


Fig. 4.4 The type of information that should be integrated in HBIM data model in comparison with standard BIM data models.

Within the framework of this plural management of the existing, the direction of development that has emerged in recent years is that of creating Digital Twins⁵² (DT), that is, digital replicas of the built en-

49. Danae P. Pocobelli, Jan Boehm, Paul Bryan, James Still, and Josep Grau-Bové, “BIM for heritage science: a review,” *Heritage Science* 1, no. 6 (2018), <https://doi.org/10.1186/s40494-018-0191-4>.

50. Pocobelli et al., “BIM for heritage science”.

51. Fabrizio Banfi, Raffaella Brumana, and Chiara Stanga, “Extended Reality and informative models for the architectural heritage: from scan-to-BIM process to Virtual and Augmented Reality,” *Virtual Archaeology Review* 21, no. 10 (2019): 14-30, <https://doi.org/10.4995/var.2019.11923>.

52. “The origin of the Digital Twin is attributed to Michael Grieves and his work with John Vickers of NASA, with Grieves presenting the concept in a lecture on product life-cycle management in 2003. In a time when Grieves describes virtual product representations as ‘...relatively new and immature’ and data collected about physical products as ‘...limited, manually collected, and mostly paper-based’, Grieves and Vickers saw a world where a virtual model of a product would provide the foundations for product life-cycle management. The initial description defines a Digital Twin as a virtual representation of a physical product containing information about said product, with

vironment connected to databases of information and to sensors that provide real-time operational data on artefacts, in order to automatically detect potential hazards and ongoing phenomena, and to assess and intervene promptly in response to such dynamics⁵³. The generation of Digital Twins of heritage from the past represents the challenge upon which the conservation of historical heritage for future generations is now founded, as well as a key driver in the advancement of new construction⁵⁴ [Fig. 4.5].

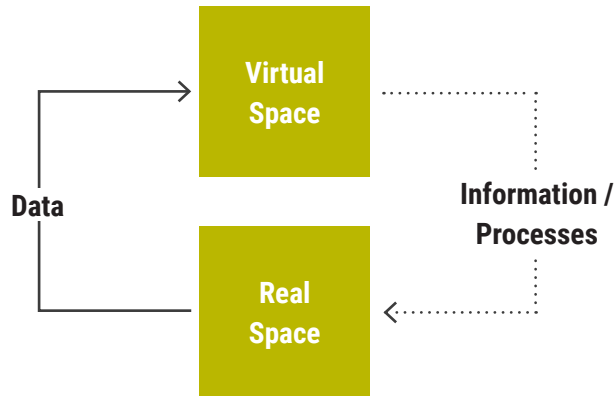


Fig. 4.5 Mirroring or Twinning between the physical and virtual spaces.

In recent years, the availability and richness of the data collected - used to generate digital models with high levels of detail (LOD), information (LOI), and accuracy⁵⁵ - together with the development, within visual culture, of multimodal and multi-scalar visualization and interaction systems aimed at evoking typical human modes of cognition and perception⁵⁶, have driven toward an increasingly immersive and interactive

its origins in the field of product life-cycle management. In an early paper Grieves expands on this definition by describing the Digital Twin as consisting of three components, a physical product, a virtual representation of that product, and the bi-directional data connections that feed data from the physical to the virtual representation, and information and processes from the virtual representation to the physical. Grieves depicted this flow as a cycle between the physical and virtual states (mirroring or twinning); of data from the physical to the virtual, and of information and processes from the virtual to the physical. The virtual spaces themselves consisting of any number of sub-spaces that enable specific virtual operations: modelling, testing, optimisation, etc.” (David Jones, Chris Snider, Aydin Nassehi, Jason Yon, and Ben Hicks, “Characterising the Digital Twin: A systematic literature review,” *CIRP Journal of Manufacturing Science and Technology* 29, p. A (2020): 36-52, <https://doi.org/10.1016/j.cirpj.2020.02.002>).

53. Pierre Jouan and Pierre Hallot, “Digital twin: a HBIM-based methodology to support preventive conservation of historic assets through heritage significance awareness,” *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* XLII-2/W15 (2019): 609-615, <https://doi.org/10.5194/isprs-archives-XLII-2-W15-609-2019>.

54. Bolognesi, “From heritage to massive future fruition,” 189.

55. Fabrizio Banfi, “The Evolution of Interactivity, Immersion and Interoperability in HBIM: Digital Model Uses, VR and AR for Built Cultural Heritage,” *ISPRS Int. J. Geo-Inf.*, no. 10 (2021): 685, <https://doi.org/10.3390/ijgi10100685>.

56. Gaiani, “Metodi di fruizione di modelli 3D digitali,” 127.

use of models, capable of reaching not only architects and engineers but also non-expert users in the fields of representation and architecture⁵⁷. The expression ‘immersive environments’ essentially refers to visualization and interaction concepts that fall under the broader umbrella of Extended Reality (XR), namely Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR). In essence, XR technology merges the real and virtual worlds, enabling users to visualize and interact with virtual objects either within a fully immersive virtual environment (VR) or within a real world enhanced by virtual elements (AR, MR)⁵⁸. “If the Cubists had been correct in believing that architecture could be defined in terms of four dimensions, our means would be sufficient for a fairly complete representation of space. But architecture [...] has more than just four dimensions”⁵⁹. Today, the new frontiers of visual culture, aimed at the dissemination and application of XR technologies, also within the field of Digital Public History, are precisely grounded in the search for new methods and frameworks to represent and communicate architecture in all its dimensions. On the other hand, as Bruno Zevi argues, “there is a physical and dynamic element in grasping and evoking the fourth dimension through one’s own movement through space. Not even motion pictures, so complete in other respects, possess that main spring of complete and voluntary participation, that consciousness of free movement, which we feel in the direct experience of space”⁶⁰. However, despite ongoing efforts to create increasingly immersive and realistic experiences, “whenever a complete experience of space is to be realized, we must included, we must feel ourself part and measure of the architectural organism, be it an Early Christian basilica, Brunelleschi’s Santo Spirito, a colonnade by Bernini or the storied stones of a medieval street. We must ourselves experience the sensation of standing among the *pilotis* of a Le Corbusier house, of following one of the several axes of the polyform Piazza del Quirinale, of being suspended in air on a terrace designed by Wright or of responding to the thousand visual echoes in a Borromini church. All the techniques of representation and all the paths to architecture which do not include direct expe-

57. Banfi, Brumana, and Stanga, “Extended Reality and informative models,” 14-30.

58. Shaoze Wu, Lei Hou, and Guomin Zhang, “Integrated Application of BIM and eXtended Reality Technology: A Review, Classification and Outlook,” in *Proceedings of the 18th International Conference on Computing in Civil and Building Engineering* (2021), 1227-1236, [10.1007/978-3-030-51295-8_86](https://doi.org/10.1007/978-3-030-51295-8_86).

59. Bruno Zevi, *As space. How to look at architecture* (Joseph A. Barry, 1957), 59.

60. Zevi, *As space*, 59.

rience are pedagogically useful, of practical necessity and intellectually fruitful; but their function is no more than allusive and preparatory to that moment in which we, with everything in us that is physical and spiritual and, above all, human, enter and experience the spaces we have been studying. That is the moment of architecture”⁶¹.

61. Zevi, *As space*, 59-60.

04.2 Data acquisition through traditional and low-cost 3D digital survey methods

In today's era, most people constantly experience the coexistence of a tangible material reality and an equally real immaterial one in both life and work. The boundary between these two realms is not clear, it has a variable path, depending on the role that is reserved for digital technologies and the continuous innovations they offer in the various activities¹. Often, due to market-driven considerations, certain technological innovations are abandoned in the bud because they are mere expressions of temporary fashions incapable of offering a true contribution to the progress of knowledge, social well-being, and environmental protection. In other cases, advancements in scientific research can lead to practices that gradually take root, reshaping the epistemological framework of our action, imparting a deep change both in the theoretical approaches and in operational tools².

The development and integration of complex digital technologies has also radically transformed the way we document and engage with architecture and cultural heritage (CH). Above all, the connection between technology and visual communication has significantly influenced the fields of architecture, design, and CH, particularly in relation to the analysis, visual representation, and interpretation of CH sites. In fact, on one hand, documentation technologies like laser scanning and digital photogrammetry enable increasingly rapid, accurate, and comprehensive 3D surveys. On the other hand, representation and fruition methods, such as 3D renderings, Building Information Modeling (BIM), Augmented Reality (AR), and Virtual Reality (VR) transform, enrich, and enhance the experience of cultural heritage sites³.

According to Douglas Pritchard⁴, the process of digitally documenting

1. Tomas Maldonado, *Reale e virtuale* (Feltrinelli, 2005).

2. Ambra Barbini, Francesco Giampiccolo, Anna Maragno, Giovanna A. Massari, and Cristina Pellegatta, "Innovation and tradition: integrated practices in the architectural survey of Pretorio palace in Trento," *SCientific RESearch and Information Technology Ricerca Scientifica e Tecnologie dell'Informazione*, v. 14, i. 1 (2024): 45-62, <http://dx.doi.org/10.2423/i22394303v14n1p45>.

3. Douglas Pritchard, "Intersezioni tra tecnologia, comunicazione grafica e rappresentazione del patrimonio culturale," *Disegnare. Idee immagini* XXXIV, no. 66 (Gangemi Editore, 2023), 48-49.

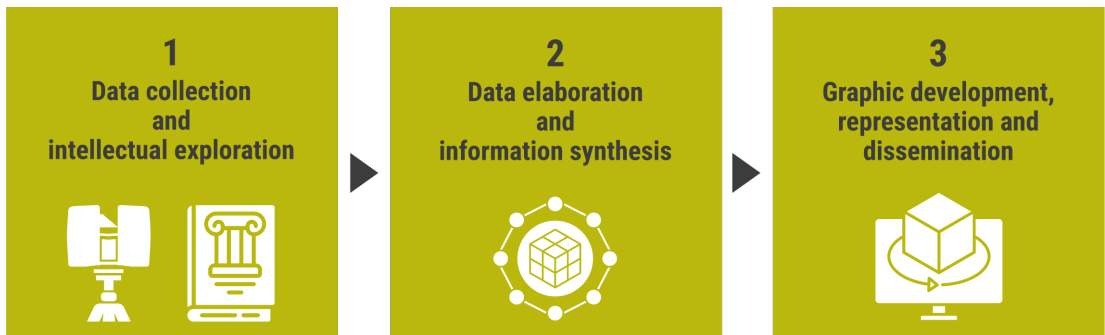
4. Douglas has directed numerous 3D projects worldwide, including the Aachen Cologne Cathedral UNESCO World Heritage Site (in collaboration with the University of Rome Sapienza), Cologne Cathedral UNESCO World Heritage Site project, LHCb at CERN, Urban Model for Glasgow, and the Scottish Ten Project. Douglas is also a Lecturer in the Advanced Academic Program at Johns Hopkins University, a former Honorary Research Fellow at the University of Glasgow and Industry Co-Chair of the Our World Heritage initiative ("Mr Douglas Pritchard," OpenAIR@RGU, accessed May 1, 2026, <https://rgu-repository.worktribe.com/person/1624585/>

heritage structures can be divided into three key phases [Fig. 4.6]:

1. Data collection and intellectual exploration;
2. Data elaboration and information synthesis;
3. Graphic development, representation and dissemination.

“The initial phase involves historical research, architectural surveying and data acquisition and is crucial for a holistic understanding of the heritage site. The second phase addresses the organisation, registration and consolidation of the amassed datasets and other sources, involving the registration and integration of various forms of data, from LiDAR scans and high-resolution digital imagery to historical research and site-specific observations. The final stage is interpreting the acquired data and information, which concerns the representation of heritage architecture using technical drawings and graphic simulations or renderings. This is a technologically driven output and an interpretive layer that adds value by conveying the heritage structure’s historical, aesthetic, and functional aspects”⁵.

Fig. 4.6 Process of digital documentation of cultural heritage.



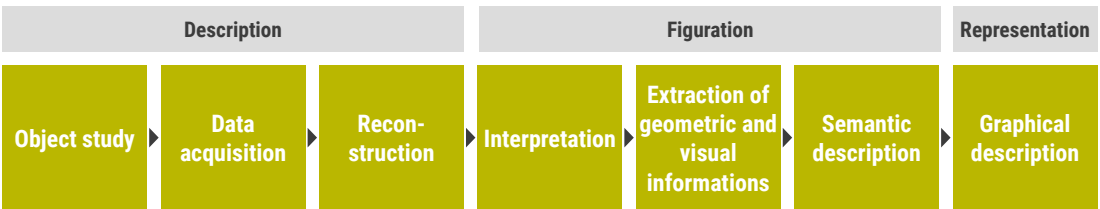
Whatever the approach, though, the undeniable first step in studying any built element is to create a “knowledge system” designed to collect, interpret, and store relevant information about it. “The components making up this system, however, are of various types: quantitative, first and foremost (essentially resulting from surveying operations), but also qualitative. While the former should advisably be channeled through a rigorous scientific approach, the latter mainly draw on the investigator’s sensitivity and interpretative skill, often the most important ingredient for achieving levels of understanding that are denied to simple ‘measurement’. For Built Cultural Heritage this process is particularly

douglas-pritchard).

5. Pritchard, “Intersezioni tra tecnologia, comunicazione grafica e rappresentazione,” 48-49.

relevant: not only is it necessary to construct a multidisciplinary database that is as consistent and rigorous as possible, but also many different skills must be integrated in order to suggest interpretations that transcend the sectorial. If the qualitative component relies on the concept of irrefutability (in the sense proposed by Popper), the quantitative one relies on the Survey, one of the most powerful and reliable tools developed over the years by researchers (archaeologist, architects, historians, etc.) to achieve what Descartes used to define ‘profound knowledge’⁶. It actually implies the idea of measurement, that is the possibility of turning into quantity some qualities of the studied phenomenon (in this case an artifact, a building, a site, etc.) by using the ratio between the measured quantity and an appropriate unit of measure. It is just thanks to this method that we can build a simplified model of the complex phenomenon we are investigating”⁷.

Beyond the theoretical framework, the practical application of this strategy heavily relies on the available measurement technologies. Traditionally, the limited number of measurable points required meticulous planning of survey operations to focus on capturing only the most significant data points (selection before acquisition). In recent decades, however, this sequence has been reversed, thanks to advanced massive measurement technologies where acquisition comes first, and selection follows. Indeed, “if in a ‘classical’ survey the observer’s analytical engagement is mobilized in situ in front of the study object, in a digital survey the identification of significant elements, their interpretation, and their hierarchization take place ex situ with a 3D copy”⁸ [Fig. 4.7].



6. “Whenever human beings have had to deal with complex phenomena during their evolution journey, they always tried to develop learning strategies that would allow them to overcome the limits of their own senses. Descartes well explained how this approach involves two different kind of knowledge: common sense (that we acquire through experience) and profound which instead can be obtained by investigation methods and techniques that can reveal to the mind what our senses cannot” (Carlo Bianchini, “Survey, modeling, interpretation as multidisciplinary components of a Knowledge System,” *SCientific RESearch and Information Technology Ricerca Scientifica e Tecnologie dell’Informazione* 4, i. 1, 2014: 15-24, <http://dx.doi.org/10.2423/i22394303v4n1p15>).

7. Bianchini, “Survey, modeling, interpretation,” 15-24.

8. Violette Abergel, Kevin Jacquot, Livio De Luca, and Philippe Veron, “Combining on-site and off-site analysis: towards a new paradigm for cultural heritage surveys,” *DISEGNARECON* 14, no. 26 (2021), <https://doi.org/10.20365/disegnarecon.26.2021.13>.

Fig. 4.7 The different stages of the digital survey divided in description, figuration and representation phases.

However, even if the 3D digital surveying techniques, capable of collecting large volumes of data in a very short period of time, together with related information processing and management procedures, are the standard in the built heritage survey sector, several challenges remain still unresolved. Currently, the debate focuses on both the data acquisition and processing phases, regarding the performance of the sensors, the accuracies that can be achieved, and the costs/times required, as well as on the phases of extracting information from point clouds, which increasingly shifts attention from construction of the parametric model to semantic analysis, i.e. the automatic extraction of contents via machine learning and artificial intelligence⁹.

Today, the most widely used and well-established digital tools for 3D data acquisition can be classified into the following categories [Fig. 4.8]:

- *Tools based on passive sensors* (image-based methods) rely on ambient light to capture images, which are then processed to extract information about the observed scene. Among these techniques, photogrammetry is the most well-known and widely used, particularly for architectural, industrial, and archaeological surveys.
- *Tools based on active sensors* (range-based methods) that emit electromagnetic signals (e.g., in the visible, infrared, or X-ray spectrum) and record the reflected signals to calculate distance ('range') measurements. Examples of range-based instruments include laser scanners (ground-based or airborne) and Mobile Mapping Systems¹⁰.

The 'direct' range-based way, entrusted to laser scanners, has developed since the beginning of the third millennium with static instruments¹¹ and is currently evolving with the experimentation of dynamic and low-cost technologies. After a few years, the 'indirect' image-based way known as photo-modelling was consolidated, overcoming the short period of

9. Barbini et al., "Innovation and tradition".

10. Fabio Remondino, "Il rilievo 3D fotogrammetrico," in *Teorie e tecniche della rappresentazione contemporanea*, ed. R. Salerno (Maggioli Editore, 2011), 195-196; Fabio Remondino, "Heritage Recording and 3D Modeling with Photogrammetry and 3D Scanning," *Remote Sensing* 6, no. 3 (2011): 1104-1138, <https://doi.org/10.3390/rs3061104>.

11. Giovanna A. Massari, Maria C. Bonora, and Katia Svaldi, "Spazi medievali scolpiti e dipinti: misura e rappresentazione," in *Graphic Expression applied to Building International Conference* (Universidad de Alicante, 2010), 55-63.



Fig. 4.8 Some of the main range-based and image-based tools used in the field of architectural survey.

digital stereophotogrammetry¹² and unconventional photogrammetry¹³. Alongside this reality-based documentation/production¹⁴, enabled by the collection and transmission of huge masses of values, a way of acting based on the traditional disciplinary fields - i.e. topography, photogrammetry, and longimetry (hand-made survey) - also survives, including the borrowed from archaeology survey of details. Three heterogeneous procedures, sometimes mutually connected, based on preventive acts of visual observation as well as a selection of the readings to be carried out, find synthesis precisely in the elaboration of the geometric model of representation. They are a valid alternative when the surfaces and volumes have simple shapes, the dimensions involved are limited, or the design purposes only require the usual graphic tables. All the mentioned methods are essentially numerical, congruent with mathematical modelling which, by its nature, has a universal character. This does not mean that their indistinct application makes sense, also

12. Giovanna A. Massari, "Outline/Interpretation," *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Science* XXXIV-5/W12 (2003): 225-230.

13. Giovanna A. Massari, Andrea Rolando, Rossella Salerno, "Metodologia di rilievo multiscala tra architettura e paesaggio: Arco di Trento," *Il rilievo dei beni architettonici per la conservazione* (Edizioni Kappa, 2005), 444-449.

14. "Reality-based 3D surveying and modeling is meant as the digital recording and 3D reconstruction of visual and existing scenes using active sensors and range data, passive sensors and image data, classical surveying (e.g., total stations or GNSS), 2D maps or an integration of the aforementioned methods. The choice or integration depends on the required accuracy, object dimensions, location constraints, instrument's portability and usability, surface characteristics, working team experience, project budget, final goal of the survey, and so on. On the other hand, non-real 3D modeling approaches are based on computer graphics software (e.g., 3D Studio Max, Maya, Sketchup, Blender, etc.) or procedural modeling approaches allowing the generation of really remarkable 3D data without any particular survey or knowledge of a site and with generally no metrical results" (Remondino, "Heritage Recording and 3D Modeling," 1106).

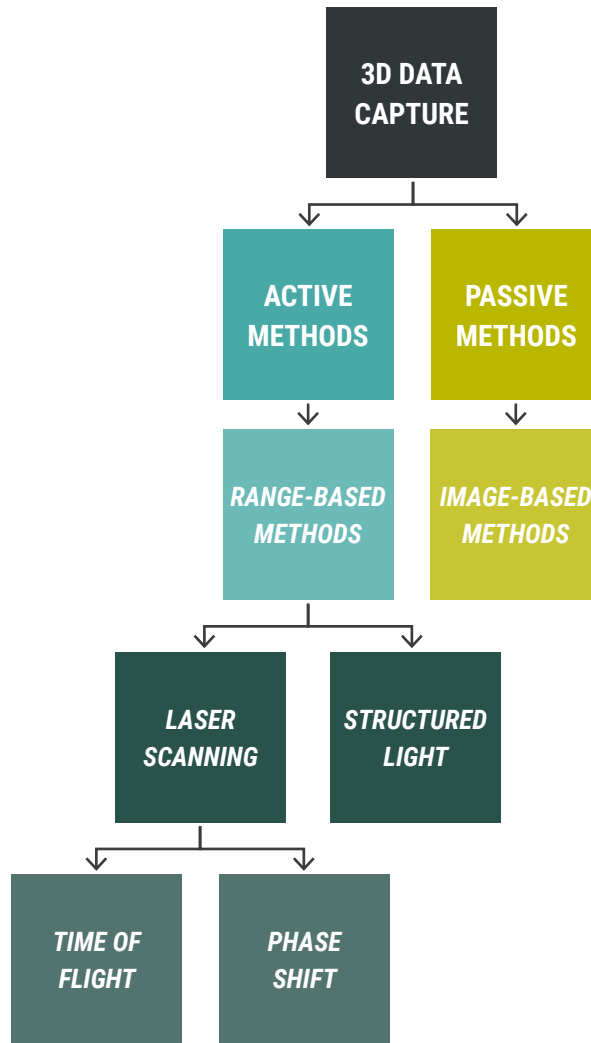


Fig. 4.9 General overview of the main 3D digital acquisition methods.

for reasons of sustainability of the work and usability of the results; indeed, we know that methodological and technical choices are always guided by the specifics of the object and purpose. The translation in quantity of the artefact's qualities, and the use of proper computerised solutions, is not always sufficient: this is why the 'traditional' survey maintains a non-negligible potential, especially at the scale of detail and material investigation, thanks to the 'tactile' component of its operations [Fig. 4.10].

However, the progressive introduction of technologically advanced instrumentation has not changed, over the years, the essence of surveying activity. Its primary purpose remains to discretise continuous, identifying the salient, evident, and remarkable points of reality, and repro-



ducing, with a limited number of signs, the object of study. From this perspective, range-based and image-based techniques are not aimed at merely replicating reality but rather at acquiring a greater quantity and density of data. Indeed, laser scanning and digital photogrammetry provide discrete and accurate point cloud models, even for buildings with very complex geometries, such as historic buildings¹⁵. “Today, the integration of active and passive systems makes it possible to obtain ever more accurate and complete surveying campaigns, ensuring a redundancy data for integration and validation activity, going de-

Fig. 4.10 Left, some traditional methods: hand-made survey and topographic survey; right, some digital methods: range-based survey (i.e. Terrestrial Laser Scanner, tablet with LIDAR sensor).

[Barbini et al., “Innovation and tradition,” 48]

15. Pritchard, “Intersezioni tra tecnologia, comunicazione grafica e rappresentazione,” 48-49.

finitively towards a multiresolution approach. Many research activities have been focused in such sense, exploiting the integrated instrumental potentialities to acquire the Cultural Heritage surface at distinct levels of detail¹⁶, showing the possibility of defining reality-based models¹⁷ or reconstructions of architecture no longer existing¹⁸ [...]. The integration between ever simpler but more powerful survey instruments and high-performance hardware and software has formally opened the massive acquisition era, being able to detect any Cultural asset without limitation in terms of extension, geometric complexity or accessibility [...]. This trend towards massive digital capturing is demonstrated by the increasing public administrations demand for extensive 3D acquisition of each architectural or archaeological artefact. In addition, the occurrence of ever more urgent constraints both in the surveying phase and in the generation of digital representations inside public call for bids is ever more evident¹⁹.

In the framework of reality-based methods to develop digital models of the built heritage, even if expensive and time-consuming terrestrial laser scanning is still the gold standard for 3D reconstructions, advancements in sensor miniaturization, processing algorithms, and computing power have recently introduced new low-cost 3D sensor alternatives. These low-cost alternatives make use of both the active sensing method, as Solid-State LiDAR (SSL) and direct time of flight (DToF) sensors in mobile devices, such as Apple iPad²⁰, and passive sensing

16. Marco Callieri, Antoni Chica, Matteo Dellepiane, Isaac Besora, Massimiliano Corsini, Jordi Moyés, Guido Ranzuglia, Roberto Scopino, and Pere Brunet, "Multiscale acquisition and presentation of very large artifacts: The case of Portalada," *Journal on Computing and Cultural Heritage*, v. 3, i. 4 (2011): 1-14, <http://doi.acm.org/10.1145/1957825.1957827>; Michele Russo and Anna M. Manfredini, "Integrated multi-scalar approach for 3D Cultural Heritage acquisitions," in *Handbook of Research on Emerging Digital Tools for Architectural Surveying, Modeling, and Representation*, ed. S. Brusaporci (IGI Global, 2015), 337-360, [10.4018/978-1-4666-8379-2.ch011](https://doi.org/10.4018/978-1-4666-8379-2.ch011).

17. Marco Carpiceci, Michele Russo, and Andrea Angelini, "The digital model of the S. Zenone chapel inside Santa Prassede in Rome: A case study for the morphological analysis," *Proceedings of 23rd International Conference on Virtual System & Multimedia (2017)*, 1-8, [10.1109/VISM.2017.8346277](https://doi.org/10.1109/VISM.2017.8346277).

18. Michele Russo and Gabriele Guidi, "Reality-based and reconstructive models: digital media for cultural heritage valorization," *SCientific REsearch and Information Technology*, v. 2, i. 4 (CASPUR-CIBER Publishing, 2011): 71-86, <http://dx.doi.org/10.2423/122394303v1n2p71>; Gabriele Guidi, Michele Russo, and Davide Anghelieddu, "3D Survey and virtual reconstruction of archaeological sites," *Digital Applications in Archaeology and Cultural Heritage*, v. 1, i. 2 (2014): 55-69, <https://doi.org/10.1016/j.daach.2014.01.001>.

19. Carlo Bianchini and Michele Russo, "Massive 3D acquisition of CH".

20. Piotr Kędzierski, Marcin Jagoda, Paweł Tysiąc, and Jacek Katzer, "An Example of Using Low-Cost LiDAR Technology for 3D Modeling and Assessment of Degradation of Heritage Structures and Buildings," *Materials* 17, no. 22 (2024), <https://doi.org/10.3390/ma17225445>; Giuseppina Vacca, and Andrea Dessi, "Low-Cost Geomatics Surveys for Emergency Interventions

method, as 360° cameras for spherical photogrammetry. Specifically, the cost of the mentioned instruments ranges from tens of thousands of euros for a Terrestrial Laser Scanner (TLS), just over a thousand euros for the latest iPhone or iPad, and from a few hundred up to a few thousand euros for a 360° camera²¹.

“The low-cost aspect is an interesting topic of discussion since many heritage conservation communities try to strike a balance between budgetary constraints and geometric precision²². In 2020, Apple Inc. released two products fitted with 3D sensors marketed as lidar sensors: a new iteration of the iPad Pro and the iPhone 12 pro. While generating much hype, the use of 3D sensors in smartphones is not new as they have previously been used for minor applications such as facial recognition. [...] While Apple has declared that their 3D sensor is mainly aimed for AR purposes requiring a lower level of geometric precision, this setup nevertheless presents an interesting combination for heritage documentation purposes. This is because such systems provide compact 3D sensors capable of providing almost real-time results with a relative low-cost compared to traditional surveying methods. A similar precedent was a research on the use of Microsoft Hololens mixed reality glasses for indoor mapping^{23,24}.

As mentioned in the previous section, the widespread use of these low-cost tools further fuels the trend of massive 3d data collection in the CH sector. Since these instruments provide lower accuracy compared to more sophisticated and expensive technologies, their use shifts the focus of the debate from the sheer volume of data collected to its actual usefulness, intended in terms of the functionality of the information acquired in relation to the purpose of the survey. The functionality of data

on Cultural Heritage. The Case of Historic Wall in Cagliari,” in *ICCSA 2023 Workshops*, ed. O. Gervasi et al. (2023), 650-664, https://doi.org/10.1007/978-3-031-37126-4_42.

21. Chiara Chioni, Anna Maragno, Angelica Pianegonda, Marco Ciolli, Sara Favargiotti, and Giovanna A. Massari, “Low-Cost 3D Virtual and Dynamic Reconstruction Approach for Urban Forests: The Mesiano University Park,” *Sustainability* 15, no. 19 (2023), <https://doi.org/10.3390/su151914072>.

22. Arnadi Murtiyoso, Pierre Grussenmeyer, and Deni Suwardhi, “Technical considerations in low-cost heritage documentation,” *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.* XLII-2/W17 (2019): 225-232, <https://doi.org/10.5194/isprs-archives-XLII-2-W17-225-2019>.

23. Kourosh Khoshelham, Ha Tran, and Debaditya Acharya, “Indoor mapping eyewear: geometric evaluation of spatial mapping capability of Hololens,” *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.* XLII-2/W13 (2019): 805-810, <https://doi.org/10.5194/isprs-archives-XLII-2-W13-805-2019>.

24. Arnadi Murtiyoso, Pierre Grussenmeyer, Tania Landes, and Hélène Macher, “First Assessments Into The Use Of Commercial-Grade Solid State Lidar For Low Cost Heritage Documentation,” *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.* XLIII-B2-2021 (2021): 599-604, <https://doi.org/10.5194/isprs-archives-XLIII-B2-2021-599-2021>.

is not an inherent property but rather depends on specific characteristics that, when properly defined, can be measured and evaluated both before and after acquisition, according to a specific objective. Measuring the characteristics of the collected data allows us to move beyond quantity and estimate its quality²⁵, and consequently, its potential functionality, with reference to specific parameters such as visual fidelity and geometric accuracy²⁶.

In light of these considerations, a research experience was carried out as part of the Ph.D. program, focusing on a section of urban space in the historic center of Trento, Italy. This experiment led to the development of a method for evaluating the quantitative and qualitative characteristics of the data contained in point clouds from 3D digital survey. This method serves two specific purposes. On the one hand, it can be used to analyse data already acquired, thus guiding their use retrospectively according to specific needs. On the other hand, it can support the survey project in its initial stages, assessing beforehand the necessity and appropriateness of acquiring large quantities of data²⁷.

25. Lucia M. Cannarozzo and Rossella Salerno, *Fotografie e misura* (Cluva, CittàStudi, 1991); Giovanna A. Massari, "Misurare Interpretare Conoscere," *XY Dimensioni del Disegno. Rappresentazione e verità*, no. 32-33 (Officina Edizioni, 1998): 5-18.

26. Marko Radanovic, Kourosh Khoshelham, and Clive Fraser, "Geometric Accuracy and Semantic Richness in Heritage BIM: A Review," *Digital Applications in Archaeology and Cultural Heritage*, v. 19 (2020), <https://doi.org/10.1016/j.daach.2020.e00166>.

27. Anna Maragno, Ambra Barbini, Elena Bernardini, Chiara Chioni, and Giovanna A. Massari, "La misura per la dismisura dei dati da rilievo digitale 3D. Il caso del centro storico di Trento = The Measure for Uncountable data from 3D Digital Survey. The Case of the Historical Centre of Trento," in *Misura / Dismisura. Atti del 45° Convegno Internazionale dei Docenti delle Discipline della Rappresentazione = Measure / Out of Measure. Transitions. Proceedings of the 45th International Conference of Representation Disciplines Teachers*, ed. F. Bergamo, A. Calandriello, M. Ciammaichella, I. Friso, F. Gay, G. Liva, and C. Monteleone (FrancoAngeli, 2024), 1679-1698, [10.3280/oa-1180-c554](https://doi.org/10.3280/oa-1180-c554).

04.2.1 In-depth study & experiences

Reflections on the survey of Duomo square and Its surroundings

Project	Survey of Duomo square in Trento and Its surroundings.
Coordinator	Giovanna A. Massari (DICAM, University of Trento).
Working group	Ambra Barbini (DICAM, University of Trento), Elena Bernardini (DICAM, University of Trento), Chiara Chioni (DICAM, University of Trento), Francesco Giampiccolo, Anna Maragno (DICAM, University of Trento), Giovanna A. Massari (DICAM, University of Trento), Cristiana Volpi (DICAM, University of Trento).
Technical support	Laboratory of Architectural Modelling and Analysis Representation and Communication (LAMARC) from the DICAM (University of Trento).
Timeframe	August 2023 - February 2024
Dissemination	Anna Maragno, Ambra Barbini, Elena Bernardini, Chiara Chioni, and Giovanna A. Massari, “La misura per la dismisura dei dati da rilievo digitale 3D. Il caso del centro storico di Trento = The Measure for Uncountable data from 3D Digital Survey. The Case of the Historical Centre of Trento,” in <i>Misura / Dismisura. Atti del 45° Convegno Internazionale dei Docenti delle Discipline della Rappresentazione = Measure / Out of Measure. Transitions. Proceedings of the 45th International Conference of Representation Disciplines Teachers</i> , ed. F. Bergamo, A. Calandriello, M. Ciammaichella, I. Friso, F. Gay, G. Liva, and C. Monteleone (FrancoAngeli, 2024), 1679-1698, 10.3280/oa-1180-c554 .

Introduction

The following reflections stem from years of research, experimentation, and dissemination activities focused on the historic centre of Trento, with particular attention to the area around the Cathedral of S. Vigilio, the Pretorio Palace, and the surrounding urban space [Fig. 4.11].

The investigation, combining architectural history, road construction, and architectural surveying, began in 2019 within the PRIN 2017 project “Stone pavements. History, conservation, valorisation and design”¹. Between 2021 and 2023, a dedicated study on the palazzo Pretorio

1. “Stone pavements. History, conservation, valorisation and design” (2019-23) was a *Progetto di Ricerca di Interesse Nazionale* (PRIN 2017) financed by MIUR (Ministry of Education, Universities and Research). The project analysed Roman infrastructure and historically significant roads that shaped Europe’s communication routes, using contemporary tools developed for modern infrastructure networks. The main outcomes of the project are: Anna Maragno and Cristiana

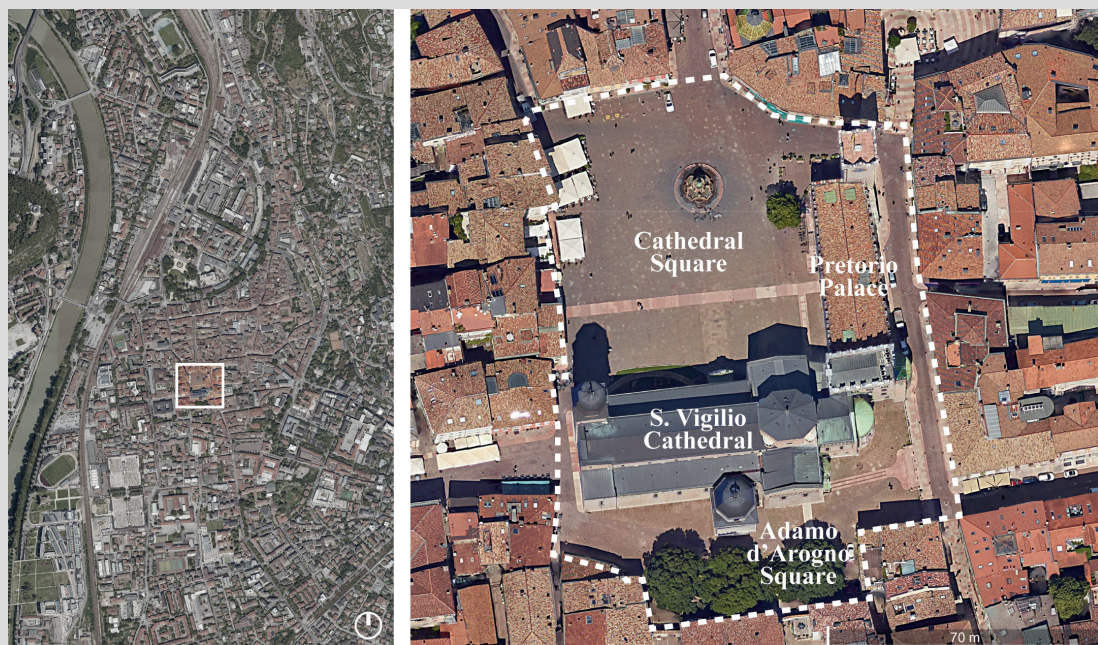


Fig. 4.11 Left, the area of interest within the city of Trento. Right, the identification of the main urban elements involved in the research.

[Maragno et al., “La misura per la dismisura dei dati da rilievo digitale 3D,” 1690]

(a) examined its current configuration to better understand its historical development².

The research continues in 2024 with an experiment in Cathedral square (or Duomo square) and Adamo d’Arognò square (b), aimed at creating immersive models of urban spaces through low-cost digital survey techniques.

These recent studies were supported by several survey campaigns using advanced digital acquisition technologies (i.e., terrestrial laser scanner, mobile laser scanner, drone, camera on telescopic rod, spherical camera, tablet with LIDAR sensor)³. The results of the 3D digital surveys were then compared with those obtained from traditional topographic methods. The large amount of data acquired, as described in [Fig. 4.12], suggested the need to develop a method for analysing and comparing the data, both to guide their management and use, and to foster greater awareness during their acquisition.

Volpi, *Dove Trento cammina. Nascita e sviluppo delle pavimentazioni stradali in porfido a Trento nella prima metà del Novecento* (Edizioni Efestò, 2021); Anna Maragno and Cristiana Volpi, *Dove Trento si ingegna. Il ruolo degli ingegneri nello sviluppo della città di Trento nel corso del XIX secolo* (Edizioni Efestò, 2023).

2. See chapter 06.3 of the present thesis.

3. José Balsa-Barreiro and Dieter Fritsch, “Generation of visually aesthetic and detailed 3D models of historical cities by using laser scanning and digital photogrammetry,” *Digital Applications in Archaeology and Cultural Heritage*, v. 8 (2018): 57-64, <https://doi.org/10.1016/j.daach.2017.12.001>.

range-based tools			image-based tools		
Faro Focus S120	Lixel X1	iPad Pro with LIDAR sensor	DJI Mavic 2 Pro	3D eye system	Ricoh Theta V
					
urban/architectural element acquired					
					
 indoor/outdoor areas full-height elevations limited elements					
amount of data acquired					
172 scans	1 scan	4 scans	919 photos	1'025 photos	7 videos (3'317 frames)
34,75 GB	3,68 GB	0,057 GB	24,23 GB	21,53 GB	23,19 GB

Method

The proposed methodological approach to ‘measure uncountable data’ is based on defining parameters⁴ that describe both qualitative and quantitative attributes. The comparison focuses on numerical models⁵ (3D point clouds) derived from processed raw data, generated for the case studies (a) and (b).

Both acquisition and processing phases influence data quality: instrument setup affects resolution and accuracy, while software processing depends on operator choices and potential errors⁶. Moreover, surveys were conducted with different tools and on partially overlapping areas.

Fig. 4.12 From top to bottom: 3D digital acquisition tools used in the survey campaigns of historical centre of Trento (range-based, left; image-based, right); areas acquired with each tool; quantification of acquired data.

[Maragno et al., “La misura per la dismisura dei dati da rilievo digitale 3D,” 1691]

4. Vittorio Ugo, “Misura-interpretazione-conoscenza-interpretazione-misura: circolo vizioso, o virtuoso?”, *XY Dimensioni del Disegno. Rappresentazione e verità*, no. 32-33 (Officina Edizioni, 1998): 19-24.
 5. Riccardo Migliari, *Geometria dei modelli: rappresentazione grafica e informatica per l’architettura e per il design* (Kappa, 2003); Mario Docci and Carlo Bianchini, “Editoriale. Il ruolo dei modelli virtuali 3D nella conservazione del patrimonio architettonico e archeologico,” *Disegnare idee immagini XXVII*, no. 53 (Gangemi Editore, 2016): 3-6.
 6. In this context, the archiving of numerical models should include their enrichment through metadata and paradata.

For this reason, parameters were defined according to the survey objectives rather than the surveyed object, supporting informed decision-making rather than providing fixed solutions.

The evaluation framework consists of two groups of four parameters: the first assesses point clouds in terms of density, geometric accuracy, visual fidelity⁷, and metric reliability [Tab. 4.1]; the second highlights technical differences, easily estimated or quantified, among commonly used 3D survey tools and methods [Tab. 4.2].

Parameter		Description	Evaluation criteria
Quantitative parameters	Density	It represents the richness of the data from a quantitative point of view. It strongly influences visual fidelity and, to some extent, geometric accuracy.	Expressed as a numerical value, it indicates the number of points within a constant, predefined unit of volume (a sphere).
	Metric reliability	It indicates the possibility of deriving accurate measurements from the numerical model.	Expressed as a numerical value, it indicates the metric deviation (cm) from a dataset acquired and validated by a different method (e.g. topographic).
Qualitative parameters	Geometric accuracy	It expresses the ability to derive realistic proportions of surveyed objects, to maintain spatial relationships between them, and to recognize 3D geometries representative of real shapes.	Expressed on a scale of 1 to 4. The minimum value (1) indicates that it is not possible to identify the geometries that comprise the object; the maximum value (4) that it is possible to identify them in detail.
	Visual fidelity	It describes the level of resemblance to reality in terms of colours, textures and balance of contrasts between areas in light and in shadow.	Expressed on a scale of 1 to 4. The minimum value (1) indicates that the colors and textures do not match the real ones; the maximum value (4) indicates complete verisimilitude.

Tab. 4.1 Quantitative and qualitative measurement parameters of point cloud data from 3D digital survey.

[Maragno et al., “La misura per la dismisura dei dati da rilievo digitale 3D,” 1692]

The parameters in [Tab. 4.1] can be evaluated through both quantitative and qualitative methods. Point cloud density is calculated using volume density in CloudCompare⁸, while metric reliability is assessed by comparing virtual measurements with direct on-site measurements. Geometric accuracy and visual fidelity are instead evaluated qualitatively through relative scoring.

For [Tab. 4.2], parameters are generally estimated qualitatively using a score from 1 to 4 to indicate increasing time and cost, except for the ac-

7. Marko Radanovic, Kourosh Khoshelham, and Clive Fraser, “Geometric Accuracy and Semantic Richness in Heritage BIM: A Review,” *Digital Applications in Archaeology and Cultural Heritage*, v. 19 (2020), <https://doi.org/10.1016/j.daach.2020.e00166>.

8. CloudCompare, accessed May 1, 2026, <https://cloudcompare.org/>.

Parameter	Description
Acquisition radius	It is the distance in metres within which an accuracy, established upstream, of the instrument is guaranteed (applicable only to range-based instruments). It affects the acquisition time.
Acquisition time	It is the estimated time required depending on the instrumental settings and acquisition modes established during the campaign phase.
Processing time	It is the estimate of the time required depending on the settings selected for processing for the same hardware and software instrumentation available.
Cost	It is the total cost of acquisition and processing operations, taking into account the instrument and applications needed to process the raw data.

quisition radius, which is a numerical value provided by the instrument manufacturer.

Results

The main outcome of this study is the illustrated evaluation tool. To demonstrate its use and test its validity, the two sets of parameters were applied to the extensive point cloud data of Trento’s historic center, focusing on the acquisitions and processing for Pretorio Palace (a) and Adamo d’Arogno square (b). The [Tab. 4.3] compares the quantity (density, metric reliability) and quality (geometric accuracy, visual fidelity) of the numerical models produced with different survey tools and software.

Density values (points within a 0.5 m radius) vary widely, from a few thousand to several hundred thousand [Fig. 4.13], depending mainly on instrument performance and specific survey choices.

This also allows a degree of comparability between models generated

Tab. 4.1 Comparative parameters for tools (and procedures) for 3D digital surveying.

[Maragno et al., “La misura per la dismisura dei dati da rilievo digitale 3D,” 1693]

Tab. 4.3 Measurement, quantitative and qualitative, of the data acquired with the different digital survey tools in the case study.

[Maragno et al., “La misura per la dismisura dei dati da rilievo digitale 3D,” 1693]

		Range-based tools			Image-based tools		
		Faro Focus S120 [TLS]	Lixel X1 [MMS]	iPad Pro with LIDAR sensor	DJI Mavic 2 Pro	3D Eye system	Ricoh Theta V
Quantitative parameters	Density	ca. 230.000	ca. 54.0000	ca. 7.000	ca. 230.000	ca. 54.0000	ca. 7.000
	Metric reliability	< 1,5 cm	< 25 cm	< 5 cm	< 3,5 cm	< 2 cm	< 100 cm
Qualitative parameters	Geometric accuracy	●●●●	●●●○	●●○○	●●●●	●●●●	●○○○
	Visual fidelity	●●●○	●○○○	●●●○	●●●●	●●●●	●○○○

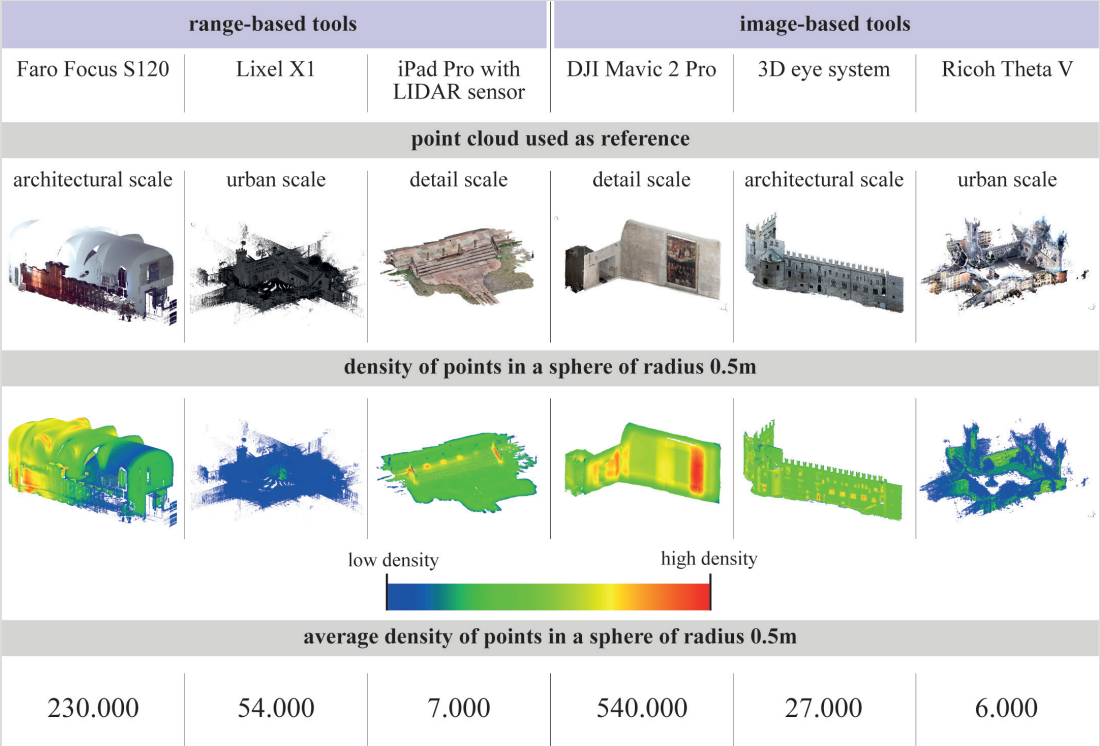


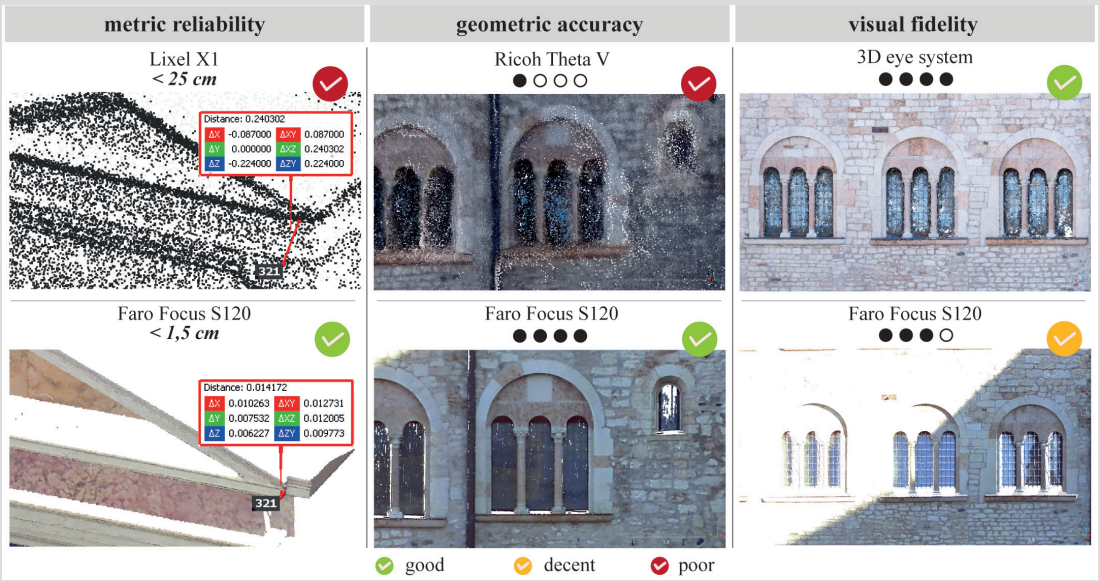
Fig. 4.13 Visual and numerical comparisons of the point clouds’ densities from data acquired with the different 3D digital survey tools. The comparison was based on the most significant portions of the clouds for each method and scale.

[Maragno et al., “La misura per la misura dei dati da rilievo digitale 3D,” 1694]

with range-based and image-based instruments: TLS and drone, MMS and camera on a telescopic rod, and tablet with LIDAR and spherical camera.

Metric reliability was assessed using an existing topographic survey for (a), confirming literature results⁹: TLS models are the most reliable, followed by photogrammetry. Spherical photogrammetry is influenced by the cost-effectiveness of the panoramic camera, while MMS performance is more critical, especially for large survey areas. Given the strong quantitative performance of TLS, it was used as a benchmark to compare other point clouds. A qualitative assessment of parameters (good, fair, poor) enables comparison across non-uniform criteria [see Tab. 3, Fig. 4.14]. In general, geometric accuracy and visual fidelity mirror density and reliability, with exceptions: MMS shows

9. Sorin Herban, Domenica Costantino, Vincenzo S. Alfio, and Massimiliano Pepe, “Use of Low-Cost Spherical Cameras for the Digitisation of Cultural Heritage Structures into 3D Point Clouds,” *Imaging* 8, no. 13 (2022), <https://doi.org/10.3390/imaging8010013>; Alfonso Ippolito, Claudia Palmadessa, Mahsa Noursati Kordkandi, and Juan C. Arias Tapiero, “The Domus of the Calendar: a qualitative comparison analysis of digital data obtained from 3D laser scanners, SfM methodologies and portable devices,” *Archeologia e Calcolatori*, no. 34.2 (2023): 247-262, <https://doi.org/10.19282/ac.34.2.2023.13>.



high geometric accuracy despite low metric reliability, and tablet models show high visual fidelity despite low density.

Finally, [Tab. 4.4] evaluates the tools and procedures involved in generating different point clouds. Beyond hardware- and software-specific details like acquisition radius and costs, general trends emerge: for image-based methods, short acquisition times lead to long processing times, increasing with density, metric reliability, and geometric precision. MMS and spherical cameras are exceptions. Acquisition times also scale with object size, as larger environments require more TLS scans or photographs.

Fig. 4.14 Visual description of the parameters of metric reliability, geometric accuracy and visual fidelity by comparing a few examples.

[Maragno et al., “La misura per la dismisura dei dati da rilievo digitale 3D,” 1695]

	Range-based tools			Image-based tools		
	Faro Focus S120 [TLS]	Lixel X1 [MMS]	iPad Pro with LIDAR sensor	DJI Mavic 2 Pro	3D Eye system	Ricoh Theta V
Acquisition radius (m)	120	120	5	-	-	-
Acquisition time	⌚	⌚	⌚⌚⌚	⌚⌚	⌚⌚	⌚
Processing time	⌚⌚⌚	⌚⌚	⌚	⌚⌚⌚⌚	⌚⌚⌚⌚	⌚⌚⌚
Cost*	€€€€	€€€€	€	€€	€€	€

* In addition to the cost of the instrument, here it is also considered the cost of the proprietary software licence required to process the acquired data.

Discussion and outlook

The study presents an evaluation tool with two complementary parameter sets: one to assess data quality and quantity, the other to compare instruments and procedures. Its purpose is both to optimise data use after acquisition and to guide survey planning.

Excessive data can create redundancy and management challenges, evident when point clouds are shared online, where size limits reduce density and compromise accuracy and visual fidelity.

Yet, integrating multiple tools is essential for detailed, reliable models, especially for historical or conservation purposes. Even ‘discarded’ data can be reused for education, research, or AI-based 3D reconstruction.

Tab. 4.4 Comparison of software tools and procedures used in the case study.

[Maragno et al., “La misura per la dismisura dei dati da rilievo digitale 3D,” 1696]

04.3 The digital model and its outputs: between physical and AR/VR/MR models

The digital revolution of the first quarter of this century has equipped us with a diverse array of hardware and software tools, enabling a profound level of interaction between the real and virtual worlds. On one hand, remarkable progress has been made in acquiring data from real objects; on the other, digital modeling software has introduced new paradigms for reconstructing them, interacting with them, and simulating their potential transformations¹. At the core of this process lies the model, a medium that, in many ways, serves as both the goal and the means of this interaction².

Currently, modern technologies used in CH make it possible to combine various types of built environment data - such as geometric, material, technological, and historical - into a single virtual model. “It is important to highlight that, despite new technologies offering wide options for data collection, elaboration, management, and communication, an informative selection, as well as the interpretation of acquired data, is still crucial to move from the complexity of reality to a functional virtual model [...]. Such an interpretative paradigm, reflecting the purpose of the model, its object and its cultural framework, is a key element for the model development”³. Indeed, as architect Carlo Bianchini argues, “from a strictly epistemological point of view a model can be considered the result of a selection carried out by a subject aiming at extracting some of the potentially infinite available information pertaining to an object. The selected data, though, are not the result of a random or automatic reading: on the contrary they strictly comply with rules set by the subject himself⁴. In this way a stable relationship real object/model is created: a relationship that intrinsically already represents itself an

1. Martina Attenni, Carlo Bianchini, Marika Griffo, and Luca J. Senatore, “HBIM Meta-Modelling: 50 (and More) Shades of Grey,” *ISPRS International Journal of Geo-Information*, no. 11, 468 (2022), <https://doi.org/10.3390/ijgi11090468>.

2. Carlo Bianchini, “Metamodelling,” *Disegnare. Idee immagini* XXXIV, no. 66 (Gangemi Editore, 2023): 80-95.

3. Ambra Barbini and Chiara Chioni, “Reality vs Virtual Modelling. From Building to Landscape Heritage Representation,” in *Proceedings of the 26th International Conference on Cultural Heritage and New Technologies* (Propylaeum, 2021), 383, [10.11588/propylaeum.1449.c20776](https://doi.org/10.11588/propylaeum.1449.c20776).

4. According to architect Fulvio Rinaudo, a virtual model could be defined as “a repository of (digital) data coming from different investigations able to give back a description of the investigated meaning of the object under one or more points of views and interest” (Fulvio Rinaudo, “From physical to digital models,” in *Digital & Documentation. Digital strategies for Cultural Heritage*, ed. M. Lo Turco, E.C. Giovannini, and N. Mafri, v. 2, Pavia University Press, 2020, 25-28).

interpretation of the selected data”⁵. Then, the model, as the final outcome of any survey process, “is always incomplete, abstract and above all subjective; only the effects and outcome of representation make it available to other actors so long as they are able to interpret the representation code. Choosing the right model⁶ (and hence the set of objective data to be selected) and representation code depends on the quantity of positively communicated data”⁷.

According to architect Fulvio Rinaudo, “when we refer to the digital model of a 3D object, the first attempt to generate it is to provide a 3D metric model of the object itself, able to constitute the geometric reference frame to collect and correctly locate the other data to build up a georeferenced database of information. The metric survey of an object, independently from its dimensions and shapes, is done today by generating a dense point cloud. Starting from these point clouds the segmentation and modelling phases have to be developed by considering both the required final metric quality of the 3D model and the structure of the final database”⁸.

This progressive replacement of physical reality with reality-based 3D virtual models, generated by very dense point clouds, responds to the demand for exhaustive knowledge of the material world and to the human need to counteract the alterations caused by time, including disappearance, through a stable memory protected on the web. On the other hand, first, the Renaissance lesson and subsequently the Galilean one teach us that the ‘intrinsic’ understanding of architecture cannot rely on the generic static and/or dynamic visualisation guaranteed by the availability of point clouds. Instead, it requires specific activities ‘individually’ oriented towards built geometries, along with the adoption of instrumental strategies capable of leading to discoveries not accessible with the capabilities of the senses alone⁹ [Fig. 4.15].

Over time, various tools and emerging technologies have been inte-

5. Carlo Bianchini, “Survey, modeling, interpretation as multidisciplinary components of a Knowledge System,” *SCientific RESearch and Information Technology Ricerca Scientifica e Tecnologie dell’Informazione*, v. 4, i. 1 (2014): 15-24, <http://dx.doi.org/10.2423/i22394303v4n1p15>.

6. Attenni, Bianchini, Griffo, and Senatore, “HBIM Meta-Modelling”.

7. Carlo Bianchini, Carlo Inglese, and Alfonso Ippolito, *I Teatri Antichi del Mediterraneo come esperienza di rilevamento integrato / The Ancient Theatres of the Mediterranean as integrated survey experience* (Sapienza Università Editrice, 2016), 5.

8. Rinaudo, “From physical to digital models,” 25-28.

9. Ambra Barbini, Francesco Giampiccolo, Anna Maragno, Giovanna A. Massari, and Cristina Pellegatta, “Innovation and tradition: integrated practices in the architectural survey of Pretorio palace in Trento,” *SCientific RESearch and Information Technology Ricerca Scientifica e Tecnologie dell’Informazione*, v. 14, i. 1 (2024): 45-62, <http://dx.doi.org/10.2423/i22394303v14n1p45>.

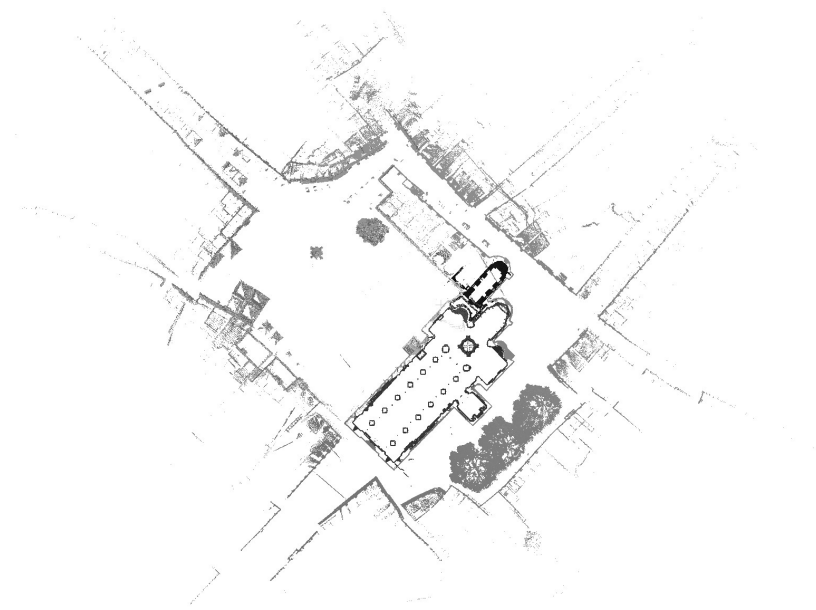


Fig. 4.15 Survey campaign of Pretorio palace. Points cloud model of the Cathedral Square and its surroundings acquired by a Mobile Mapping System tool.

grated into approaches for the reality-based 3D model reconstruction, enabling the reproduction of the morphological complexity of heritage structures and supporting diverse analytical requirements. “These reconstruction strategies permit both to collect and organize information issues from architectural surveys and to produce multiple representations of buildings”¹⁰.

A traditional procedure that has represented the reference standard for several decades and is still widely used, both by technicians and researchers, is the creation of 3D digital models by plans in a CAD environment. This model formalises, in digital space, the project of description and interpretation of the buildings and is structured according to the horizontal and vertical planes of discretization of the architecture. Such planes tell of a 3D modelling *ante litteram* precisely because, despite their two-dimensional development, preserve the spatial and relational logic of a three-dimensional model [Fig. 4.16].

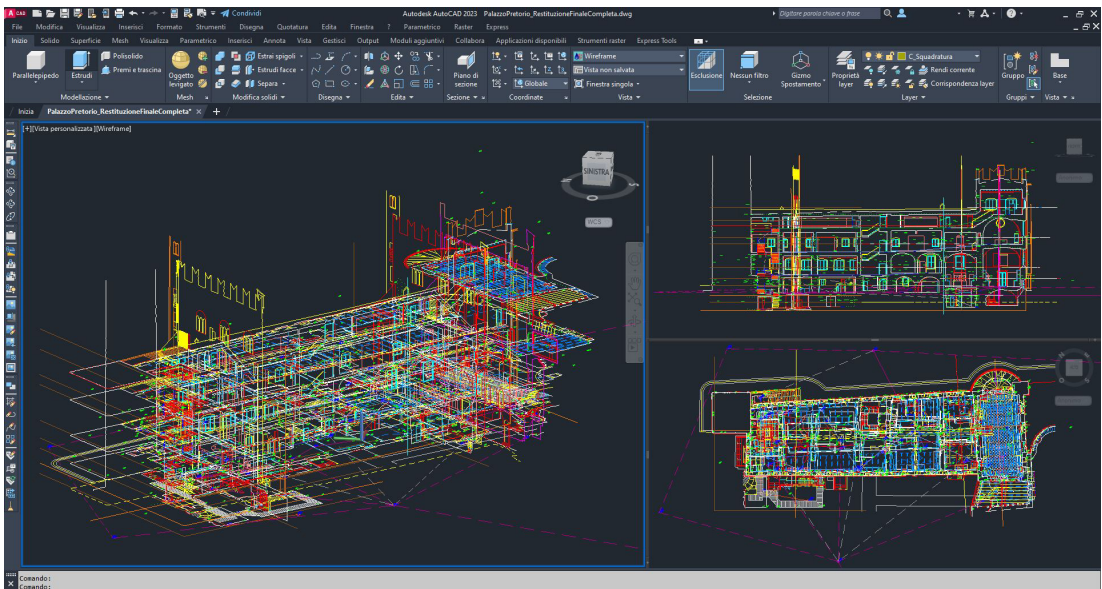
The 3D model by planes has a dual value. In addition to the overall consistency, implicitly it shows the main result of the restitution phase, that is, the drawing. The information reprocessing operation involves the definition of the digital objects constituting the drawn architectural elements according to consolidated graphic codes. We can therefore spe-

10. Livio De Luca, Chawee Busayarat, Chiara Stefani, Philippe Véron, and Michel Florenzano, “A semantic-based platform for the digital analysis of architectural heritage,” *Computers & Graphics*, v. 35, i. 2 (2011): 227-241, <https://doi.org/10.1016/j.cag.2010.11.009>.

ak of graphic communication as ‘prefiguration’, upstream linked to the choice of the final documents’ printing scale, a real guide to the survey as it helps to establish both the acquisition detail and the restitution one, therefore the degree of ‘synthesis’ in the representation. The 3D model by planes is built on a 1:1 scale but the deriving graphic documents apply the codes of graphic communication specific to the different scales. Therefore, the architectural line drawing is the synthesis of the studies and operations carried out and shows, *super partes*, the shape/figure of the represented object; it does not favour one procedure and does not take advantage of one technique or tool over another¹¹.

However, in the last years, the attention of researchers, technicians, and general users has gradually shifted from the ‘model’ to ‘modelling’. «In other words, the focus has been moving from the final output to the set of decisions and actions guiding the process of construction and information (in the sense of defining an informative content) of all digital elements composing, together, the final output»¹². This is largely due to the rapid expansion of 3D modelling, driven by the widespread adoption in the EAC industry of Building Information Modelling (BIM). As a result, modelling has become increasingly important, not only for producing coherent and reliable outcomes, but also for shedding light on the conceptual reference framework governing the entire process¹³.

Fig. 4.16 Survey campaign of Pretorio palace. Restitution phase: 3D geometric model construction and 2D section drawing.



11. Barbini et al., “Innovation and tradition”.
12. Attenni, Bianchini, Griffo, and Senatore, “HBIM Meta-Modelling”.
13. Bianchini, “Metamodelling”.

In fact, “BIM relies on a 3D model made of objects with a rich set of attributes stored in a database. Objects are defined as parametric objects with relationships to other parametric objects. The 3D model is not only a static representation of the facility, but also an advanced computer technology to manage information for the automatic generation of drawings (sections, plans, etc.) and reports, design analysis, schedule simulation, thermal and structural simulation, facilities management, and much more”¹⁴.

From an interoperability perspective, Building Information Modeling (BIM) represents a major advancement over traditional computer-aided design (CAD) systems, shifting from 2D and 3D vector-based representations to a more integrated and collaborative approach. In effect, managing multiple CAD files - such as plans, elevations, sections, and 3D models - across various specialists frequently leads to unsynchronized and inconsistent design versions. “BIM paradigm moves the traditional design concept towards reducing problems caused by the lack of communication between specialists who can take advantage of new interoperability standards. BIM relies on a 3D model of the structure with additional parametric geometry so that objects can be modified without redrawing”¹⁵.

In the field of built environment, this shift in trend is also a result of the growing awareness about the worth and at the same time the vulnerability of CH, an entity that increasingly needs protection and preservation, both as single elements and as an aggregate. From this perspective, at the scale of individual buildings, most approaches are advancing toward HBIM (Historic Building Information Modelling)¹⁶, consolidating the process known as scan-to-BIM¹⁷ [Fig. 4.17]. Initially conceived

14. Luigi Barazzetti, “Parametric as-built model generation of complex shapes from point clouds,” *Advanced Engineering Informatics*, v. 30, i. 3 (2016): 298-311, <https://doi.org/10.1016/j.aei.2016.03.005>.

15. Luigi Barazzetti, Fabrizio Banfi, Raffaella Brumana, and Mattia Previtali, “Creation of Parametric BIM Objects from Point Clouds Using Nurbs,” *The Photogrammetric Record*, no. 30 (2015): 339-362, <https://doi.org/10.1111/phor.12122>.

16. Maurice Murphy, Eugene McGovern, and Sara Pavia, “Historic building information modelling (HBIM),” *Structural Survey*, v. 27, no. 4 (2009): 311-327, <https://doi.org/10.1108/02630800910985108>.

17. Mauro Lo Brutto, Emanuele Iuculano, and Paolo Lo Giudice, “Integrating topographic, photogrammetric and laser scanning techniques for a scan-to-BIM process,” *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences XLIII-B2-2021* (2021), 883-890, <https://doi.org/10.5194/isprs-archives-XLIII-B2-2021-883-2021>; Alessandra Ferro, Mauro Lo Brutto, and Gaspare M. Ventimiglia, “Scan-to-BIM process for the monitoring and conservation of the architectural heritage: integration of thematic information in a HBIM

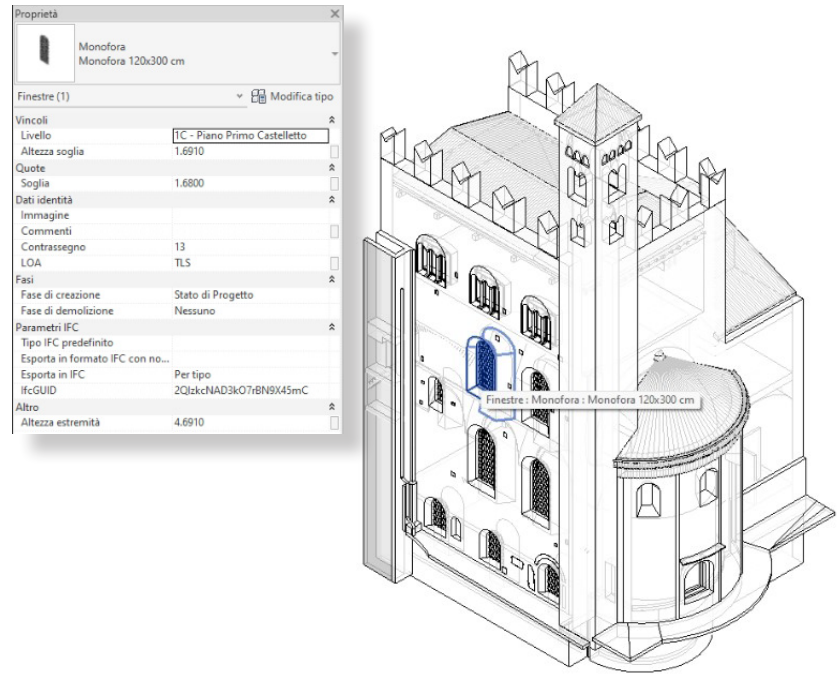


Fig. 4.17 Survey campaign of Pretorio palace. Restitution phase: the multi-dimensional parametric model.

as a library of parametric components for historic structures, HBIM has since evolved to enable the semi-automatic creation of complex geometries, allowing for the identification and detailed representation of components. In parallel, there is also a growing *momentum* at the landscape scale to align with the BIM paradigm. This trend is reflected in the emergence of the term LIM (Landscape Information Modelling) and increasing research into integrating BIM's architectural scale with the territorial scope of Geographical Information Systems¹⁸ (GIS)¹⁹.

A further important consideration must be pointed out about the reality-based 3D model reconstruction, namely, the difference between 'direct geometric modeling' and 'parametric modeling'. According to the distinction proposed by architect Luigi Barazzetti, 'direct geometric modeling' is the process of creating static 3D models with both simple and complex surfaces²⁰. Today, most 3D modelling projects are based

model," *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences XLVIII-M-2-2023* (2023), 549-556, <https://doi.org/10.5194/isprs-archives-XLVIII-M-2-2023-549-2023>.

18. Thomas H. Kolbe, and Andreas Donaubauer, "Semantic 3D City Modeling and BIM," in *Urban Informatics. Singapore: The Urban Book Series*, ed. W. Shi, M.F. Goodchild, M. Batty, M.P. Kwan, A. Zhang (Springer, 2021), 609-636. https://doi.org/10.1007/978-981-15-8983-6_34.

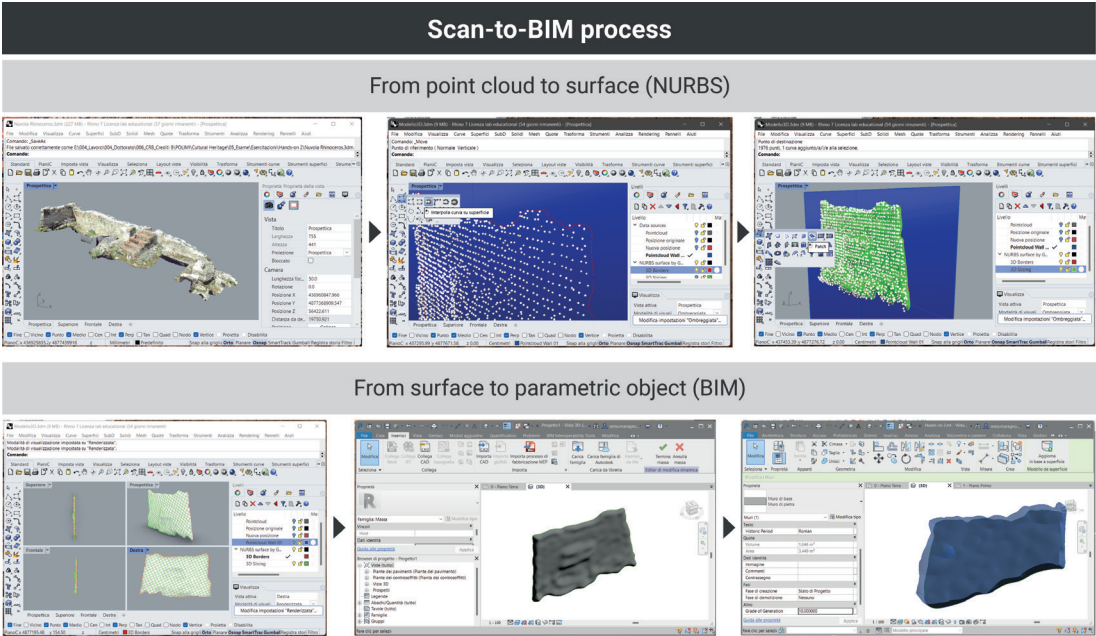
19. Barbini and Chioni, "Reality vs Virtual Modelling," 383.

20. Barazzetti, "Parametric as-built model generation".

on this procedure, that is basically able to generate surfaces with the interpolation of the point cloud using different 3D modelling techniques, such as mesh-based algorithms²¹ or non-uniform rational basis spline (NURBS) algorithms²².

Conversely, ‘parametric modeling’ requires a parametric representation of geometry and not simply a static shape. It can then “be intended as the process of ‘redrawing without redrawing’”. If (direct) geometric modeling aims at providing a static reconstruction of the objects, in parametric modeling distinct objects can be interactively modified by changing the numerical values in a set of predefined parameters stored in a database”²³. “This means that a model generated from point clouds is not a BIM unless (1) parametric intelligence, (2) relationships and (3) attributes are added. [...] As commercial BIM packages were not developed for complex objects, there is a lack of tools for managing complex NURBS curves and surfaces in such packages”²⁴. Thus, the scan-to-BIM procedure consists of transforming complex NURBS surfaces into specific BIM families from sets of raw point clouds of a real object [Fig. 4.18].

Fig. 4.18 Example of Scan-to-BIM process. Figures from the hands-on sessions of the course “Cultural heritage and built environment surveying, modelling and monitoring HBIM-GIS-XR based”, held by Raffaella Brumana, Branka Cuca, Daniela Oreni, Fabrizio Banfi, Mattia Previtali, Politecnico di Milano, ABC PhD Programme (A.Y. 2021-2022)



21. Barazzetti, Banfi, Brumana, and Previtali, “Creation of Parametric BIM Objects”.

22. Fabrizio Banfi, “The Evolution of Interactivity, Immersion and Interoperability in HBIM: Digital Model Uses, VR and AR for Built Cultural Heritage,” *ISPRS International Journal of Geo-Information* 10, no. 10 (2021), <https://doi.org/10.3390/ijgi10100685>.

23. Barazzetti, “Parametric as-built model generation,” 298.

24. Barazzetti, Banfi, Brumana, and Previtali, “Creation of Parametric BIM Objects,” 340-353.

In the coming years, much of the physical world is expected to be increasingly replaced or supplemented by digital reality. This shift places a significant historical responsibility on new digital models, extending well beyond the role of mere contemporary dissemination and redefining the concept of memory²⁵. In this perspective, creating Digital Twins (DT) of historical heritage seems to represent a critical effort to ensure its preservation for future generations²⁶. In fact, «the contemporary notion of Digital Twin specifically intends the model as a working tool for heritage and data management, operating directly on the real environment from the virtual realm, considering smaller time frames until the real-time update»²⁷.

To date, however, a further step forward has been made in this direction, that is the Digital Memory Twin. “Building upon HHBIM [Holistic Heritage BIM]²⁸, the Memory Twin represents the next conceptual evolution in heritage digitisation. While HHBIM enhances the richness and complexity of digital heritage models, the Memory Twin explicitly embeds paradata (documentation of the creation process), metadata, and intangible values such as affective responses, contested histories, and community narratives within a dynamic, interoperable framework. It shifts the emphasis from preservation and representation to meaning-making and memory construction, fostering ongoing dialogue between past and present. The Memory Twin is not merely a more detailed model; it is a living, evolving construct, capable of adapting to

25. “In virtual reality, the mnemonic function that characterizes drawing - together with its nature as idea and communication - is amplified and expanded. Within virtual representation, three forms of memory emerge: decision-making memory, which preserves design choices and their underlying reasons; constructive memory of the image, referring to the set of specific procedures that produced the visual outcome; and representational memory, linked to movement, in which the dimension associated with the ‘art of memory’ is realized. To the illusory three-dimensionality of the virtual image is thus added a fourth dimension, time. Yet this is not all. A fifth dimension seems to appear on the horizon - one that may be defined as a dimension of synthesis: a plane of meaning in which what is measured is simultaneously displaced into an ambiguous field of systematic conceptual misalignment, becoming itself a principle of interpretation” (Franco Purini, “Tre divagazioni al margine,” *XY Dimensioni del disegno. Nuove tendenze IX*, no. 23-24-25, Officina, 1995, 15-18).

26. Cecilia Bolognesi, “From heritage to massive future fruition,” in *Digital & Documentation. Digital strategies for Cultural Heritage*, ed. M. Lo Turco, E.C. Giovannini, and N. Mafrici, v. 2 (Pavia University Press, 2020), 189-191.

27. Barbini and Chioni, “Reality vs Virtual Modelling,” 386.

28. “HHBIM aims to expand beyond architectural and historical documentation by incorporating interdisciplinary data sources; archival research, oral histories, community engagement, and environmental context. This approach recognises that heritage is not merely a static remnant of the past but a living, layered narrative embedded in place, memory, and identity” (Anthony Cassar, Drew Baker, and Marinos Ioannides, “From Digital Twin to Memory Twin: A Holistic Framework for Cultural Heritage Documentation, Interpretation, and Adaptive Reuse,” *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.* XLVIII-M-9-2025, 2025: 204, <https://doi.org/10.5194/isprs-archives-XLVIII-M-9-2025-203-2025>).

new inputs, narratives, and technologies. By aligning with FAIR data principles and integrating into broader infrastructures like GIS platforms and the *European Common Data Space for Cultural Heritage*, it ensures sustainable access, monitoring, public engagement, and long-term relevance in digital heritage practice”²⁹.

The increasingly close relationship between the real and virtual worlds is evident not only in the development of digital models, but also in new ways of communicating and experiencing them. This evolution is reshaping how architecture, and CH in general, are experienced and appreciated. Their aesthetic parameters are transforming, mirroring changes that have already occurred in the art world, particularly with the dissolution of the ‘fixed image’ traditionally represented by painting and sculpture³⁰. In its place, there is a growing emphasis on performance art and installations designed to astonish, leaving a lasting impression. These are collectively experienced as events, amplifying their impact and fostering shared engagement.

This transformation relates to a new way of describing and narrating the world through representation. Architect Fabio Quici argues that, in the digital age, the traditional hermeneutic approach to representation is increasingly supplanted by illusion and an imagination that challenges reality. This shift gives rise to a scenario basically different from that of constructed reality. However, this scenario does not present itself merely as an alternative confined to the realm of the ‘possible’. Instead, through new technologies, it increasingly finds avenues for tangible manifestation in the physical world, sometimes even overlapping with and merging into it. Representation, therefore, is no longer merely a ‘duplicate’ of reality but has evolved into an extension of it, even forming an autonomous ‘reality’ of its own³¹.

Within this framework, cultural and museum institutions, along with

29. Cassar, Baker, and Ioannides, “From Digital Twin to Memory Twin,” 204.

30. “Information visualization, as a multidisciplinary field, is an active area of research and practice in both mainstream computer science and simulation applications. [...] Visualizations are recognized as an innovative form of communication, leveraging the power of images to convey information, ideas, and emotions. In the past, 2D renderings were commonly used for this purpose, and only experts with specialized equipment could create 3D renderings. However, we are now in a new era where 3D representations, visualizations, and animations are increasingly popular and, in some cases, even replace the traditional communication paradigm based on words, symbols, and 2D representations” (Dubravko Gajski, Robert Župan, Ivana Racetin, and Ruzica Krstic, “Straightforward Stereoscopic Techniques for Archaeometric Interpretation of Archeological Artifacts,” *Heritage*, no. 6, 2023: 5066-5081, <https://doi.org/10.3390/heritage6070268>).

31. Fabio Quici, “Un progetto per la rappresentazione,” in *Tempo forma immagine dell’architettura*, ed. G.A. Massari (Officina Edizioni, 2010), 163-168.

EAC professionals and researchers, are increasingly exploring innovative approaches to the representation and communication of CH. Latest trends are directed towards interactive model outputs, adopting an approach progressively centered on dynamic and emotional experiences rather than the static presentation of content³² [Fig. 4.19].

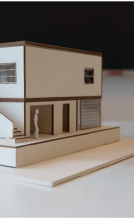
3D digital model			
Static outputs		Interactive outputs	
2D technical or illustrative drawings	3D physical models	VR experiences	AR experiences
Fruition interfaces		Fruition interfaces	
Analog / Digital	Analog	Digital	Analog / Digital
			

Fig. 4.19 The possible outputs of 3D digital models and user interfaces.

Starting with reality-based models or virtual reconstructions that integrate data from surveys and historical documents, static outputs can take the form of traditional 2D representations, such as technical or illustrative drawings (e.g., renderings), or 3D physical representations, typically created using 3D printing³³, laser cutting, and other fabrication methods. While it may not be necessary to elaborate on the prevalence and utility of 2D representations, it is important to highlight the

32. Tommaso Empler, Adriana Caldarone, and Alexandra Fusinetti, “L’interazione visibile: transizioni tra modelli analogici e digitali per le ricostruzioni storiche/Visible Interaction: Transitions between Analogical and Digital Models for Historical Reconstructions,” in *Transizioni. Atti del 44° Convegno Internazionale dei Docenti delle Discipline della Rappresentazione/Transitions. Proceedings of the 44th International Conference of Representation Disciplines Teachers*, ed. M. Cannella, A. Garozzo, and S. Morena (FrancoAngeli, 2023): 1231-1248, doi.org/10.3280/oa-1016-c346.

33. “Three-dimensional printing allows for the creation of complex and customized objects with a high degree of precision and at a relatively low cost. Three-dimensional printing works by depositing material layer by layer to build an object from a 3D model. There are several technologies used in 3D printing, including Fused Deposition Modeling (FDM), Stereolithography (SLA), and Selective Laser Sintering (SLS)” (Antreas Kantaros, Theodore Ganetsos, and Florian I.T. Petrescu, “Three-Dimensional Printing and 3D Scanning: Emerging Technologies Exhibiting High Potential in the Field of Cultural Heritage,” *Applied Sciences*, no. 13 (2023), <https://doi.org/10.3390/app13084777>).

significant value of 3D physical models across various fields, above all cultural heritage³⁴. These models enable access to a wide audience, including individuals with special needs (e.g., older adults, those who are ill, people with various disabilities, such as mobility or visual impairments)³⁵. Moreover, they serve as valuable tools for all users, offering opportunities to gain a deeper understanding of the cultural asset, through more immersive and multisensory experiences.

Emerging communication trends centered on dynamic and interactive visualization are likely driven not only by significant technological advances in recent decades but also by a new approach to interpreting CH sites. “Whereas previously cultural sites represented static warehouses to acquire, preserve, conserve, and study artifacts, their mission has now changed. People today consider cultural sites as active learning environments, where the importance of objects is questioned in favor of the importance of information. The entire cultural experience is now designed in a user-centric manner: every aspect of the offered experience and activities must contribute to the visitor’s satisfaction and the advancement of the visitor’s knowledge. The use of digital technologies like AR, MR, and VR offers new forms of learning, makes knowledge and works accessible, and allows the visitor to personalize the visit; the development of XR serious games engages new audiences, traditionally far from cultural environments, thanks to the type of interaction and the familiarity of the storytelling, facilitating their learning in an edutainment key using the ‘learning by doing’ paradigm”³⁶.

These interactive outputs rely on user interfaces, which can be categorized as either analog or digital. The first ones “are defined as ‘Tangible User Interface’³⁷, which is a type of interface that deals with providing tangible representations, enabling users to have access to information (digital or otherwise) according to physical and manipulable tools. The

34. Gencay Çubuk, “3D printing for the reinterpretation of architectural heritage: Proposal of a model,” *Cultural Heritage and Science*, no. 5, i. 1 (2024): 24-37, <https://doi.org/10.58598/cu-hes.1415522>.

35. Jerzy Montusiewicz, Marcin Barszcz, and Sylwester Korga, “Practical Aspects of Using 3D Technology to Disseminate Cultural Heritage Among Visually Impaired People,” in *Learning in the Age of Digital and Green Transition*, ed. M.E. Auer, W. Pachatz, and T. Rüttmann, v. 633 (Springer, 2023), 468-478, https://doi.org/10.1007/978-3-031-26876-2_45.

36. Chiara Innocente, Luca Ulrich, Sandro Moos, and Enrico Vezzetti, “A framework study on the use of immersive XR technologies in the cultural heritage domain,” *Journal of Cultural Heritage*, v. 62 (2023): 268-283, <https://doi.org/10.1016/j.culher.2023.06.001>.

37. Orit Shaer and Eva Hornecker, “Tangible User Interfaces: Past, Present and Future Directions,” *Foundations and Trends in Human-Computer Interaction*, v. 3, no. 1-2 (2010): 4-137, <http://dx.doi.org/10.1561/11000000026>.

use of the different forms of representation that result, integrated with each other, allow on one hand to overcome the usual three-dimensional visualization modalities offered by digital interfaces, and on the other hand to build new paradigms of communication, allowing an easier access to information for users, thanks to a perpetual and bi-univocal exchange of data between the real and virtual worlds”³⁸.

Digital interfaces for experiencing XR can vary in their level of immersion, ranging from smart devices, such as computer PC workstation, laptop, tablets, and smartphones, which support dynamic and partially immersive navigation of VR and AR environments, to AR HMDs, VR headsets, and CAVE systems, which offer a fully immersive and sensory-encompassing experience. “These immersive technologies allow a controlled exploration of the environment and the presentation of information with greater depth and breadth. This method of presenting cultural content encourages psychological immersion and a sense of presence, both of which increase engagement and make users more prone to knowledge awareness”³⁹. Virtual Reality, augmented reality, and mixed reality, have significantly transformed the study, conservation, and public accessibility of CH. Widely applied across fields such as education, entertainment, sustainable construction, and medicine, these technologies have brought CH into a more visible and engaging realm, making it accessible to a broader audience⁴⁰ [Fig. 4.20].

Fig. 4.20 Left, AR analog installation at ancient harbour of Classe in Ravenna; right, the VR experience of the Cave Automatic Virtual Environment at EVL, University of Illinois, August 2001.

[“Antico Porto di Classe,” Ravenna antica, accessed May 1, 2026, <https://ravennantica.it/cosa-vedere/antico-porto-di-classe/>; Davepape, <https://commons.wikimedia.org/w/index.php?curid=868395>]



38. Empler, Caldarone, and Fusinetti, “L’interazione visibile”.

39. Innocente, Ulrich, Moos, and Vezzetti, “A framework study on the use of immersive XR technologies”.

40. Jingru Zhang, Wan A.J. Yahaya, and Mageswaran Sanmugam, “The Impact of Immersive Technologies on Cultural Heritage: A Bibliometric Study of VR, AR, and MR Applications,” *Sustainability* 16, no. 15 (2024), <https://doi.org/10.3390/su16156446>.

In conclusion, the use of digital tools like photogrammetry and laser scanning has enabled fast, accurate, and comprehensive 3D documentation of CH sites. Combined with emerging technologies such as XR, these tools facilitate the mapping, reconstruction, and revival of cultural elements, including monuments, artifacts, and historical events, bringing them to life in immersive and interactive ways⁴¹. Over the past two decades, research has highlighted the potential of these methods to enhance both the preservation of heritage and the cultural experience associated with it, while also including and engaging an increasingly large and diverse range of users.

Digital documentation supports diverse outcomes, from architectural drawings and 3D models to BIM databases and 3D-printed replicas. These tools not only allow for visualizing CH in its current state or as a reconstruction but also enable the simulation of hypotheses about archaeological findings. Additionally, they provide opportunities for innovative design interventions that integrate preservation with modern architectural renewal.

In summary, the integration of digital technologies is revolutionizing the way CH is documented, conserved, and experienced, ensuring its longevity and accessibility for future generations while enriching the cultural experience for contemporary audiences.

Building on these considerations, a research initiative was undertaken as part of the Ph.D. program, focusing on new aesthetic paradigms for communicating and experiencing CH images. Indeed, contemporary image aesthetics, influenced by advances in digital technologies discussed in previous paragraphs, seeks new dimensions for the fruition of historical documents and iconography. Therefore, this contribution aims to present a low-cost workflow for creating a new digital iconography and explorable digital models of an existing urban environment and its unrealized alternative scenarios, that align with contemporary image aesthetics. The methodology was applied to Piazza d'Arognò, a pivotal urban space in Trento's historic center, with a particular focus on the staircase connecting it to one of the primary street axes. The results of this project include two distinct 3D models designed for exploration in Virtual and Augmented Realities, as well as newly created digital ima-

41. Efstratios Stylianidis, Konstantinos Evangelidis, Rebeka Vital, Panagiotis Dafiotis, and Stella Sylaiou, "3D Documentation and Visualization of Cultural Heritage Buildings through the Application of Geospatial Technologies," *Heritage* 5, no. 4 (2022), 2818-2832, <https://doi.org/10.3390/heritage5040146>.

gery that can be experienced both statically and interactively. In conclusion, this research demonstrates the potential of integrating low-cost 3D digital surveying with archival documentation to produce visual outputs that allow users to engage with alternative narratives of urban history, either through analytical or emotional perspectives.

04.3.1 In-depth study & experiences

The immersive experience of Adamo d'Arogno square

Project	Virtual reconstruction of different design hypotheses for Piazza d'Arogno in Trento.
Coordinator	Giovanna A. Massari (DICAM, University of Trento), Cristiana Volpi ((DICAM, University of Trento).
Working group	Ambra Barbini (DICAM, University of Trento), Elena Bernardini (DICAM, University of Trento), Chiara Chioni (DICAM, University of Trento), Anna Maragno (DICAM, University of Trento).
Technical support	Laboratory of Architectural Modelling and Analysis Representation and Communication (LAMARC) from the DICAM (University of Trento).
Timeframe	August 2023 - March 2024
Dissemination	Anna Maragno, Ambra Barbini, Elena Bernardini, and Chiara Chioni, "Other Stories. Virtual Reconstruction of Different Design Hypotheses for Piazza d'Arogno in Trento," in <i>eXploRA UID 2024. Virtual Journeys to discover inaccessible heritages</i> , ed. F. Stilo, V. Castiglione, I. Cazzaro, M. Ceracchi, F. Natta, M. Pilleri, L. Pizzonia, A. Tomalini, N. Tomasella, and M.B. Trivi (PUBLICA, 2024), 533-545.

Introduction

Contemporary cities reflect just one of countless possible historical trajectories. Our understanding of both built and unbuilt projects relies heavily on historical documents, especially visual sources such as drawings, maps, prints, and postcards, which allow us to imagine past or hypothetical contexts. Although widely recognized as cultural heritage and increasingly digitized, these materials remain underutilized outside specialist circles, and their broader dissemination is still an evolving challenge.

In recent decades, efforts to preserve heritage from physical decay and cultural oblivion have driven interdisciplinary research¹, though greater integration across fields is still needed². At the same time, the rapid evo-

1. Grazia Tucci, Caterina Balletti, Valentina Bonora, Francesco Fassi, Antonia Spanò, Erica I. Parisi, Mattia Previtali, and Giulia Sammartano, "Documenting, understanding, preserving cultural heritage. Humanities and digital technologies for shaping the future: preface," *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences* X-M-1-2023 (2023), <https://doi.org/10.5194/isprs-annals-X-M-1-2023-1-2023>.

2. Sofia Pescarin, "Digital heritage into practice," *SCientific REsearch and Information Tech-*

lution of visual culture calls for updated methods of representation and engagement, leveraging new technologies to enhance the accessibility and relevance of historical iconography³.

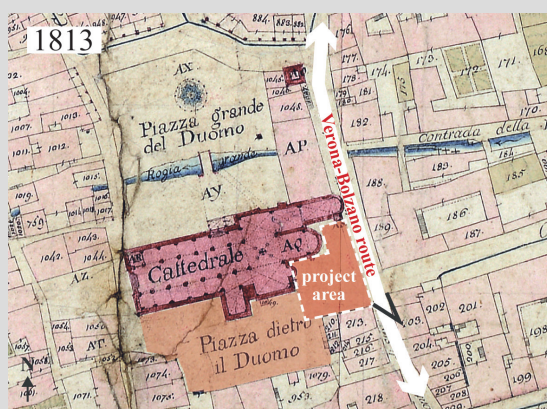
One promising approach involves combining digital tools with archival sources in two key ways: first, by using historical imagery to compare past representations with present realities; and second, by employing these sources to reconstruct 3D models of unrealized projects, enabling exploration from new and unconventional perspectives. This experience investigates a low-cost workflow that adapts traditional two-dimensional materials to contemporary visual language, expanding the ways historical documentation can be experienced through digital media while also visualizing alternative urban scenarios.

Case study and research framework

The research focuses on the staircase project in Adamo d'Arogno square, a key node in Trento's historic centre. Historically part of the cathedral complex of San Vigilio, the square evolved from a cemetery to a commercial space, while maintaining a key role as a transit and connecting point within the city⁴ [Fig. 4.21].

Fig. 4.21 Left, detail from the Napoleonic land register showing the location of the staircase project area; right, historical image depicting the site before the intervention (J. Arnout, C.J. Billmark, Duomo di Trento, 1841, Biblioteca Digitale Trentina, TI 1 f 151).

[Maragno et al., "Other Stories," 537]



nology *Ricerca Scientifica e Tecnologie dell'Informazione*, v. 6, i. 1 (2016): 1-4, <http://dx.doi.org/10.2423/i22394303v6n1p1>.

3. Ramona Quattrini, Roberto Pierdicca, Emanuele Frontoni, R. Barcaglioni, "Virtual Reconstruction Of Lost Architectures: From The TIs Survey To Ar Visualization," *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* XLI-B5 (2016): 383-390, <https://doi.org/10.5194/isprs-archives-XLI-B5-383-2016>; Luca Catana, Giuseppe D'Acunto, and Starlight Vattano, "Archive Drawing in Digital Reconstructions. Unbuilt Venice in Cannaregio Ovest (1978)," *TRIA* 15, no. 1 (2022): 19-40, <https://doi.org/10.6093/2281-4574/9252>; Fabio Bianconi, Marco Filippucci, Filippo Cornacchini, Michela Meschini, and Chiara Mommi, "Cultural Heritage And Virtual Reality: Application For Visualization Of Historical 3d Reproduction," *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* XLVIII-M-2-2023 (2023): 203-210, <https://doi.org/10.5194/isprs-archives-XLVIII-M-2-2023-203-2023>.

4. Renato Bocchi and Carlo Oradini, *Le città nella storia d'Italia*. Trento (Laterza, 1983).

Between 1840 and 1842, the square was redesigned: its level was lowered and a staircase was built to link it to the adjacent street. This project revealed both collaboration and conflict between Civic and District Engineers (*Kreisingenieurs*) under Habsburg rule, particularly in the different design approaches of Giovanni Rossetti and Floriano Menapace⁵ [Fig. 4.22].

The study is part of a broader interdisciplinary research framework combining archival analysis and advanced digital survey methods. It integrates data from previous projects on historic road systems and Palazzo Pretorio with ongoing doctoral research on heritage representation, low-cost surveying, 3D modelling, and virtual and augmented reality⁶.

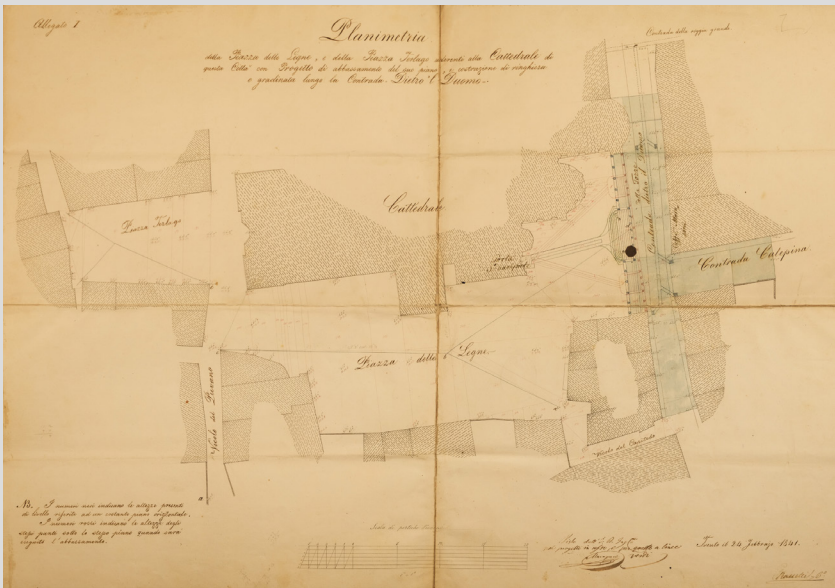


Fig. 4.22 Drawing summarising some of the design hypotheses for the staircase (the double staircase and the single central staircase) and the connecting walkway at the northern entrance to the Cathedral. The plan is drawn by Civic engineer Rossetti and seen and signed by District engineer Menapace (ASCTn, 3.8 – IV.65.1891).

[Maragno et al., “Other Stories,” 538]

5. Anna Maragno and Cristiana Volpi, *Dove Trento s'ingegna. Il ruolo degli ingegneri nello sviluppo della città di Trento nel corso del XIX secolo* (Edizioni Efesto, 2023).

6. Ambra Barbini, “Integrazione automatizzata e parametrica di oggetti BIM in un contesto urbano. Automatic and parametric integration of BIM objects in an urban context,” in *3D MODELING & BIM: Digital Twin 3*, ed. T. Empler, A. Caldarone, and A. Fusinetti (DEI s.r.l. Tipografia del Genio Civile, 2021), 128-142; Elena Bernardini, “Tecniche di rappresentazione e modellazione per il progetto sul patrimonio del Novecento,” in *3D MODELING & BIM: Digital Twin 3*, ed. T. Empler, A. Caldarone, and A. Fusinetti (DEI s.r.l. Tipografia del Genio Civile, 2021), 176-193; Chiara Chioni, Anna Maragno, Angelica Pianegonda, Marco Ciolli, Sara Favargiotti, and Giovanna A. Massari, “Low-Cost 3D Virtual and Dynamic Reconstruction Approach for Urban Forests: The Mesiano University Park,” *Sustainability* 15, (2023), <https://doi.org/10.3390/su151914072>; Chiara Chioni, Arnadi Murtiyoso, Sara Favargiotti, and Giovanna A. Massari, “Low-Cost Workflow For 3d Urban Forest Virtual Reconstruction,” *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences XLVIII-1/W2-2023* (2023): 1723-1728, <https://doi.org/10.5194/isprs-archives-XLVIII-1-W2-2023-1723-2023>.

Method

Fig. 4.23 Workflow of the research exploration: (i) survey data and historical data collection; (ii) integration of metric and historical information; and finally, (iii) visualisation of the different outputs.

[Maragno et al., “Other Stories,” 539]

The methodology is structured into three main phases: (i) acquisition, (ii) processing, and (iii) visualisation [Fig. 4.23]. First, key archival documents related to the Piazza d’Arogno staircase were selected, including artistic depictions of the site and technical drawings illustrating different design proposals by Rossetti (G. Rossetti, 24th February 1841, ASCTn, 3.8 - XI.363.1843) and Menapace (F. Menapace, 8th March 1842, ASCTn, 3.8 - XI.363.1843). Geometric and visual data of the existing staircase were then collected using a low-cost tool - a 360° camera [Fig. 4.24] - allowing the creation of a scaled, coloured 3D point cloud through photogrammetry.

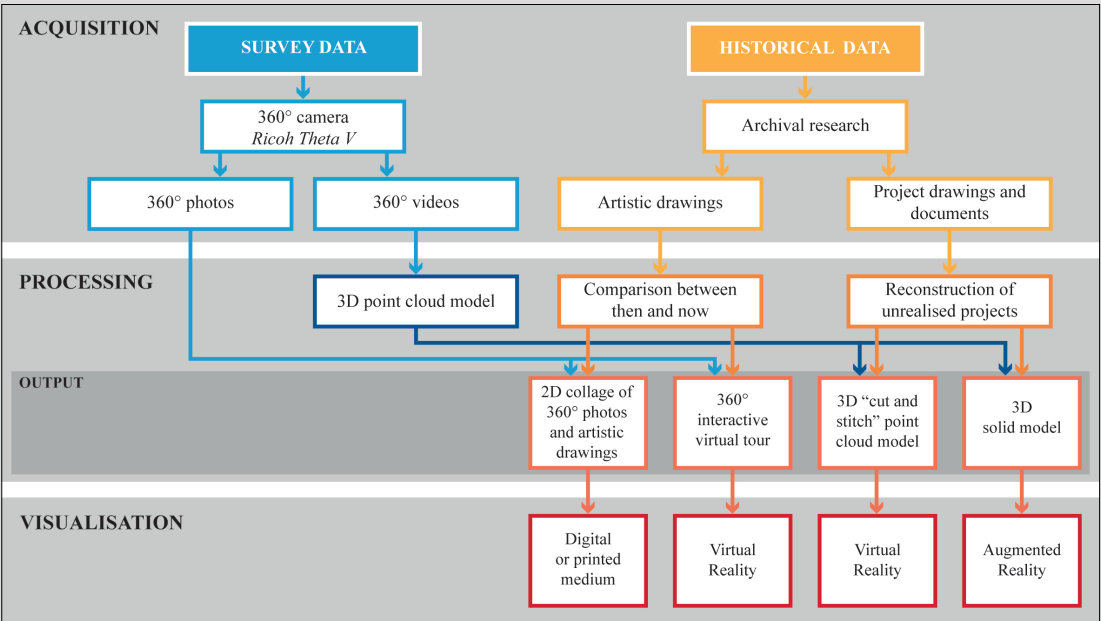


Fig. 4.24 Digital survey campaign in August 2023: the current state of the square and the staircase were recorded in a spherical video with the Ricoh Theta V 360° camera, following the blue path in the figure.

[Maragno et al., “Other Stories,” 540]



The collected and processed data were integrated with archival materials in two ways. Historical images were used to compare past and present conditions [Fig. 4.25, top], both evocatively - through photomontages combining old postcards and current elements - and analytically, via an interactive virtual tour with embedded historical references. At the same time, project drawings supported the reconstruction of unrealised designs in 3D [Fig. 4.25, down].

Two modelling approaches were adopted: an evocative one, using point clouds to suggest urban scenarios, and a rational one, based on volumetric modelling to accurately place unbuilt elements within the current context. In the first case, a new ‘drawing-based’ coloured 3D point cloud, representing the unrealised design hypothesis of the double staircase, was created by manipulating (ie., cutting and stitching) in the open-source software CloudCompare (<https://www.danielgm.net/cc/>) the point cloud resulting from the spherical photogrammetry procedure (fig. 5c); in the second case, a 3D model of the never realised double convergent staircase was created via solid modelling in the commercial software Autodesk Revit (<https://www.autodesk.it/products/revit/overview?term=1-YEAR&tab=subscription>), using the survey data as reference to properly position and size the model.

These methods enabled both interpretative visualisations and precise digital reconstructions of the proposed but never executed staircase designs.

Results

The experimentation produced a range of outputs combining archival research and 3D digital surveying: 2D collages, interactive 360° virtual tours, and three types of 3D models (a reality-based point cloud of the existing staircase, a ‘drawing-based’ coloured point cloud of an unrealised proposal, and a solid model of another unbuilt design. These results can be accessed through printed or digital media, as well as through Virtual Reality (VR) and Augmented Reality (AR) [Fig. 4.26].

The 2D collages (a) offer static yet synthetic views that merge different historical phases into a single image, reinterpreting archival iconography through the integration of present-day elements.

The 360° images (b) (c) can be explored through virtual tours, navigable either immersively or on-screen, allow users to explore past configurations while remaining anchored to the current environment.

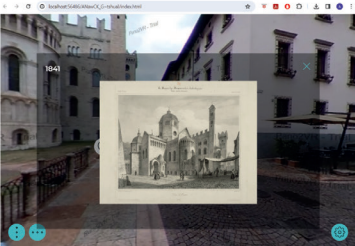
The choice of visualisation environments depends on the nature of the

Fig. 4.25 Top, figurative integration of historical images and 360° photos: (a) 2D digital collage, (b) virtual tour with hot-spots. Down, virtual reconstruction of two design hypotheses: (c) double staircase realised by manipulating point clouds, (d) double convergent staircase created by solid modelling.

[Maragno et al., “Other Stories,” 533]

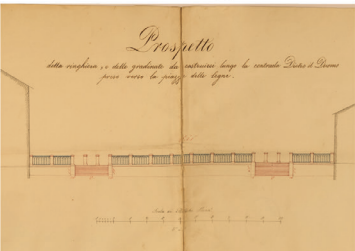
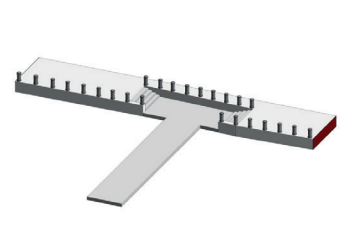
Comparison between then and now

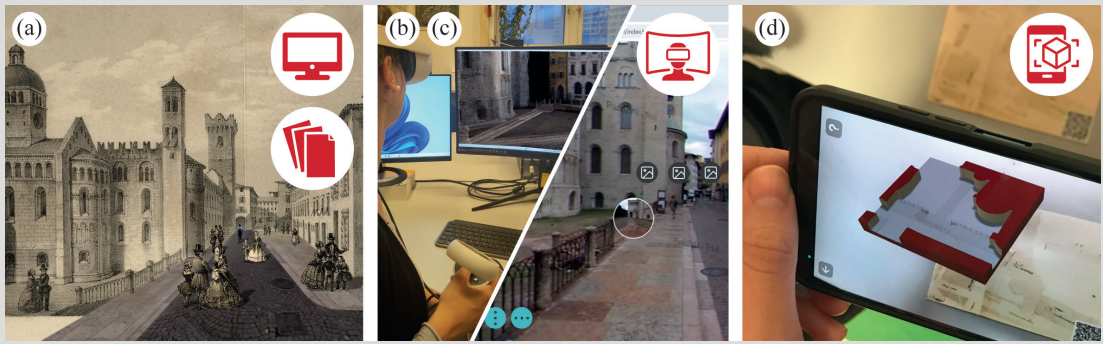
Archival sources as figurative support

SURVEY DATA	HISTORICAL DATA	OUTPUT
360° photos of the current state	State after the project	(a) Evocative
		
	State before the project	(b) Rational
		

Reconstruction of unrealised projects

Archival sources as historical reference

SURVEY DATA	HISTORICAL DATA	OUTPUT
3D point cloud model of the current state	Double staircase hypothesis	(c) Evocative
		
	Double convergent staircase hypothesis	(d) Rational
		



models. Point clouds support immersive VR experiences, evoking unreal urban scenarios, while solid models (d) are better suited for AR, where they can be overlaid onto the real setting to enrich it with historical information.

The first case, whose virtual environment has been created with the free Twinmotion real-time visualisation tool (<https://www.twinmotion.com/en-US/home>), is designed for a remote fruition of the project through a workstation and a VR headset (in our case, the Oculus Meta Quest 2); on the other hand, the solid model has to be experienced directly on site with a portable device (ie., smartphone, tablet) equipped with an AR app (in our case, UniteAR: <https://www.unitear.com/>) by scanning a QR code or framing a target image.

Discussion and outlooks

In conclusion, the study demonstrates how low-cost 3D digital surveying combined with archival documents can generate visual outputs that enable both analytical and emotional engagement with alternative historical narratives. These results expand the ways architectural heritage can be experienced, enhancing the communicative value of archival materials through diverse digital formats and forms of visual storytelling, suitable for both specialists and a wider audience.

Two main strategies are highlighted. The first is an evocative approach, using coloured survey data - such as panoramic images and point clouds - to merge past and present or to create immersive visualisations of unrealised projects. The second is a more analytical approach, based on overlaying visual data: integrating archival images into current environments or using simplified solid models to represent unbuilt scenarios directly on-site through AR.

The experimentation also clarifies the strengths and limits of each

Fig. 4.26 Different stories of Adamo d'Arogno square in Trento.

[Maragno et al., "Other Stories," 541]

method. Fast, accessible workflows were prioritised to maximise existing data, such as using conceptual solid models for AR applications. While more detailed modelling could improve realism, it requires greater effort, whereas point cloud manipulation offers higher visual fidelity but is only effective when proposed designs closely resemble the current context.

Overall, combining these approaches enables both local communities and visitors, physical or virtual, to explore not only past urban configurations but also alternative versions of the present.

05

From digital resource to
digital record. Constructing
the digital cultural heritage



Chapter 05 • From digital resource to digital record. Constructing the digital cultural heritage

This chapter analyses the process through which digital resources related to the built environment become digital cultural heritage, adopting an archival perspective that moves beyond a purely technical notion of digitisation. Digital objects are framed as cultural records whose value depends on contextualisation, metadata enrichment, and long-term preservation. The chapter clarifies the distinction between digitised and born-digital materials and highlights the role of metadata and paradata in transforming raw data into meaningful digital records.

A critical overview of European and Italian policies and guidelines for heritage digitisation follows, with specific attention to the challenges of 3D documentation of built heritage, including issues of quality, interoperability, and standardisation. The analysis points to significant convergences between European and national frameworks, while also identifying gaps, particularly regarding born-digital materials and the actors involved in the production of digital built heritage.

The final section focuses on contemporary architectural archives, increasingly composed of born-digital and hybrid records produced within professional practice. It clarifies how these materials constitute the digital cultural heritage of the future and calls for the integration of archival principles into architectural practice to ensure the sustainability, accessibility, and long-term cultural value of digital built heritage.

05.1 Digital cultural heritage: Italian and European perspectives

A growing proportion of global cultural and educational resources is now created, disseminated, and consulted in digital formats instead of on paper¹. This shift has driven an evolution in the concept of digital cultural heritage (DCH), which has developed considerably over the past two decades, moving from a merely technical understanding of digitization as the ‘digital reproduction’ of cultural artefacts to a broader epistemological reflection on the cultural status of digital entities themselves. “Digital heritage is made up of computer-based materials of enduring value that should be kept for future generations», yet not all digital materials possess such enduring value. «Those that do require active preservation approaches if continuity of digital heritage is to be maintained”².

As Barbuti notes, cultural heritage³ - whether tangible or intangible - becomes heritage when it acts as an activator of interest across generations, capable of transferring knowledge about its lifecycle, transformations, and socio-historical contexts. In this perspective, entities created digitally, whether by digitization of analogue artefacts or born-digital practices, must be seen as potential future digital cultural heritage and not merely as technical derivatives of scanning or documentation⁴.

A central issue in the study of DCH is the distinction between digitized and born-digital cultural heritage, a difference concerns both scholars working in the Digital Humanities and professionals in cultural institutions such as libraries, archives, and museums⁵. In line with ICOM Italia, digitized cultural heritage includes digital objects derived from

1. “Digital Heritage,” UNESCO, accessed May 1, 2026, <https://webarchive.unesco.org/web/20230615235525/https://en.unesco.org/themes/information-preservation/digital-heritage>.

2. “Concept of Digital Heritage,” UNESCO, accessed May 1, 2026, <https://webarchive.unesco.org/web/20230616073538/https://en.unesco.org/themes/information-preservation/digital-heritage/concept-digital-heritage>.

3. According to UNESCO, “Cultural heritage includes artefacts, monuments, a group of buildings and sites, museums that have a diversity of values including symbolic, historic, artistic, aesthetic, ethnological or anthropological, scientific and social significance. It includes tangible heritage (movable, immobile and underwater), intangible cultural heritage (ICH) embedded into cultural, and natural heritage artefacts, sites or monuments. The definition excludes ICH related to other cultural domains such as festivals, celebration etc. It covers industrial heritage and cave paintings” (“Cultural heritage,” Glossary, UNESCO, accessed May 1, 2026, <https://databrowser.uis.unesco.org/resources/glossary/2488>).

4. Nicola Barbuti, *La digitalizzazione dei beni documentali. Metodi, tecniche, buone prassi* (Editrice bibliografica, 2022), 177.

5. Capaccioni Andrea, “Digitized and born-digital cultural heritage: implications for digital humanities,” *JLIS.it* 16, no. 3 (2025): 2, <https://doi.org/10.36253/jlis.it-657>.

pre-existing physical artefacts⁶ (books, paintings, documents, and so forth) which, despite widespread misconceptions, are not mere copies but new digital entities with their own materiality, lifecycle, and metadata requirements. Born-digital cultural heritage, by contrast, refers to cultural objects that exist solely in digital form (digital artworks, e-books, digital databases, video games, software, websites), whose creation and use rely entirely on software and computational tools⁷.

In 2019, UNESCO clarified that both categories fall within digital cultural heritage, defining it as “unique resources of human knowledge and expression [...] created digitally, or converted into digital form from existing analogue resources. Where resources are ‘born-digital’, there is no other format but the digital object”⁸. More recently, Barbuti further expanded this definition by conceptualizing DCH as an “ecosystem of processes, entities, and digitized and born-digital records that embed, within their metadata and structural components, information and narratives concerning their creation, transformations, and user interactions over time. These records thereby become sources of knowledge and historical memory for future generations, bearing witness to the evolution of communities in the digital age”⁹.

A particularly significant conceptualisation is provided in the Italian *Piano Nazionale di Digitalizzazione* (PND)¹⁰, namely the strategic vision through which the *Ministero della Cultura* intends to promote and organise the process of digital transformation for the 2022-2026 five-year period. The Plan recalls that, as early as 2014, the Council of the European Union recognized digital cultural heritage as an autonomous category that includes both digitized and born-digital resources¹¹. “This recognition enables a shift away from conceiving digital objects as ancillary replicas of physical artefacts and affirms the legitimacy of autonomous, original pathways of knowledge. Such originality does not derive from the object itself, but from the intellectual processes through which the digital entity takes shape and acquires new transmis-

6. ICOM Italia, ed., *Glossario museologia digitale e nuove tecnologie* (2020), <https://www.icom-italia.org/wp-content/uploads/2020/10/ICOMItalia.CommissioneTecnologie.2020.GlossarioTecnologie.pdf>.

7. Capaccioni, “Digitized and born-digital cultural heritage,” 2.

8. UNESCO, *Charter on the Preservation of the Digital Heritage* (2009), <https://unesdoc.unesco.org/ark:/48223/pf0000179529>.

9. Barbuti, *La digitalizzazione dei beni documentali*, 177.

10. “Il Piano,” Digital Library, accessed June 1, 2026, <https://digitallibrary.cultura.gov.it/il-piano/>.

11. Capaccioni, “Digitized and born-digital cultural heritage,” 4.

sible meanings¹².

Understanding what constitutes a digital cultural object, however, requires clarifying how a digital entity becomes a digital record. Digitization produces digital entities that initially exist as raw data (a term rooted in the Latin *datum*, ‘something given or transferred’). In this elementary form, data are inherently transferable but remain ‘mute’: whether captured from analogue artefacts or created digitally, they lack contextualisation and narrative, offering visually interpretable content without explicit explanation or validation. Their cognitive and cultural potential thus remains unrealised.

Crucially, what qualifies a digital object as a cultural resource is not its visual appearance alone but the completeness, accuracy, and continual enrichment of the metadata and paradata that describe the object in all its dimensions and record its evolving life cycle. Metadata and paradata ensure the preservation, accessibility, and usability of digital assets¹³ [Fig. 5.1]. In particular, «metadata ensures digital assets are searchable and identifiable within databases and repositories. Without comprehensive metadata, digital collections risk becoming inaccessible or difficult to navigate. Paradata is vital for 3D digitised cultural heritage assets, documenting the complex processes and decisions involved in creating 3D models through methods like photogrammetry, RTI, and multispectral imaging. It is not simply a case of documenting the hardware and software used, the settings and parameters chosen, but also documenting the rationale behind these choices and how multiple image sets have been compiled to form one model, as is increasingly the case today. Such detailed documentation ensures long-term preservation and potential recreation of these assets from raw data captures, maintaining

12. Istituto Centrale per la Digitalizzazione del Patrimonio Culturale - Digital Library, *Piano nazionale di digitalizzazione del patrimonio culturale 2022-2023 (Versione 1.1)* (2023), https://digitallibrary.cultura.gov.it/wp-content/uploads/2023/10/PND_V1_1_2023-1.pdf.

13. “Metadata is structured information that describes, explains, locates, or facilitates the retrieval, use, or management of a resource. In cultural heritage digitisation, metadata includes the title, creator, date, format, and keywords, which are essential for cataloguing and retrieving digital assets. Paradata documents the processes and methodologies involved in creating, transforming, and preserving digital objects, particularly 3D models. It includes technical specifications, software used, digitisation decisions, and alterations. Paradata ensures transparency and reproducibility, allowing future users to understand the context and methods behind a digital asset’s creation, which is vital as the fidelity of digital representations increases. Documenting both metadata and paradata is essential in digitising of cultural heritage” (Anthony Cassar, “Digitising the National Collection,” in *3D Research Challenges in Cultural Heritage V. Paradata, Metadata and Data in Digitisation*, ed. M. Ioannides, D. Baker, A. Agapiou, and P. Siegkas, Springer, 2024, 191, https://doi.org/10.1007/978-3-031-78590-0_16).

Fig. 5.1 Example of metadata and paradata for newly acquired 3D digitisations.

[Luisa Ammirati, Bethany Watrous, Amira Ftaita, Thomas Rigauts, and Michelle de Gruchy, “Dive into Heritage: Paradata and Metadata in an Immersive Digital Heritage Experience,” in *3D Research Challenges in Cultural Heritage V. Paradata, Metadata and Data in Digitisation*, ed. M. Ioannides, D. Baker, and A. Agapiou, P. Siegkas (Springer, 2024), 42, https://doi.org/10.1007/978-3-031-78590-0_4]

Metadata for newly acquired 3D digitisations	Paradata for newly acquired 3D digitisations
Photogrammetry models	Data acquisition
Site location/GPS data	Image capture/scan methodology
Time and date	Image capture/scan parameters (e.g. camera settings, resolution, and sampling frequency)
Number of vertices/triangles	Image capture/scan conditions (e.g. weather, environmental)
File size	Number of photos/scans
Scale	Average camera/scanner distance to subject
Vertex colour	Camera/scanner positions
Material	Targets used (Y/N)
Light source information	Data Pre- and Post-Processing
Laser scan models	How missing information is handled (e.g. whether gaps in data were filled)
Site location/GPS data	The data used/not used to construct the model (e.g. which, if not all, photos were used, if the model/point cloud was cropped)
Time and date	Steps taken to clean up or optimize the data (i.e., removing artefacts, aligning features, enhancing visual quality)
Number of points	Computer specifications (processor, RAM, video card, VRAM, storage)
File size	
Scale	
Light source information	

their relevance as technology evolves”¹⁴. Transforming raw data into meaningful digital resources requires metadata that clearly describe, identify, and comprehensively define the components of a digital object within coherent interpretative frameworks. This, in turn, calls for the careful selection of metadata standards, schemas, and documentation practices that ensure the intelligibility of the digital entity and sustain the interest of both current and future users. When enriched with well-structured metadata and paradata, the raw datum becomes a ‘digital resource’, an inseparable integration of digital structure (bits and bytes), visual content (pixel-based information), and the informational layer that enables interpretation, preservation, dissemination, and interaction¹⁵. According to the Digital Library, a digital record is the complete informational unit that emerges from the synergistic integration of a ‘digital

14. Cassar, “Digitising the National Collection,” 191.
15. Barbuti, *La digitalizzazione dei beni documentali*, 177-184.

resource’ and its ‘description’. A digital resource (whether born-digital or digitised) is understood as an entity composed of one or more digital objects (or media) and an informational component consisting of administrative and structural metadata. A digital resource acquires full meaning and operational value only when accompanied by an accurate description that clarifies its properties, relationships, and semantic position within the system¹⁶.

The description is an informational device that documents the identity of a physical or conceptual object and explicates its significant relationships within a digital environment through a structured set of descriptive metadata. In other words, it constitutes a representation of the object and its interpretative context. Through description, the physical or conceptual object becomes accessible, queryable, and interoperable, assuming a computable form that also enables automatic enrichment. Description thus plays a fundamental role in supporting knowledge creation, use, and reuse. Owing to its informational nature, it may exist in a digital environment even in the absence of a corresponding digital resource, acting as an autonomous element capable of preserving evidence of an object and providing the keys to understand and contextualise it even when it is not yet - or only partially - digitised. When associated with a digital resource, the description enables the reconstruction of meaning and context [Fig. 5.2].

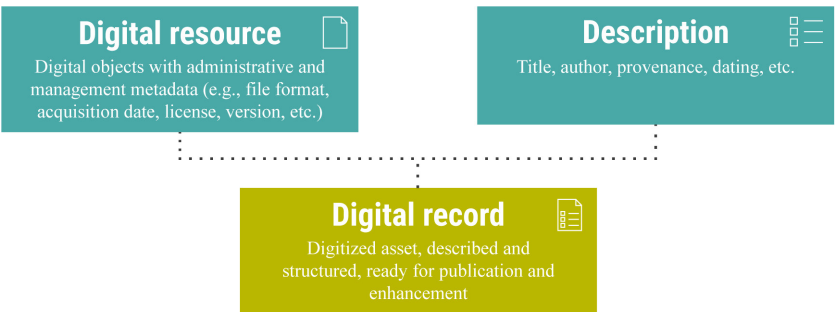


Fig. 5.2 The role of description in documenting the identity and context of an object through structured metadata, enabling accessibility, interoperability, and meaning reconstruction.

The digital record therefore arises from this synergistic integration: it is a digital resource equipped with a description, and thus capable of generating meaning and participating in processes of access, interpre-

16. Istituto centrale per la digitalizzazione del patrimonio culturale - Digital Library, *Economic. Ecosistema digitale per la cultura. Report di inquadramento concettuale* (2025), 34-35, https://digitallibrary.cultura.gov.it/wp-content/uploads/2025/09/Ecomiic_Report-di-inquadramento-concettuale_v1.0.pdf.

tation, and valorisation. Its effectiveness depends not only on the presence of data and digital objects but, above all, on their integration into a coherent logical, documentary, and semantic context¹⁷. When these conditions are met, and the FAIR principles are applied, digital records qualify as digital cultural records, contributing to the broader domain of digital cultural heritage¹⁸.

The digital record constitutes the core element within the life cycle of digital cultural heritage, which can be summarised in the following phases: creation, enrichment, management, access, and reuse¹⁹ [Fig. 5.3].

1st phase • Creation

Creation includes both the acquisition of new digital record (together with their descriptions and metadata) through digitisation or born-digital production, and the integration of pre-existing digital resources and descriptions. This phase underpins the digitisation of cultural heritage and serves as the starting point for the effective functioning of data management and access platforms, whose potential grows in proportion to the quantity and quality of available digital assets. Ensuring full reliability, compliance with quality standards, and adherence to FAIR principles is essential at this stage.

2nd phase • Enrichment

Enrichment concerns the semantic and structural processing of digital assets, performed manually or automatically (e.g., OCR/HCR, NER). This phase enables the cultural valorisation of data, fostering intelligent, contextualised use and opening new opportunities for creative and economic reuse.

3rd phase • Management

Management involves the modification, updating, and deletion of digital resources and their descriptions. It ensures the long-term interoperability and semantic quality of digital assets, supporting sustained and robust valorisation.

4th phase • Access

Access encompasses the processes of exploring, searching, and consulting digital assets. This phase should prioritise broad, inclusive, and

17. Istituto centrale per la digitalizzazione del patrimonio culturale - Digital Library, *Economic*, 34-36.

18. Barbuti, *La digitalizzazione dei beni documentali*, 177-184.

19. Istituto centrale per la digitalizzazione del patrimonio culturale - Digital Library, *Economic*, 38-40.

personalised public engagement, opening new avenues for social participation and for the cultural enhancement of heritage.

5th phase • Reuse

Reuse includes the re-elaboration and transformation of digital record for specific purposes: scientific research, interoperability between datasets, commercial and non-commercial uses, and the creation of new digital objects. It facilitates the circulation and cross-fertilisation of content, supporting knowledge production, process innovation, and new forms of cultural and economic valorisation²⁰.

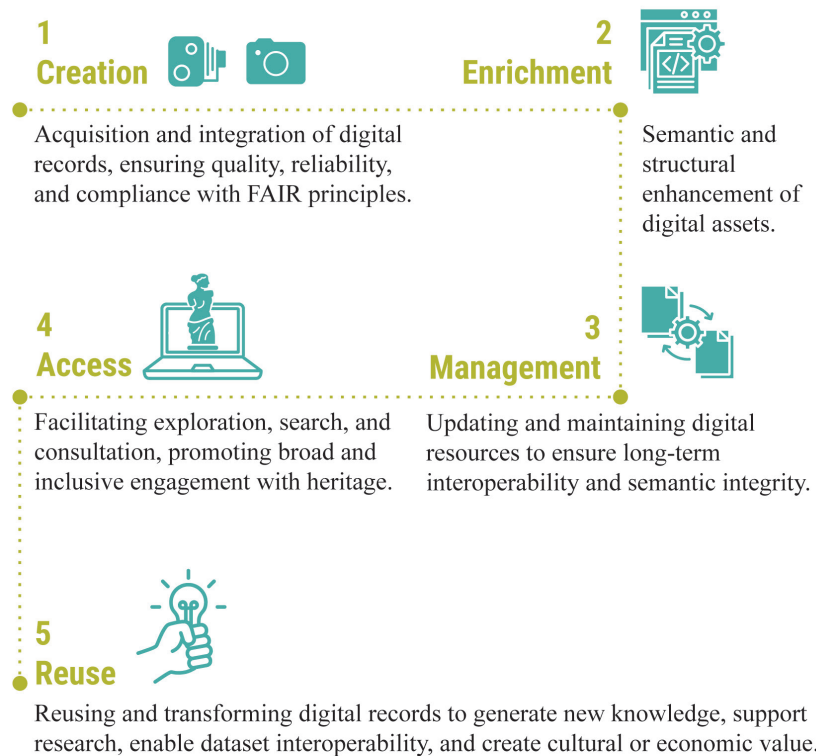


Fig. 5.3 The life cycle of digital cultural heritage.

Recalling once again UNESCO’s words, we may affirm that “the world’s documentary heritage belongs to all, should be fully preserved and protected for all and, with due recognition of cultural mores and practicalities, should be permanently accessible to all without hindrance. [...] Documentary heritage is a legacy of humankind, through which we can look back into the past, enrich our present lives, and look into the future

20. Istituto centrale per la digitalizzazione del patrimonio culturale - Digital Library, *Economic*, 38-40.

with the boldness forged by enduring memories”²¹. Within the broader framework of tangible cultural heritage, the European Commission, in line with UNESCO, emphasise that “the digital recording of CH is an essential step in understanding and conserving the values of the memory of the past, creating an exact digital record for the future, providing a means to educate, skill, and communicating the knowledge and value of the tangible objects to the society”²².

In this context, over the past three decades, the fields related to built heritage documentation, as discussed in the previous chapter, have taken advantage of digital and survey techniques development. Today, “3D data is a critical component to permanently record the shape of important objects and sites so that, at least in digital form, they might be handed down to future generations. Reality-based 3D modeling today has become an effective solution for providing dense and accurate 3D representations which are the basis for further uses such as documentation material production, restoration and conservation policies, physical replicas, digital inventories, etc.”²³.

Building on this understanding, heritage digitisation has advanced significantly, from basic 2D documentation to sophisticated 3D technologies. This evolution underscores a persistent challenge: the absence of harmonised standards for 3D digitisation²⁴. Indeed, it has been observed that “if the (constantly growing) mass of data has effectively enabled to approach the reconstruction of complex geometries, this overgrowth (of data) does not seem to increase the level of intelligibility of the re-

21. “Memory of the World. About the programme,” UNESCO, accessed May 1, 2026, <https://www.unesco.org/en/memory-world/about?hub=1081>.

22. “Study on quality in 3D digitisation of tangible cultural heritage,” European Commission, last modified April 19, 2022, <https://digital-strategy.ec.europa.eu/en/library/study-quality-3d-digitisation-tangible-cultural-heritage>.

23. Livio De Luca and David Lo Buglio, “Geometry vs Semantics: Open Issues on 3D Reconstruction of Architectural Elements,” in *3D Research Challenges in Cultural Heritage*, ed. M. Ioannides, and E. Quak (Springer, 2014): 36-37, https://doi.org/10.1007/978-3-662-44630-0_3.

24. “In current years much of research has been done for collecting complex data of built cultural heritage, however its organization is more complex task than collection. Built heritage data is huge, heterogeneous and requires expertise of different domains such as architecture, history, archeology, vision and web sciences. Also, considering multidisciplinary nature of this data, the data representation models and standards used in each relevant domain is distinct and overlap is insufficient” (Salma Noor, Lubna Shah, Mohammad Adil, Neelam Gohar, Gul E. Saman, Sehrish Jamil, and Fawad Qayum, “Modeling and representation of built cultural heritage data using semantic web technologies and building information model,” *Comput. Math. Org. Theory* 25, no. 3, 2019: 247-270, <https://doi.org/10.1007/s10588-018-09285-y>). “Additionally, data acquisition and curation techniques differ from archive to archive and from country to country. Alongside these issues, lack of standards and shared understanding has had a substantial effect on data heterogeneity in the CH domain” (De Luca and Lo Buglio, “Geometry vs Semantics,” 36-49).

presentations produced»²⁵.

In the absence of widely accepted benchmarks, processes for scanning or modelling heritage assets differ substantially across countries, generating inconsistencies in quality, interoperability, and long-term preservation. Such fragmentation limits the potential for shared access, comparative research, and sustainable digital heritage management.

Over the past two decades, the European Union has progressively developed a comprehensive vision for the digital transformation of the cultural heritage sector. What initially consisted of fragmented digitisation initiatives in the early 2000s has now evolved into a coordinated ecosystem of policies, standards, infrastructures, and funding programmes²⁶. Today, this ecosystem culminates in the *Common European Data Space for Cultural Heritage*, funded under *Digital Europe Programme* (DIGITAL) of the European Union, and designed to enable large-scale, high-quality, interoperable, and sustainable digitisation, especially in 3D²⁷.

The first major step toward a unified European digital heritage strategy was marked by the launch of *Europeana* in 2008. *Europeana* remains the European Union's primary digital platform for cultural heritage, designed to aggregate content from museums, libraries, and archives across Member States. The vision behind *Europeana* was articulated by José Manuel Barroso, then President of the European Commission, during the platform's launch. Invoking the words of Robert Schuman from 1951, Barroso stated: "*Europeana* has the potential to change the way people see European culture. It will make it easier for our citizens to appreciate their own past, but also to become more aware of their

25. De Luca and Lo Buglio, "Geometry vs Semantics," 36-37

26. "Over the last 20 years, the European Union (EU) has invested more than €1 billion in supporting cultural heritage (CH) institutions and stakeholders (museums, sites, monuments, archives and libraries) to digitise their assets, archive, protect, preserve and make them available for use and re-use in research, innovation and education. The instruments used for this purpose comprised Limited liability company (d.o.o.) the Research Framework Programmes (FP) including FP6 (2002-2006), FP7 (2007-2013) and H2020 (2014-2020), eContent3 and ContentPlus, the European regional development fund (ERDF), European social fund (ESF) and other programmes. This investment has driven a unique period for research, innovation, education and intersectorial development across the European CH area, in which organisations of all scales have developed models and methodologies for digitisation. [...] At the same time, unresolved issues remain, concerning aspects that may refer to the digital twin, short and long-term preservation, use/re-use, sustainability, return on investment and long-term cost. Such aspects relate to broader questions on the topics of accuracy, complexity and quality" (European Commission, *Study on quality in 3D digitisation of tangible cultural heritage: mapping parameters, formats, standards, benchmarks, methodologies, and guidelines*, VIGIE 2020/645, 2022, 4).

27. "Common European data space for cultural heritage," EuropeanaPro, last modified May 15, 2025, <https://pro.europeana.eu/page/common-european-data-space-for-cultural-heritage>.

common European identity. And anyone in the world with an interest in literature, art, politics, science, history, architecture, music or cinema will be able to see the important contributions that Europe has made in all these fields, without even leaving their home”²⁸. Today, millions of cultural heritage items from over 3500 data providers across Europe are accessible online via the Europeana website²⁹.

During the 2010s, political commitment to digital heritage further strengthened. Notably, the European Commission “Recommendation of 27 October 2011 on the digitisation and online accessibility of cultural material and digital preservation” (2011/711/EU)³⁰, under the *Digital Agenda for Europe*³¹, encouraged Member States to develop national strategies, adopt improved metadata standards, and ensure long-term access³². While 3D digitisation was already present in scattered research initiatives, it remained technically inconsistent across many institutions.

The subsequent milestone³³ was the signing of the “Declaration of coo-

28. “A history of Europe’s relationship with culture,” EuropeanaPro, last modified February 6, 2025, <https://pro.europeana.eu/post/a-history-of-europes-relationship-with-culture>. “Cultural heritage is not only a key element in building a European identity that relies on common values but also an important contributor to the European economy, fostering innovation, creativity and economic growth” (European Commission, *Commission Recommendation (2021/1970/EU) on a common European data space for cultural heritage*, 2021, <https://eur-lex.europa.eu/eli/reco/2021/1970/oj/eng>).

29. “Mission,” EuropeanaPro, accessed May 1, 2026, <https://pro.europeana.eu/about-us/mission#our-vision>.

30. European Commission, *Commission Recommendation (2011/711/EU) on the digitisation and online accessibility of cultural material and digital preservation* (2011), <https://eur-lex.europa.eu/eli/reco/2011/711/oj/eng>.

31. “The Digital Agenda presented by the European Commission forms one of the seven pillars of the Europe 2020 Strategy which sets objectives for the growth of the European Union (EU) by 2020. The Digital Agenda proposes to better exploit the potential of Information and Communication Technologies (ICTs) in order to foster innovation, economic growth and progress” (“Digital Agenda for Europe,” EUR-Lex, last modified June 25, 2010, <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=legisum:si0016>).

32. “La Raccomandazione della Commissione sulla digitalizzazione e l’accessibilità online e la conservazione digitale del materiale culturale (2011/711/UE) ha rappresentato una pietra miliare nella politica culturale digitale. È l’unico strumento politico a livello dell’Unione europea che affronta l’intero ciclo di vita digitale dei beni culturali: pianificazione, monitoraggio e digitalizzazione, finanziamenti, facilitazione dell’accesso online e del riutilizzo, conservazione digitale. La raccomandazione invitava gli Stati membri a intensificare gli sforzi, mettere in comune le proprie risorse e coinvolgere il settore privato nella digitalizzazione del materiale culturale, al fine di aumentare l’accessibilità online del patrimonio culturale europeo, stimolare il coinvolgimento dei cittadini e la crescita delle industrie creative europee. Il materiale digitalizzato dovrebbe essere reso accessibile tramite Europeana, la piattaforma culturale europea che fornisce l’accesso a un’ampia gamma di contenuti digitali provenienti dalle istituzioni culturali europee” (“Patrimonio culturale e tecnologie digitali: documenti strategici,” Cultura Italia, accessed May 1, 2026, <https://www.culturaitalia.it/patrimonio-culturale-e-tecnologie-digitali-documenti-strategici/>).

33. “European policy initiatives and legislations, like the “Recommendation on digitisation and online accessibility and digital preservation of cultural material” and the “New European Agenda for Culture”, helped Member States develop strategies and improve conditions for the entire digitisation lifecycle. Promoting solutions that make cultural heritage accessible to all, including

operation on advancing digitisation of cultural heritage” by 27 European countries during “Digital Day 2019”. Through this declaration, the signatory states committed to collaborate more closely to leverage state-of-the-art digital technologies in addressing the challenges facing Europe’s rich cultural heritage, enhancing its accessibility and visibility, fostering citizen engagement, and promoting spillover benefits across other sectors³⁴. By signing, the countries acknowledged the strategic significance of 3D digitisation, the necessity of common standards and quality frameworks, and the urgency of establishing cross-border digital infrastructures to prevent fragmentation.

In the early 2020s, the European Union issued crucial guidance for 3D digitisation. Among these, the “Basic principles and tips for 3D digitisation of tangible cultural heritage”³⁵, developed in 2020 by the expert group on digital cultural heritage and *Europeana*, outlined ten guiding principles and practical recommendations for institutions initiating or conducting 3D digitisation projects. This initiative provided a pragmatic, high-level framework covering use-case definition, format selection, and planning for preservation and rights management, and it remains a key reference for public funders and cultural institutions.

Very significant was also the publication of the “VIGIE 2020/654 study”, a study on quality in 3D digitisation of tangible cultural heritage³⁶. This research systematically mapped parameters, formats, standards, benchmarks, workflows, and methodologies for 3D digitisation, establishing a quality-assessment framework tailored to different use cases (e.g., preservation, research, visualisation). It has since become the primary technical reference for public funders and large-scale digitisation programmes requiring reproducible and auditable quality criteria³⁷.

In response to growing societal, economic and technological challenges (including the COVID-19 pandemic, the need for data sovereignty, and the rise of advanced digital technologies), the EU launched the *Digi-*

via digital means, was also one of the objectives of the European Year of Cultural Heritage 2018 and the recent European Framework for Action on Cultural Heritage goes further in this direction. The EU has invested €265 million in research and innovation for advanced digitisation technologies, digital curation and innovative cultural projects” (“EU Member States sign up to cooperate on digitising cultural heritage,” European Commission, last modified April 9, 2019, <https://digital-strategy.ec.europa.eu/en/news/eu-member-states-sign-cooperate-digitising-cultural-heritage>).

34. “EU Member States sign up”.

35. “Basic principles and tips for 3D digitisation of cultural heritage,” European Commission, last modified September 11, 2020, <https://digital-strategy.ec.europa.eu/en/library/basic-principles-and-tips-3d-digitisation-cultural-heritage#l.%20Consider%20the%20value>.

36. European Commission, *Study on quality in 3D digitisation of tangible cultural heritage*.

37. Cassar, Baker, and Ioannides, “From Digital Twin to Memory Twin,” 203-209.

tal Europe Programme (DIGITAL). “The Programme is a part of the long-term EU budget (the *Multiannual Financial Framework*) covering 2021 to 2027. It provides funding for projects in six key capacity areas: supercomputing, artificial intelligence, cybersecurity, advanced digital skills, ensuring the wide use of digital technologies across the economy and society and semiconductors”³⁸. Cultural heritage is explicitly included in this strategic agenda.

The current long-term objectives of Europe regarding the digitisation of cultural heritage were established by the European Commission on 10 November 2021 with the adoption of the “Recommendation on a common European data space for cultural heritage” (C/2021/7953 - 2021/1970)³⁹. The primary aim of the Recommendation “is to pave the way for a common European data space for cultural heritage (‘data space’), thereby helping cultural heritage institutions to accelerate their digitisation and preservation efforts, and to seize the opportunities created by the digital transformation. [...] This Recommendation covers all types of cultural heritage (tangible, intangible, natural, born digital), including all the categories of cultural heritage at risk”⁴⁰. In particular, the Recommendation calls for Member States to ensure that, by 2030, all monuments and sites at risk, as well as 50% of the most frequently visited cultural and heritage monuments, buildings, and sites, are digitised in 3D.

The text highlights that «the development of advanced digital technologies, such as 3D, artificial intelligence, machine learning, cloud computing, data technologies, virtual reality and augmented reality, has brought unprecedented opportunities for digitisation, online access and digital preservation. Advanced digital technologies lead to more efficient processes (e.g. automated generation of metadata, knowledge extraction, automated translation, text recognition by optical character recognition systems) and higher quality content. They allow innovative forms of artistic creation, while opening up new ways of digitally engaging with and enjoying cultural content through co-curation, co-design and crowdsourcing, empowering public participation. Artificial intelligence, blockchain and other advanced technologies can also be

38. “Digital Europe Programme (DIGITAL),” European Commission. EU Funding & Tenders Portal, accessed May 1, 2026, <https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/programmes/digital>.

39. European Commission, *Commission Recommendation* (2021/1970/EU).

40. European Commission, *Commission Recommendation* (2021/1970/EU).

explored for automatically identifying cultural goods that are illicitly trafficked. The uptake of such advanced technologies has a significant impact on European recovery and growth following the COVID-19 pandemic, and Member States should support it by taking appropriate measures”⁴¹.

Considering these developments, the Recommendation further encourages the establishment of “a comprehensive digital strategy for the cultural heritage sector, setting up a clear and concrete vision and the most appropriate means for implementing it, would ensure a more effective policy response and make the sector stronger”⁴².

This data space is built around *Europeana*, whose infrastructure will be expanded to provide federated and interoperable access to heritage data, with particular emphasis on high-quality 3D models, enriched metadata, and paradata⁴³. “*Europeana* has been key in strengthening cooperation and standardisation activities across borders, in the EU and beyond. Its standardised frameworks for sharing digital content and metadata online, in particular, the Europeana Data Model, Rights Statements and the Europeana Publishing Framework have been taken up widely in the cultural heritage sector in Europe and internationally. For instance, the Europeana Data Model (EDM) allows a standardised representation of data delivered in Europeana by cultural heritage institutions from different domains using different formats”⁴⁴.

The latest and most ambitious European initiative to support cultural heritage institutions and the research community in embracing the digital age is the *European Collaborative Cloud for Cultural Heritage* (ECCCH)⁴⁵. The *Cultural Heritage Cloud* aims to create a digital infrastructure that facilitates unprecedented collaboration among heritage

41. European Commission, *Commission Recommendation (2021/1970/EU)*.

42. European Commission, *Commission Recommendation (2021/1970/EU)*.

43. “The data space will build on the current Europeana strategy for 2020-25 (22), whose aim is to empower cultural heritage institutions in their digital transformation. Europeana currently gives access to 52 million cultural heritage assets, 45 % of which can be reused in various sectors. Images and text make up 97,5 % of the assets, with only 2,47 % audiovisual content and 0,03 % in 3D. Increased contributions of high quality digitised assets, such as in 3D, would enhance innovation and creation through the use and reuse of the digitised cultural heritage assets in various key domains (e.g. education, smart cities and environmental modelling, sustainable tourism and cultural creative sectors). Bringing an additional 40 million, high quality, digitised and diversified types of assets through the data space would add to the richness of the material available online, while further promoting our European cultural heritage” European Commission, *Commission Recommendation (2021/1970/EU)*.

44. European Commission, *Commission Recommendation (2021/1970/EU)*.

45. “The Cultural Heritage Cloud,” European Commission, accessed May 1, 2026, https://research-and-innovation.ec.europa.eu/research-area/social-sciences-and-humanities/cultural-heritage-and-cultural-and-creative-industries-ccis/cultural-heritage-cloud_en.

professionals and researchers across the EU in a secure environment. “It will provide, among others, cutting-edge tools to share research and scientific work and findings online, digitise artefacts and study them collaboratively. Through continuously updated virtual replicas of heritage, called digital twins, the *Cultural Heritage Cloud* will also contribute to documenting and virtually preserving heritage, including threatened heritage, for future study and immersive interaction. [...] The creation of the *Cultural Heritage Cloud* is supported by *Horizon Europe*, the 9th EU framework programme for research and innovation”⁴⁶.

The *Cultural Heritage Cloud* and the *Data Space for Cultural Heritage* are designed to operate synergistically, particularly in terms of data sharing and capacity building. “Through interoperable frameworks, data from the data space will flow securely to the cloud for heritage professionals to work with, while research outputs and data generated in the cloud will be accessible through the data space for reuse across various sectors. To enable exchange, both initiatives’ tools and services will be based on Findable, Accessible, Interoperable and Reusable (FAIR) principles. By enabling the documentation and virtual preservation of cultural heritage, including heritage that is threatened, and the creation of digital twins for future study and immersive interaction, the *Cultural Heritage Cloud* will support Member States and their cultural heritage institutions in the realisation of the objectives outlined in the Commission Recommendation of 2021”⁴⁷.

Over the past decades, numerous U-funded projects have advanced the digitisation of cultural heritage. Among these, *Time Machine: Big Data of the Past for the Future of Europe* (2019-2020), supported under the *Horizon 2020* programme, stands out. The project developed large-scale digitisation of cultural heritage and the corresponding computing infrastructure, mapping millennia of European historical and geographical evolution. “*Time Machine* was aiming to join Europe’s rich past with up-to-date digital technologies and infrastructures, creating a collective digital information system mapping the European economic, social, cultural and geographical evolution across times. In the proposed approach, digitisation is only the first step of a long series of extraction processes, including document segmentation and understanding enhan-

46. “Shaping the Future of Cultural Heritage,” European Commission, last modified August, 2024, <https://www.echoes-ecch.eu/wp-content/uploads/2025/02/shaping-the-future-of-cultural-heritage-KI0923174ENN.pdf>.

47. “Shaping the Future of Cultural Heritage”.

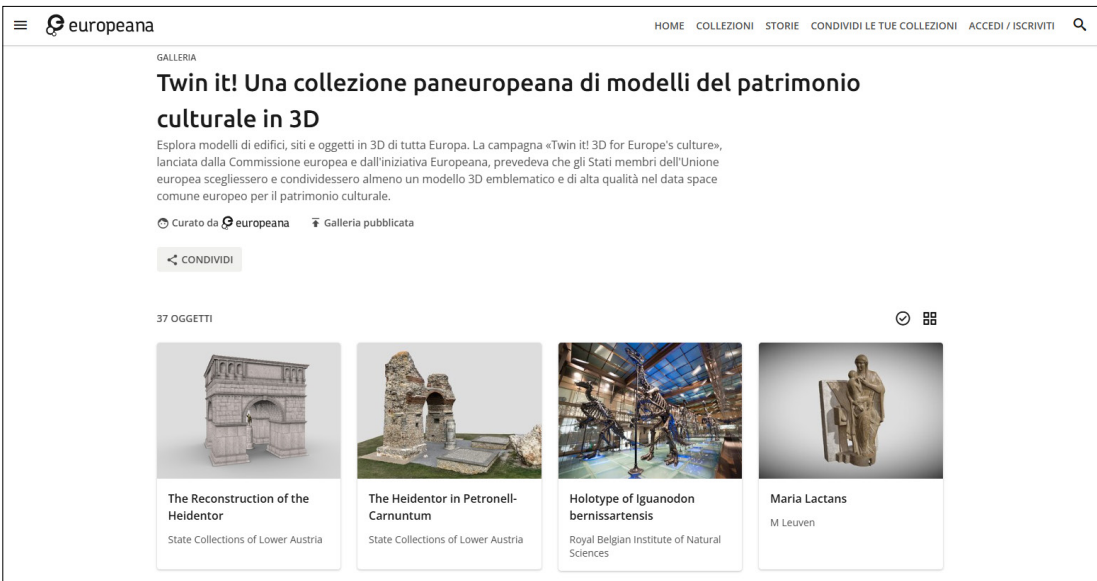
ced by Augmented/Virtual Reality (AR/VR) applications, leading to simulations of hypothetical spatiotemporal 4D reconstructions”⁴⁸. By the end of the project, the consortium partners came together to create the *Time Machine* organisation and ensure the continuance of the work that was started with the *Time Machine* project⁴⁹.

A series of EU-funded operational initiatives currently feed the *European Data Space for Cultural Heritage* with content, guidelines, best practices, training, technical tools, and data governance frameworks. Among these initiatives are *Twin it!* and *EUreka3D*.

Twin it! has been developed in two successive phases: 2023-2024 and 2025-2026 [Fig. 5.4]. Through this project⁵⁰, “Ministries of Culture of the European Union Member States were invited to liaise with their national cultural institutions to submit at least one 3D digitised heritage asset to the common European data space for cultural heritage”⁵¹.

Fig. 5.4 Homepage of Twin it! 3D for Europe’s culture project.

[“Twin it! A pan-European collection of heritage 3D models,” Europeana, accessed May 1, 2026, <https://www.europeana.eu/it/galleries/15694-twin-it-a-pan-european-collection-of-heritage-3-d-models>]



48. “About us,” Time Machine Europe, accessed May 1, 2026, <https://www.timemachine.eu/about-us/>.

49. “Time Machine,” EuropeanaPro, accessed May 1, 2026, <https://pro.europeana.eu/project/time-machine/>.

50. The concept of the digital twin also underpins several other European projects, among which Digital Twin for the Reconstruction of Ukraine is particularly significant. Through this initiative, “by generating 3D virtual replicas of cities, AI models will help public authorities define reconstruction plans, enhance urban planning, and precisely quantify budgetary needs. The European AI Office is developing these technologies to address the urgent needs of countries such as Ukraine” (“Digital Twin for the Reconstruction of Ukraine,” European Commission, last modified November 13, 2025, <https://digital-strategy.ec.europa.eu/en/news/digital-twin-reconstruction-ukraine>).

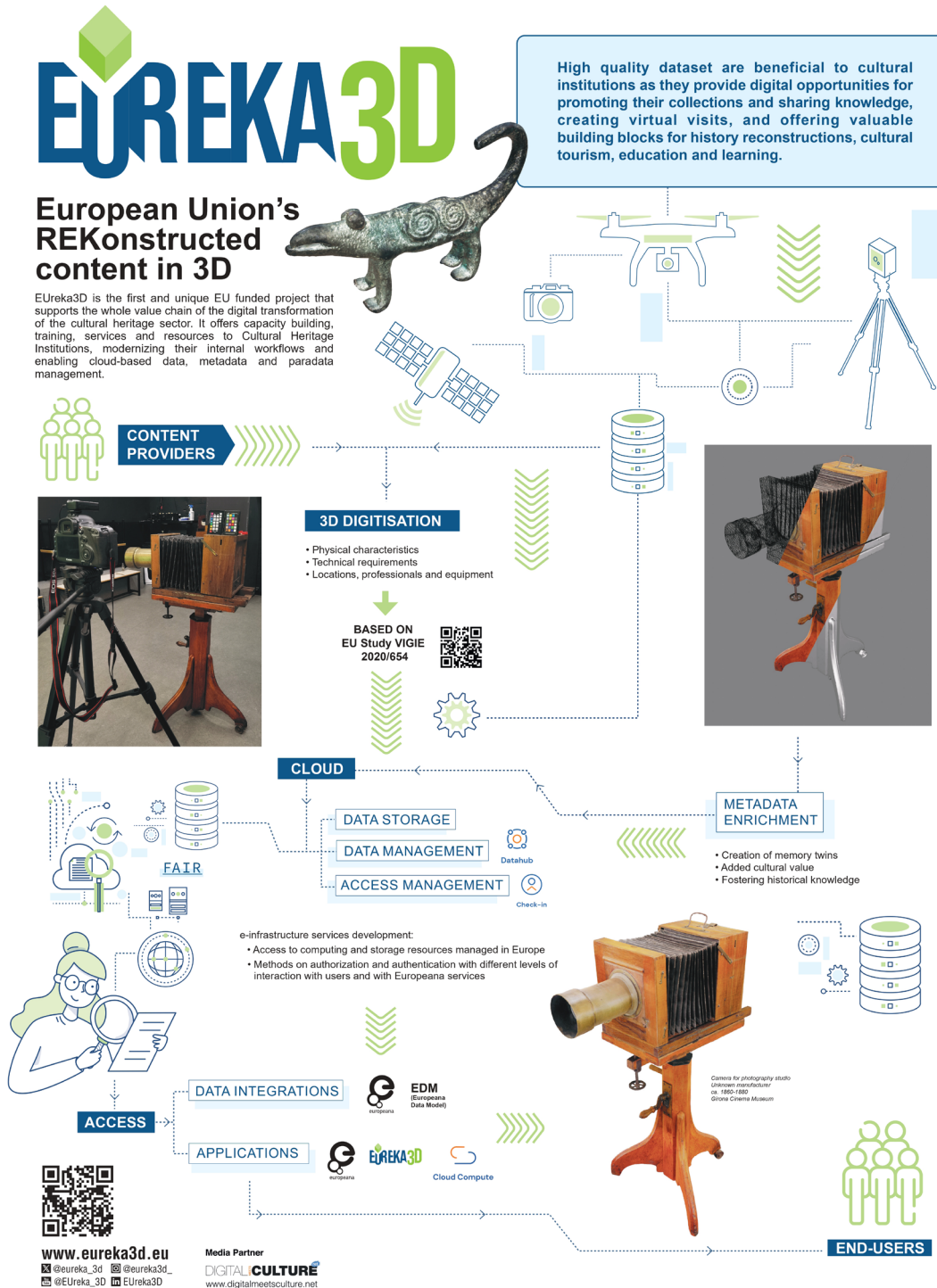
51. “Twin it! 3D for Europe’s culture,” EuropeanaPro, accessed May 1, 2026, <https://pro.europeana.eu/page/twin-it-3d-for-europe-s-culture#introduction>.

EUreka3D (2023-2024) and *EUreka3D-XR* (2025-2026) represent two phases of a single project co-funded by the European Union under the *Digital Europe Programme*. These initiatives serve as supporting actions for the *Common European Data Space for Cultural Heritage* and address key challenges faced by cultural heritage institutions, including 3D digitisation, the storage and management of 3D assets, innovative methods and tools for the reuse of 3D collections, and the capacity building required for professionals in the sector. *EUreka3D* (European Union's REKOnstructed content in 3D) specifically supports cultural institutions - particularly small and medium-sized organisations - in 3D digitisation, data management, and publication within the *Common European Data Space* [Fig. 5.5]. Assistance is provided through guidelines, training, workflows, technical tools, and ready-to-share 3D datasets via *Europeana*⁵².

The establishment of the *Data Space* marks a new phase in digital heritage: no longer isolated projects, but a shared, robust infrastructure. The “VIGIE study”’s quality framework and the “Basic Principles and Tips” provide methodological anchors, while *Europeana*, supported by DIGITAL funding, offers the technical and organisational backbone. Nevertheless, significant challenges remain, including ensuring widespread adoption by smaller institutions, the long-term preservation of 3D data, capturing and sharing rich paradata, and embedding effective rights management within the infrastructure.

In Italy, the systematic digitisation of cultural heritage began in the 1990s, both at the national and regional levels, and has been progressively developed over the years through a comprehensive set of methodological tools, primarily devised by the Istituti centrali del Ministero. To date, there is no comprehensive dataset that provides a complete qualitative and quantitative overview of the work carried out by all institutions across the territory; however, an analysis of the national cataloguing and description systems can offer a useful point of reference. Overall, the information systems managed by the Istituti del Ministero contain over 37 million catalogue records, linked to approximately 26 million images. This is complemented by data still maintained at regional levels or in local applications, which have not been incorporated into national databases. This is a substantial yet fragmented body of

52. “About EUreka3D initiative,” EUreka3D, accessed May 1, 2026, <https://eureka3d.eu/eureka3d-initiative/>.



heritage, as noted in previous chapters⁵³.

The Italian body responsible for overseeing the digitisation of cultural heritage is the Direzione Generale Digitalizzazione e Comunicazione of the Ministero della Cultura (MiC), which operates under the Dipartimento per l'amministrazione generale (DIAG). Its primary mission is to promote digital transformation and technological innovation, with a particular focus on the digitisation of cultural heritage and institutional communication. Within the Direzione generale, the Istituto centrale per la digitalizzazione del patrimonio culturale - Digital Library⁵⁴, established in January 2020, serves as the organisational unit tasked with coordinating and promoting digitisation programmes for cultural heritage under the supervision of the Ministero della Cultura.

According to the Digital Library, there are currently 128 active digitization projects underway. These are organized into four main thematic areas: microfilm, paper materials (archives and libraries), photographic archives, and museum objects. Despite considerable progress, challenges persist, including the fragmentation of initiatives, uneven distribution of resources, and a shortage of specialized digital skills within cultural institutions⁵⁵.

In 2021, following the pandemic, the Italian government has aligned its digitization strategies with broader European objectives through the *Piano Nazionale di Ripresa e Resilienza* (PNRR), funded by the *European Union's Next Generation EU programme*⁵⁶. The cultural measures of the PNRR fall under *Missione 1 - Digitalizzazione, Innovazione, Competitività, Cultura e Turismo, Componente 3 - Turismo e Cultura 4.0*. They encompass a series of initiatives aimed at supporting and revitalising the tourism and cultural sectors, as well as digitising cultural heritage through the development of both databases and digital collections⁵⁷.

Specifically, within the M1C3 investment framework, four interven-

Fig. 5.5 Dissemination poster about the *Eureka3D* digitisation project, from content providers to end-users.

[https://eureka3d.eu/wp-content/uploads/2024/04/Poster-Eureka3d_2024_3.pdf]

53. Istituto Centrale per la Digitalizzazione del Patrimonio Culturale - Digital Library, *Piano nazionale di digitalizzazione*.

54. Istituto Centrale per la Digitalizzazione del Patrimonio Culturale - Digital Library, accessed May 1, 2026, <https://digitallibrary.cultura.gov.it/>.

55. Chiara Veninata, "Il Piano nazionale di digitalizzazione del patrimonio culturale: stato di attuazione e sviluppi futuri," in *La digitalizzazione del patrimonio culturale. Linee guida, standard, esperienza*, ed. S. Allegrezza (Civita Editoriale, 2021), 19-21.

56. "NextGenerationEU," European Union, accessed May 1, 2026, https://next-generation-eu.europa.eu/index_en.

57. "PNRR Cultura," Istituto Centrale per la Digitalizzazione del Patrimonio Culturale - Digital Library, accessed May 1, 2026, <https://digitallibrary.cultura.gov.it/pnrr-cultura/>.

tion measures are planned. In this context, the Digital Library operates under *Misure 1 - Patrimonio culturale per la prossima generazione*, with the aim of creating a digital cultural heritage by facilitating access to information and supporting the development of new services. The Institute is also tasked with coordinating *Investment 1.1 - Strategie e piattaforme digitali per il patrimonio culturale*⁵⁸.

Investment M1C3 1.1, for which €500 million has been allocated, is structured into twelve autonomous, yet complementary, projects or sub-investments. These initiatives are designed to establish four distinct service domains: enabling services, production services, document management and preservation services, and access services⁵⁹ [Fig. 5.6]. The conceptual framework resulting from the twelve sub-investments lays the foundation for *Ecomic - Ecosistema digitale nazionale per la Cultura*⁶⁰, coordinated by the Digital Library. Ecomic is a distributed collaborative environment designed to enhance the value of digital cultural heritage. By integrating advanced technologies and operational services, it transforms heritage data into enriched, usable digital assets, thereby fostering the development of new services, products, and modes of access to cultural heritage⁶¹.

Inspired by *Europeana*, particularly its interoperable and federated design, and by the *Cultural Heritage Cloud*, a transdisciplinary infrastructure accessible even to small and remote institutions, *Ecomic* also builds on the *Common European Data Space*, a secure and federated environment where content can be collected, managed, shared, and reused in accordance with the FAIR principles (Findable, Accessible, Interoperable, Reusable). Within this evolving ecosystem, *Ecomic* emerges as a strategic national initiative, fully aligned with European guidelines in both vision and adopted technologies, including open-source solutions, Linked Open Data, APIs, and knowledge graphs⁶².

58. “Strategia digitale e piattaforme per il patrimonio culturale,” Italia Domani. Piano Nazionale di Ripresa e Resilienza, accessed May 1, 2026, <https://www.italiadomani.gov.it/it/Interventi/investimenti/strategia-digitale-e-piattaforme-per-il-patrimonio-culturale.html>.

59. Luigi Cerullo, Margherita Bartoli, Lina A. Coppola, Costantino Landino, Antonio D. Madonna, Antonella Negri, Giovanni Pescarmona, Chiara Fauda Pichet, Margherita Porena, and Valentina Rossetti, “Verso la creazione di un Ecosistema digitale nazionale per la Cultura,” *Digitalia* 19, no. 2 (2024): 11-48, <https://doi.org/10.36181/digitalia-00101>.

60. “Ecosistema digitale per la cultura,” Ecomic, accessed May 1, 2026, <https://ecomica.cultura.gov.it/>.

61. Istituto centrale per la digitalizzazione del patrimonio culturale - Digital Library, *Economic*, 34.

62. Istituto centrale per la digitalizzazione del patrimonio culturale - Digital Library, *Economic*, 4-5.

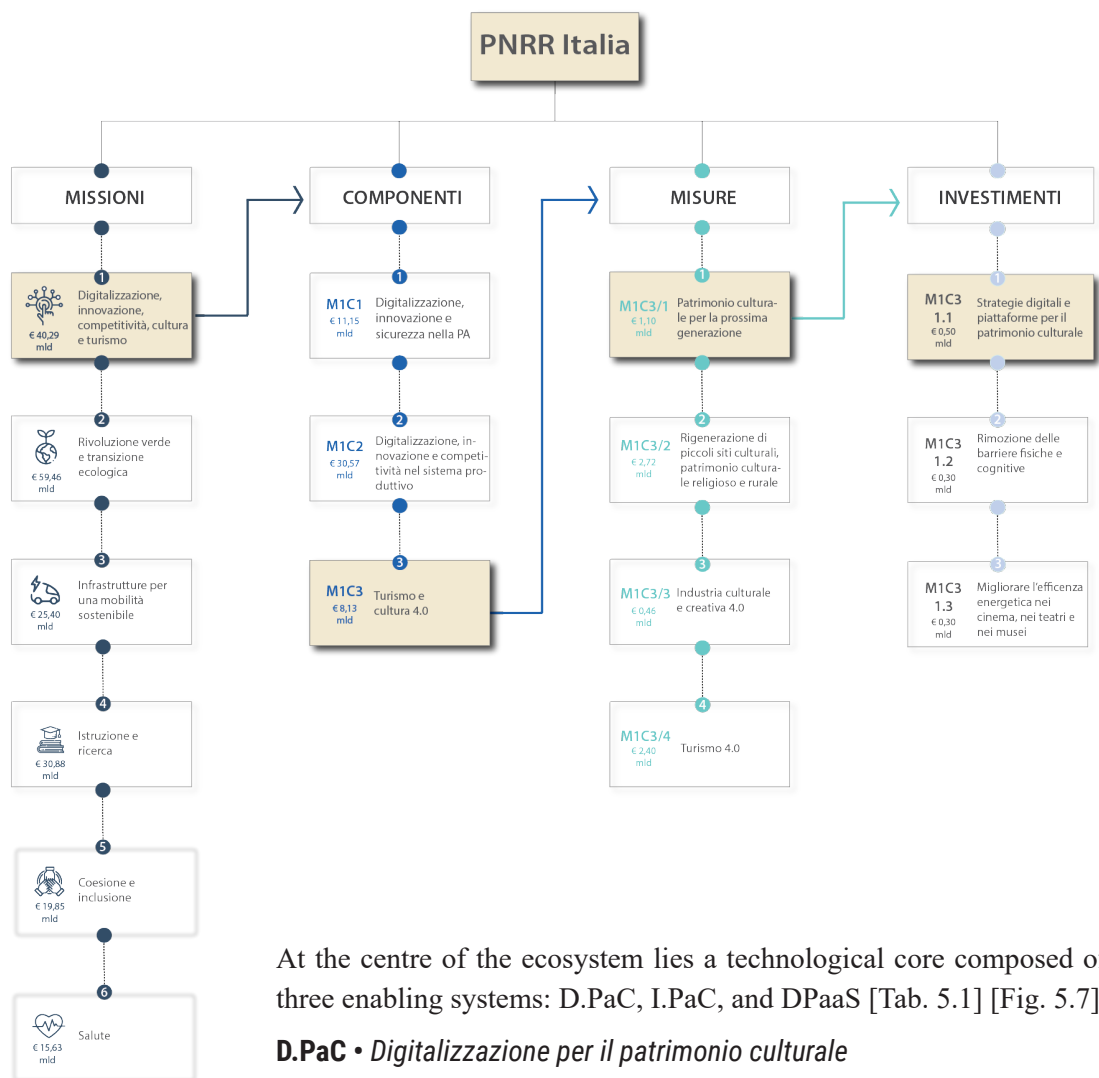


Fig. 5.6 Overview of Italian PNRR.

["PNRR Cultura," Digital Library - Istituto centrale per la digitalizzazione del patrimonio culturale, accessed May 1, 2026, <https://digitallibrary.cultura.gov.it/pnrr-cultura/>]

At the centre of the ecosystem lies a technological core composed of three enabling systems: D.PaC, I.PaC, and DPaaS [Tab. 5.1] [Fig. 5.7].

D.PaC • Digitalizzazione per il patrimonio culturale

D.PaC is the platform designed to support the structured and efficient management, monitoring, and oversight of cultural heritage digitisation campaigns. Through an accessible web interface, it facilitates collaboration among commissioning authorities, cultural heritage institutions, and service providers in the implementation of shared digitisation projects. D.PaC is currently available free of charge to all organisations and companies participating in the PNRR sub-investment *M1C3 1.1.5 Digitalizzazione del patrimonio culturale*⁶³.

63. Istituto centrale per la digitalizzazione del patrimonio culturale - Digital Library, *D.PaC Executive Summary. Report di inquadramento concettuale* (2025), 13, https://digitallibrary.cultura.gov.it/wp-content/uploads/2025/09/Ecomic_Report-di-inquadramento-concettuale_v1.0.pdf.

I.PaC • Infrastruttura e servizi digitali per il patrimonio culturale

I.PaC forms the central infrastructure of *Ecomic*, integrating digital cultural resources and enabling their advanced management and full valorisation. “The platform strives to eliminate barriers to the access to cultural information and to solve issues related to the management of heterogeneous data in terms of format, category and domain”⁶⁴. Although not intended for direct interaction with end users, it is designed to interface with the systems operated by the ecosystem’s actors⁶⁵.

DPaaS • Piattaforma data product as a service

DPaaS constitutes *Ecomic*’s space for experimentation and innovation. Conceived as a laboratory-platform, it supports the development of new digital products and services based on cultural data resources. It targets cultural, creative, and technology-driven enterprises, developers, research institutes, and public bodies interested in exploring new forms of digital-heritage enhancement.

	Enablement	Interoperability	Valorisation
D.PaC	Provides a shared platform, integrated with a common operational model, for the production, description, and dissemination of digital assets.	Ensures the production of digital resources compliant with semantic and technological integration within the ecosystem (<i>Ecomic</i>).	Makes the digitisation process traceable, documented, and scalable.
I.PaC	Provides a public, secure, and shared infrastructure for the management and publication of digital assets.	Enables application-level and semantic cooperation among heterogeneous cultural systems.	Enhances the informational value of digital assets through a shared semantic structure and intelligent services.
D.PaaS	Enables the development and customisation of digital cultural products and services.	Promotes the reuse and publication of content according to open standards.	Enables the creation of new digital services and experiences, transforming cultural data into shared value.

Tab. 5.1 Contribution of D.PaC, I.PaC, and DPaaS to *Ecomic*.

[Traduction of: Istituto centrale per la digitalizzazione del patrimonio culturale - Digital Library, *Economic*, 56]

64. Margherita Porena, Antonella Negri, and Luigi Cerullo, “I.PaC: the National Data Space for Cultural Heritage,” in *Proceedings of the Ital-IA Intelligenza Artificiale - Thematic Workshops colocated with the 4th CINI National Lab AIIS Conference on Artificial Intelligence. Ital-IA 2024* (CEUR-WS.org, 2024), 419.

65. Istituto centrale per la digitalizzazione del patrimonio culturale - Digital Library, *Economic*, 30.

Fig. 5.7 Lifecycle of digital assets within the Ecomic ecosystem.

[Traduction of:
Istituto centrale per la
digitalizzazione del
patrimonio culturale
- Digital Library,
Economic, 38]



Designed to meet the digitisation objectives defined in the PNRR, D.PaC supports the structured planning and management of the entire digitisation workflow: from the definition of required activities and re-sources to asset description, digital file upload, and quality control. The platform integrates tools for monitoring project progress, ensuring alignment with national standards, and enabling interoperability with the other enabling systems of the ecosystem, particularly I.PaC. More than a technical instrument, D.PaC acts as an organisational enabler that promotes process standardisation, reduces operational costs, enhances the quality of the digital resources produced, and strengthens the skills of the professionals involved⁶⁶.

At the technological core of the ecosystem lies the I.PaC software infrastructure - *Infrastruttura e servizi digitali per il patrimonio culturale* (sub-investment 1.1.4). Launched in August 2025⁶⁷, I.PaC responds to the need to systematise digitised heritage data, which currently remain dispersed across heterogeneous supports (databases, hard drives, and other repositories)⁶⁸. It offers a unified cloud environment for storing,

66. Istituto centrale per la digitalizzazione del patrimonio culturale - Digital Library, *Economic*, 29.

67. "Online il nuovo sito di I.PaC - Infrastruttura e servizi per il Patrimonio Culturale. Il primo punto di accesso all'infrastruttura tecnologica di Ecomic", Istituto centrale per la digitalizzazione del patrimonio culturale – Digital Library, last modified August 18, 2025, <https://digitallibrary.cultura.gov.it/notizie/online-il-nuovo-sito-di-i-pac-infrastruttura-e-servizi-per-il-patrimonio-culturale/>.

68. Istituto centrale per la digitalizzazione del patrimonio culturale – Digital Library, *Inquadramento generale del concept di I.PaC "infrastruttura e servizi digitali per il patrimonio culturale"* (2024), 9.

managing, and enriching the country's digital cultural assets, in line with major national and European strategic frameworks⁶⁹.

The digital resources preserved within the I.PaC Cloud (sub-investment 1.1.3) are uniquely identified through the digital identity system (sub-investment 1.1.2). These resources derive both from new digitisation campaigns (sub-investment 1.1.5) and from pre-existing digital materials preserved in third-party systems, such as national catalogues. Their heterogeneity - across data types and domains of knowledge - is supported by long-term preservation and document management services (sub-investments 1.1.8 and 1.1.9).

As public information assets, the data will be made accessible through multiple touchpoints: via the national access and crowdsourcing platform (sub-investments 1.1.10 and 1.1.11) and through third-party systems. These external platforms, using enriched data provided by I.PaC services, will be able to develop and present tailored user pathways that highlight the historical and cultural richness of local territories.

The digital resources archived, managed, and enhanced within I.PaC will also be available to cultural and creative industries. Through a dedicated laboratory environment (sub-investment 1.1.12), enterprises will be able to develop new value-added services that respond to the needs expressed by cultural institutions and heritage sites across the national territory⁷⁰.

The strategic, intellectual, and operational framework guiding the implementation of Investment M1C3 1.1 is defined within the *Piano Nazionale di Digitalizzazione* (sub-investment 1.1.1), developed and implemented by the *Digital Library*. Revised in 2022, the PND constitutes the methodological and operational foundation of Italy's digitisation strategy for the period 2022-2026. Its adoption responds not only to the urgent need to modernise the systems operating in the digital environment, but also to the broader objective of aligning national practices with the *European agenda on cultural heritage digitisation*⁷¹.

The PND is articulated into three interconnected sections, conceived

69. "Online il progetto I.PaC Infrastruttura e servizi digitali per il Patrimonio Culturale," Istituto centrale per la digitalizzazione del patrimonio culturale – Digital Library, last modified March 8, 2024, <https://digitallibrary.cultura.gov.it/progetti/online-il-progetto-i-pac-infrastruttura-e-servizi-digitali-per-il-patrimonio-culturale/>.

70. Cerullo et al., "Verso la creazione di un Ecosistema digitale nazionale per la Cultura," 11-48, <https://doi.org/10.36181/digitalia-00101>.

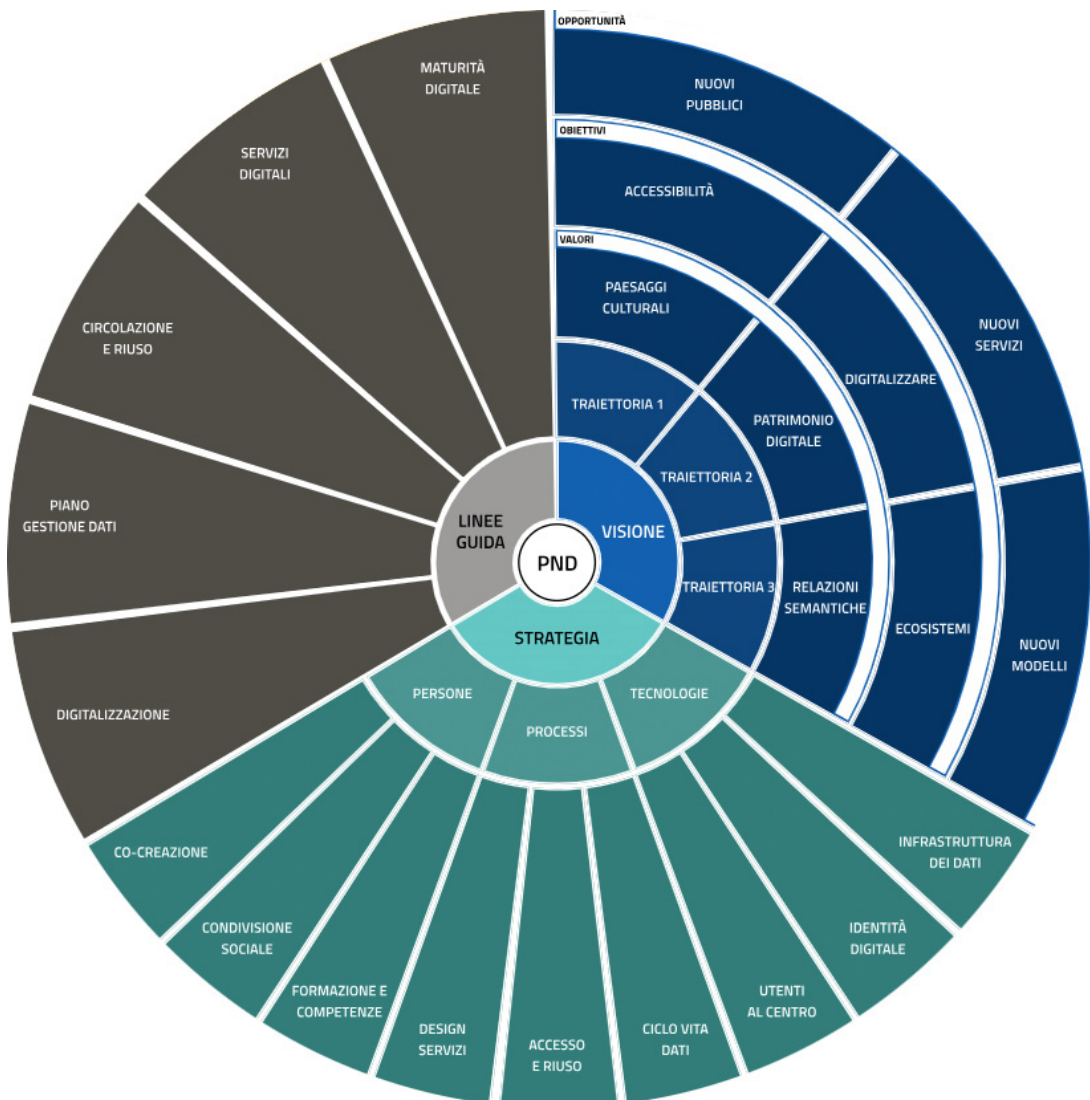
71. Istituto Centrale per la Digitalizzazione del Patrimonio Culturale - Digital Library, *Piano nazionale di digitalizzazione*, 6.

Fig. 5.8 Schematic map of the Piano Nazionale di Digitalizzazione (PND).

[“Il PND,” Istituto centrale per la digitalizzazione del patrimonio culturale - Digital Library, <https://digitallibrary.cultura.gov.it/mappa/>]

as a processual *continuum*: “a vision, which outlines the anticipated transformation and long-term opportunities; a strategy, which defines the pathway for achieving the stated objectives; and a set of guidelines, which provide operational tools supporting the planning and execution of digitisation activities and the digital transformation of cultural institutions and heritage sites”⁷² [Fig. 5.8].

The Plan provides detailed guidelines and standards for digital projects, including protocols concerning metadata management, storage, accessibility, and reuse of digital assets.



72. Istituto Centrale per la Digitalizzazione del Patrimonio Culturale - Digital Library, *Piano nazionale di digitalizzazione*, 2.

Its scope includes not only digitizing tangible cultural heritage, but also developing digital services, immersive experiences, and policies promoting open access⁷³.

The processes outlined within the PND are implemented by cultural heritage professionals, who are supported by a dedicated programme for training and skills development (sub-investment 1.1.6). This framework, sustained by essential operational support measures (sub-investment 1.1.7), constitutes the enabling context through which all actors involved in producing, managing, and disseminating cultural heritage can undertake their own digital transformation pathways⁷⁴.

At the technical-operational level, the Italian national institution historically responsible for the digitisation of archives, and for cultural heritage digitisation more broadly, is the Istituto Centrale per il Catalogo e la Documentazione (ICCD). Established in 1975 by the Ministero per i beni culturali e ambientali, now the Ministero della Cultura, the ICCD plays a central role in coordinating national efforts in heritage documentation. Among its various activities, the Institute “promotes and coordinates initiatives relating to cataloguing, digitisation, valorisation, access, and documentation of archaeological, architectural, historical, artistic, and ethno-anthropological heritage, in collaboration with Italian and international research bodies, in accordance with the guidelines of the Direzione generale per l’Archeologia, Belle arti e Paesaggio”⁷⁵.

The ICCD also manages the *Catalogo generale dei Beni Culturali*, which aggregates the results of cataloguing activities carried out by the State with the contribution of Regions and other territorial authorities. Its purpose is to support the protection and valorisation of cultural heritage by providing systematic knowledge of assets within their broader context. The data currently included in the catalogue are largely supplied through *SiGECWeb* (the Catalogo Generale Information System)⁷⁶, which was developed to unify and streamline cataloguing processes, ensure the quality of data produced, and guarantee adherence to national standards. Data consistency is an essential prerequisite for their

73. “Il Piano”.

74. Cerullo et al., “Verso la creazione di un Ecosistema digitale,” 11-48.

75. “Chi siamo,” Istituto Centrale per il Catalogo e la Documentazione, accessed May 1, 2026, <http://www.iccd.beniculturali.it/it/istituto/chi-siamo>.

76. “I numeri del SiGECweb,” Istituto Centrale per il Catalogo e la Documentazione, accessed May 1, 2026, <http://www.iccd.beniculturali.it/it/i-numeri-del-sigeweb>.

immediate availability, correct use, and effective sharing⁷⁷. At present, the *Catalogo generale* contains approximately three million records encompassing all categories of cultural assets, except for archival and library materials⁷⁸.

To enhance the accessibility and valorisation of online heritage resources and contribute to the broader national digitisation effort, the ICCD launched a new website for the *Catalogo generale dei Beni Culturali* in 2021. The platform's consultation interface aligns with national open data policies, enabling the creation of unlimited relationships between pieces of cultural heritage information according to the paradigm of Linked Open Data.

The homepage of the new catalogue website is organised into three main sections: at the top, continuously updated data concerning creators and cultural venues; in the central section, catalogue data organised by asset type; and, further down, an interactive map-based navigation tool allowing users to explore cultural sites and the objects they preserve.

The website offers two search modes: a simple "Google-like" search that scans all information published on the catalogue and returns the most relevant results, and an advanced search that enables queries across a wide range of informational fields common to most catalogue records.

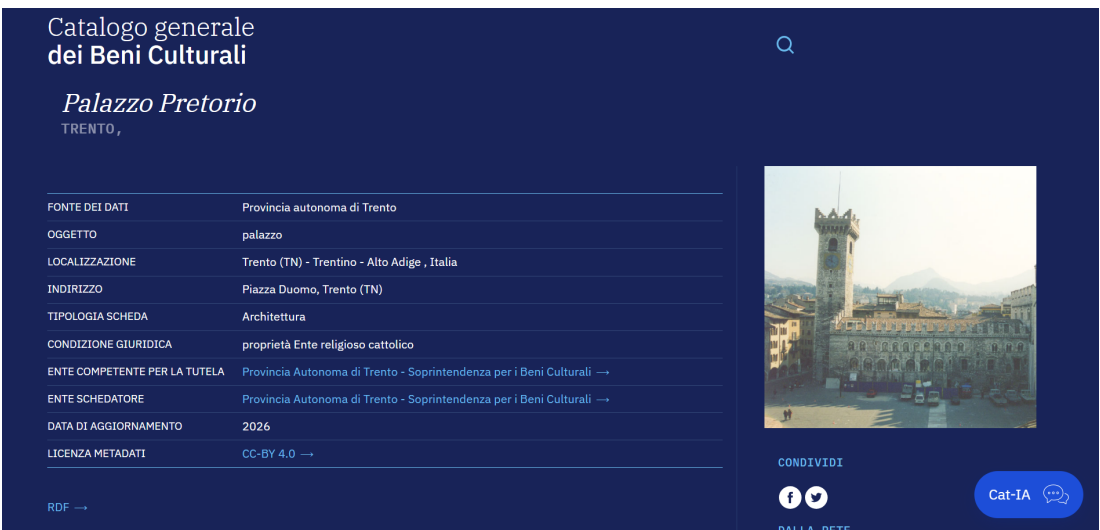
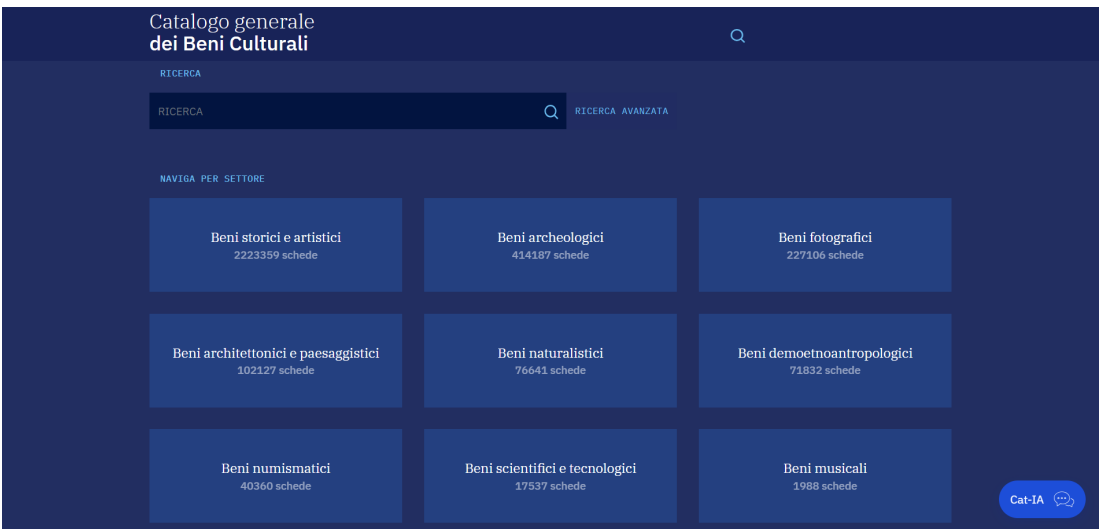
Since April 2025, the search and consultation experience on the catalogue website has been further enhanced through the introduction of 'Cat-IA' (from 'Catalogo' and 'Intelligenza Artificiale'), a conversational agent based on generative artificial intelligence. Constantly evolving, the chatbot facilitates access to the catalogue by allowing users to submit natural-language questions and receive both direct answers and suggestions for further exploration⁷⁹ [Fig. 5.9].

The conceptual frameworks provided by the digital record (as an enriched and contextualized informational unit) and the ambitious, federated infrastructures like the *Common European Data Space* and *Ecomic* offer a clear strategic direction. Nevertheless, the success of these initiatives depends on effectively addressing technical and organisational challenges related to standardisation, widespread implementation, and

77. "Cos'è il catalogo generale dei beni culturali," *Catalogo Generale dei Beni Culturali*, accessed May 1, 2026, <https://catalogo.beniculturali.it/progetto>; Veninata, "Il Piano nazionale di digitalizzazione," 17.

78. "I numeri del SIGECweb".

79. Veninata, "Il Piano nazionale di digitalizzazione," 17.



long-term data preservation. Despite sustained efforts to harmonize procedures and coordinate initiatives at a supranational level, the framework outlined thus far may still appear disorienting and difficult to interpret, owing to the breadth and complexity of the subject matter. The numerous European projects developed over the past two decades have sought to systematize digitization processes; however, they have often taken the form of circumscribed initiatives, characterized by a limited capacity for structural impact. Although these projects have drawn upon recommendations issued by the European Union, they have frequently adopted a self-referential approach, thereby reducing their effectiveness in shaping a truly coherent and unified framework.

A similar condition of pronounced fragmentation has long been observed in the Italian context, resulting from the proliferation of local initiatives that often lack continuity and, in some cases, are destined to disperse within the digital domain without achieving genuine systemic integration. Efforts to address this situation have led to the development of the “Linee guida per la digitalizzazione del patrimonio culturale” (2022)⁸⁰, produced within the framework of the PND, which aim precisely to respond to the need for coordination and methodological coherence.

At this stage, it therefore appears appropriate to undertake a systematic comparison between the most recent guidelines and best practices promoted at the European level and those set forth in the *Piano Nazionale di Digitalizzazione*, with the aim of more clearly delineating their respective scopes of application and identifying their potential, limitations, as well as any areas of overlap or divergence.

Fig. 5.9 Top, the new homepage of the *Catalogo Generale dei Beni Culturali*; down, example of an item record in the catalogue (Palazzo Pretorio, Trento).

[Top, Catalogo generale dei Beni Culturali, accessed May 1, 2026, <https://catalogo.beniculturali.it/>; down, “Palazzo Pretorio, Trento,” Catalogo generale dei Beni Culturali, accessed May 1, 2026, https://catalogo.beniculturali.it/detail/Trento/ArchitecturalOrLandscapeHeritage/SBC002_4847_S222]

80. Istituto centrale per la digitalizzazione del patrimonio culturale – Digital Library, *Linee guida per la digitalizzazione del patrimonio culturale. Release v1.0-giugno-2022* (Ministero della Cultura, 2022), <https://docs.italia.it/italia/icdp/icdp-pnd-digitalizzazione-docs/it/v1.0-giugno-2022/index.html>.

05.2 A critical review of the main guidelines for the digitisation of the built heritage

Activities related to the digitisation of cultural heritage are currently situated within a complex, highly stratified, and not always linear international framework, in which the European Union and the Italian context have developed approaches that are partly convergent and partly divergent. Over recent decades, numerous guidelines and best practices for the digitisation of cultural heritage have been published, progressively refining the identification of requirements and addressing the practical challenges that emerge alongside technological advancements [Tab. 5.2].

Tab. 5.2 Main guidelines and best practices for the digitisation of cultural heritage published in the European and Italian context in recent years.

European context			Italian context		
Document	Year	Development context	Document	Year	Development context
"3d-Icons Guideline"	2014	<i>3D-ICONS</i> is an EU-funded project aimed at enriching <i>Europeana</i> by complementing existing collections made available through initiatives such as <i>CARARE</i> , <i>Europeana Local</i> , and <i>ATHENA</i> .	"Linee guida per la digitalizzazione del patrimonio culturale"	2022	<i>Piano Nazionale di Digitalizzazione</i> (PND).
"Basic principles and tips for 3D digitisation of cultural heritage"	2020	"Declaration of Cooperation on advancing the digitisation of cultural heritage" (9.04.2019).	"Linee guida per l'acquisizione 3D dei beni storico-artistici e museali (beni mobili)"	2025	Technical appendix of the "Linee guida per la digitalizzazione del patrimonio culturale" (PND).
"Share3D Guidelines"	2020	<i>Share3D</i> project, a response to EU Council conclusions on promoting access to culture via digital means with a focus on audience development (OJ C, C/425, 12.12.2017).	"Linee guida per l'acquisizione 3D dei beni storico-artistici e museali (beni immobili)"	forthc.	Technical appendix of the "Linee guida per la digitalizzazione del patrimonio culturale" (PND).
"VIGIE 2020/645. Study on quality in 3D digitisation of tangible cultural heritage"	2022	The study led by Cyprus University of Technology and cofounded by European Commission.			
"3d Digitisation Guidelines. Steps To Success"	2024	<i>EUreka3D</i> is a project funded by the <i>Digital Europe Programme</i> of the European Union.			

A comparison between the most recent European guidelines, represented by the document “3D Digitisation Guidelines: Steps to Success”, developed within the *EUreka3D* project, an EU initiative co-funded by the European Union, and the Italian guidelines contained in the *Piano nazionale di Digitalizzazione del Patrimonio culturale* issued by the Ministero Italiano della Cultura (MiC), makes it possible to clearly identify similarities and differences in the way the digitisation process as a whole is conceptualised. This comparison also highlights the objectives that motivated the development of these documents, as well as their defining characteristics.

The European guidelines summarise and operationalise the methodologies recommended in the EU “Study on quality in 3D digitisation of tangible cultural heritage: mapping parameters, formats, standards, benchmarks, methodologies, and guidelines, VIGIE 2020/645”, published in April 2022)¹, which was prepared in response to “Recommendation (EU/2021/1970) on a common European data space for cultural heritage”². The document adopts a more operational and practice-oriented approach, focusing almost exclusively on the 3D digitisation of tangible cultural heritage³.

These guidelines are intended to support all users involved in 3D digitisation, with particular emphasis on cultural heritage professionals engaged in the digitisation of tangible collections⁴. They are structured around two core principles identified by the EU “VIGIE study”: data quality and object complexity⁵. Quality is understood not merely in terms of output resolution and geometric accuracy, but also as the completeness and reliability of the associated data describing both the object and the digitisation process. High-quality digitisation is therefore expected to generate results that extend beyond geometry and textures, preserving the cultural memory embedded in the object itself. This, in turn, requires the systematic recording of metadata and paradata linked

1. European Commission, *Study on quality in 3D digitisation of tangible cultural heritage: mapping parameters, formats, standards, benchmarks, methodologies, and guidelines, VIGIE 2020/645* (2022).

2. European Commission, *Commission Recommendation (2021/1970/EU) on a common European data space for cultural heritage* (2021), <https://eur-lex.europa.eu/eli/reco/2021/1970/oj/eng>.

3. EUreka3D, *3D Digitisation Guidelines: Step to Success. A guide based on the EU VIGIE2020/654 Study on quality in 3D digitisation of tangible cultural heritage* (European Union, 2024), 5-6, <https://eureka3d.eu/wp-content/uploads/2024/06/3D-digitisation-guidelines-EU-reka3D.pdf>.

4. EUreka3D, *3D Digitisation Guidelines*, 5.

5. European Commission, *Study on quality in 3D digitisation*, 23-72.

to the generated digital files⁶.

The assessment of complexity supports the identification of appropriate teams, equipment, and workflows, enabling the accurate documentation of both 3D content and the contextual information necessary for meaningful interpretation. An inadequate understanding of object complexity may compromise the fitness-for-purpose of 3D models and limit their applicability to purely visual or illustrative uses.

The document organises the digitisation workflow into four main phases, placing strong emphasis on the technical quality of data acquisition [Fig. 5.10]:

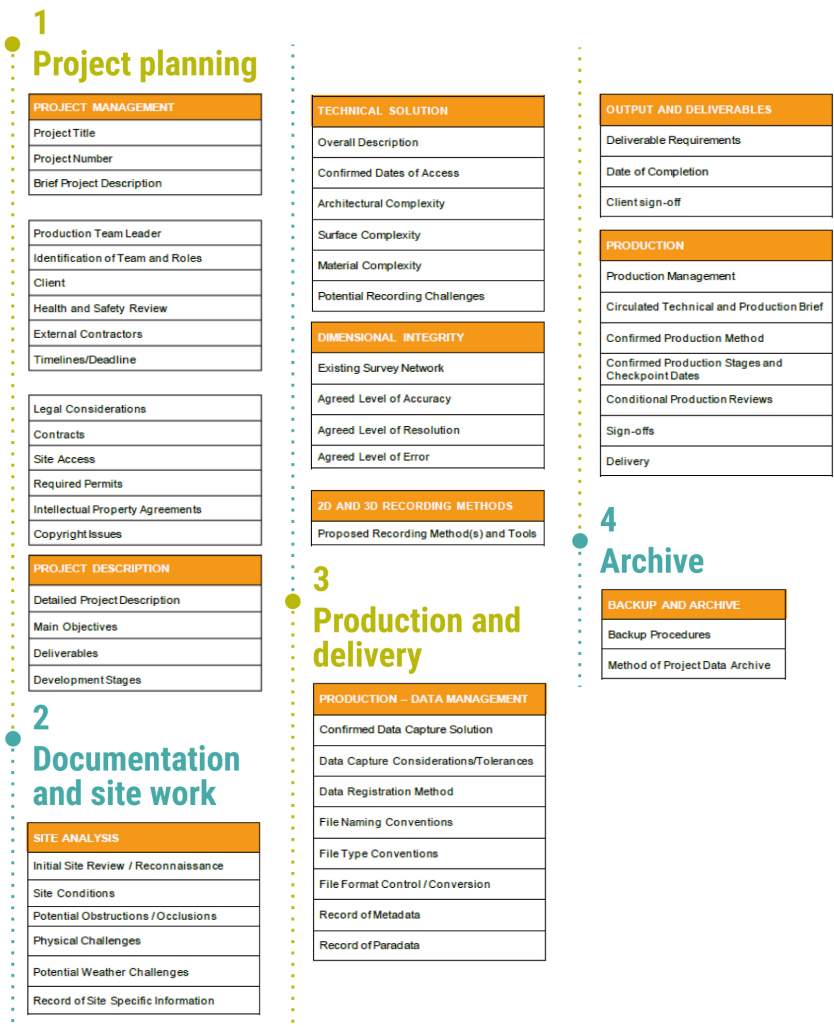


Fig. 5.10 Project planning and production stages for digitisation projects as identified at the preliminary approach at the launch of the study.

6. Eureka3D, *3D Digitisation Guidelines*, 6.

1 • Project planning

This phase encompasses project management activities, including the definition of all essential project information - such as the project title and identification number, object ID, team leader, commissioning body, schedule, and deadlines - as well as the formal project description, which establishes expectations, deliverables, and timelines. Further requirements include specifying when and where data acquisition will take place, identifying the necessary infrastructure and equipment, defining human resources and budget allocations, and establishing minimum acceptable standards for the quality of metadata and paradata⁷.

2 • Documentation and site work

This phase involves the analysis of the object or site, the identification of appropriate technical solutions, and the selection of suitable 2D and 3D recording methods. It also includes defining the equipment to be used and agreeing in advance with stakeholders on levels of accuracy, resolution, and acceptable error margins. The assessment of the object or site, in combination with project requirements and constraints, informs the choice of recording techniques and digitisation tools⁸.

3 • Production and delivery

This phase comprises the final preparations before digitisation, the systematic recording of data during acquisition, and the post-processing tasks required for final delivery. It includes the production and management of metadata, which describe the digital object, and paradata, which document the conditions and procedures of acquisition.

As stated in the guidelines, “metadata entry is likely to be processed after the digitisation process is completed but can be done in advance on a separate spreadsheet or DAM [digital asset management] system ready for import/link to the published 3D models”. The recording of paradata begins during the project planning phase and continues throughout the digital acquisition process.

Once the outputs are confirmed in terms of number of items, formats, and associated data, the file data can be processed. Raw data must first be archived and subsequently cleaned and pre-processed to generate 3D models that meet stakeholder expectations⁹.

7. Eureka3D, *3D Digitisation Guidelines*, 11.

8. Eureka3D, *3D Digitisation Guidelines*, 12-14.

9. Eureka3D, *3D Digitisation Guidelines*, 16-18.

4 • Archive and preserve

Ensuring the long-term integrity and accessibility of data is a critical requirement. Adequate storage capacity must be estimated for all phases of the workflow, including acquisition, post-processing, and long-term archiving, considering storage location, service providers, and preservation costs over time. All project-related data (file data, metadata, paradata, working files, high-quality master models, and optimised dissemination models) must be archived, with backup copies securely stored offline¹⁰.

In the European guidelines, particular attention is given to publication and dissemination. From this perspective, discoverability is considered a prerequisite for the effective use and reuse of 3D models. However, publishing 3D content online presents significant technical challenges, notably the lack of standardisation in 3D file formats and the limited interoperability between processing and visualisation software. For this reason, the guidelines recommend producing multiple versions and formats of each model to accommodate the needs of diverse user groups and use cases.

The guidelines also address issues related to intellectual property rights. As 3D models often constitute faithful reproductions of physical objects, open-access approaches are encouraged. When the original object is in the public domain, its 3D reproduction should likewise remain in the public domain. Intellectual property rights must therefore be clearly defined in contracts or service agreements, ensuring that content holders retain the greatest possible freedom to distribute the models under appropriate reuse licences¹¹.

The “Linee guida per la digitalizzazione del patrimonio culturale”, published in 2022 by the Istituto centrale per la digitalizzazione del patrimonio culturale – Digital Library, represent the first of five technical and operational annexes to the Italian *Piano Nazionale di Digitalizzazione*¹². The document is conceived as both an informative and theoretic-

10. EUreka3D, *3D Digitisation Guidelines*, 19.

11. EUreka3D, *3D Digitisation Guidelines*, 21.

12. “The five guidelines of the National Plan for the Digitization of Cultural Heritage outline and recommend methodologies and procedures to address the challenges associated with implementing the processes identified in the Strategy section. They provide informative, non-prescriptive references and establish a technical and methodological framework, accompanied by relevant bibliographic resources. Each annex of the Plan explores a specific aspect of digitization practices and will be subject to periodic review to ensure alignment with evolving regulations, methodologies, standards, and technological advancements” (“Linee guida,” Istituto centrale per la digitalizzazione del patrimonio culturale – Digital Library, accessed May 1, 2026, <https://digitallibrary>).

cal tool, addressed primarily to staff of cultural institutions responsible for the preparation and management of digitisation projects.

Unlike the European guidelines, the Italian guidelines cover a broader range of digitisation practices, including 2D, 3D, and audiovisual content. In this case, the digitisation process is not structured into explicitly defined operational phases; nevertheless, three main stages can be implicitly identified: the creation of digital objects, their metadata enrichment, and their archiving.

As stated in the introduction to the document, the guidelines define the digitisation project in relation to its underlying motivations, the actors involved in the process, operational methodologies, the selection of assets to be digitised, and execution timelines. They provide specifications regarding file formats, metadata standards, resource identifiers, digital resource naming conventions, and storage media for preservation. In addition, the guidelines offer indications concerning budget definition and administrative procedures, considering the development of the project from the initial planning and procurement phases through to the testing of digitisation activities and the quality control of results¹³.

The document places particular emphasis on defining the professional roles that constitute the optimal team for a digitisation project, specifying their core competencies as well as their responsibilities within the project framework. Key roles include the Project Director (corresponding to the Italian *Responsabile Unico del Procedimento*), the Project Manager, the Subject Matter Expert or Curator, the Conservator-Restorer, and other specialised professionals involved in the planning, execution, and quality assurance of the digitisation process¹⁴.

Overall, the Italian guidelines “offer process paradigms and operational models aimed at establishing a solid common foundation for the correct design of cultural heritage digitisation projects that are consistent with the vision of the *Piano Nazionale di Digitalizzazione* and embedded within a long-term digital transformation process”. The objective of the document is to ensure that digitisation activities undertaken by individual institutions are conducted in a conscious, organised, and effective manner, producing high-quality data aligned with the most up-to-date

cultura.gov.it/linee-guida/).

13. Istituto centrale per la digitalizzazione del patrimonio culturale – Digital Library, *Linee guida per la digitalizzazione*, 3.

14. Istituto centrale per la digitalizzazione del patrimonio culturale – Digital Library, *Linee guida per la digitalizzazione*, 8-10.

standards and capable of ensuring interoperability and long-term sustainability. To ensure that these guidelines remain a valid and authoritative reference, they are subject to periodic revision and updating by the Istituto centrale per la digitalizzazione del patrimonio culturale – Digital Library¹⁵.

In 2025, these guidelines were expanded through a technical appendix specifically dedicated to the 3D acquisition of historical artistic and museum objects (movable heritage), while a second technical appendix addressing immovable, or architectural, heritage is currently under development¹⁶.

A comparison of the two sets of guidelines [Tab 5.3] reveals a substantial convergence of overarching objectives, alongside certain differences in methodological and operational approaches. These differences can be partly attributed to the fact that the comparison is based on a single European reference document, whereas the Italian guidelines are informed by a much broader and more heterogeneous body of sources, including numerous national and international documents that extend beyond the European context. This aspect is explicitly reflected in Section 11, “Bibliographical References”¹⁷, of the Italian guidelines, where - among the cited national and international guidelines and manuals - only the document “Basic Principles and Tips for 3D Digitisation of Cultural Heritage”¹⁸ (2020) represents a European reference, while several other sources originate from non-European institutional and research contexts.

Both documents share the primary objective of promoting high-quality digitisation processes that are sustainable over the long term and oriented towards the enhancement of cultural heritage. Nevertheless, while the Italian guidelines seek to establish a unified strategic and organisational framework for the national cultural heritage system, drawing on a wide spectrum of theoretical and operational contributions, the European guidelines adopt a more focused and circumscribed approach. They

15. Istituto centrale per la digitalizzazione del patrimonio culturale – Digital Library, *Linee guida per la digitalizzazione*, 3.

16. “Linee guida per la digitalizzazione 3D di beni storico-artistici e museali,” ParteciPa, accessed May 1, 2026, <https://partecipa.gov.it/processes/Linee-Guida-Digitalizzazione-3D?locale=it>.

17. Istituto centrale per la digitalizzazione del patrimonio culturale – Digital Library, *Linee guida per la digitalizzazione*, 51-52.

18. “Basic principles and tips for 3D digitisation of cultural heritage,” European Commission, last modified September 11, 2020, <https://digital-strategy.ec.europa.eu/en/library/basic-principles-and-tips-3d-digitisation-cultural-heritage#l.%20Consider%20the%20value>.

Tab. 5.3 Overview of the key aspects of recent European and Italian guidelines on cultural heritage digitisation.

	"3D Digitisation Guidelines: Step to Success" (Eureka3D / VIGIE2020/654)	"Linee guida per la digitalizzazione del patrimonio culturale" (ICDP – PND)
Primary objective	To provide practical operational support for the digitisation of tangible European cultural heritage, with a particular focus on the quality of 3D cultural heritage assets.	To offer a unified methodological and organisational framework for the digitisation of national cultural heritage.
Field of application	Tangible cultural heritage, both movable and immovable, with a specific focus on 3D digitisation.	Comprehensive digitisation of cultural heritage, encompassing 2D, 3D, and audiovisual assets.
Document character	Operational and practical guide, including procedural instructions, project templates, and checklists for the concrete implementation of digitisation processes.	Theoretical and informative policy framework, aimed at providing process paradigms rather than detailed technical instructions.
Document structure	Structure organised according to the project life cycle: planning, acquisition, production, archiving, and dissemination.	Structure organised around key thematic areas: digitisation project, file formats, metadata, rights, naming conventions for digital objects, cost items, tender specifications, verification and testing, storage media, and associated costs.
Intended audience	Museum managers seeking to digitise part or entire collections under controlled conditions; public administrations or monument/site owners willing to digitise large immovable objects; stakeholders undertaking extensive site digitisation projects.	Staff of cultural institutions engaged in digitisation activities.
File formats	Comprehensive review and critical analysis of standards and formats specific to 3D.	Concise review of formats for images, audio, video, and 3D files, with orientation toward international and open standards.
Metadata	Provides a list of all main standards in cultural heritage digital documentation (Smithsonian 3D Metadata Model, LIDO, CARARE, ARCO, CRMDIG, METS), with implicit recommendation of EDM (Europeana Data Model).	Structured treatment of descriptive metadata (archival, bibliographic, cataloguing), technical metadata, rights metadata, structural metadata, and preservation metadata. Recommended standard: METS (Metadata Encoding and Transmission Standard).
Paradata	Thoroughly addressed, considered fundamental, but noting that CH currently lacks a formal schema for expressing them.	Not explicitly addressed.
Licences and rights	Explicit promotion of open licences as enabling tools for the reuse of 3D models.	Strong focus on proper attribution and licensing, with explicit reference to open licences as instruments to be evaluated case by case, in line with national regulations and institutional policies.
Updates and future perspectives	Strong attention to future perspectives and the impact of emerging technologies (XR, digital twins, AI, open data).	Document designed for periodic revisions and updates by the ICDP, in response to technological and methodological developments.
Specific themes	Concept of quality; concept of complexity; metadata and paradata; publication and dissemination.	Roles and competencies; naming conventions; cost items and tender specifications; verification and testing; storage media.

aim to provide practical tools “to help anyone on their 3D digitisation journey” and to support the production of high-quality 3D models in order to ensure their reusability and long-term preservation. This divergence in scope and source material is also reflected in the overall nature of the documents: the PND functions primarily as a theoretical and informative policy framework, whereas the European guidelines are conceived as a distinctly operational, action-oriented guide addressing specific practical challenges.

This distinction is reflected in the respective scopes of application. In the Italian case, the scope is broad and transversal, encompassing different categories of cultural assets (2D, 3D, and audiovisual) and a wide range of acquisition technologies. By contrast, the European document adopts a more vertically focused approach, concentrating on tangible cultural heritage, both movable and immovable, and limiting its scope to 3D digitisation. In both cases, however, the primary intended audiences are cultural institutions, heritage professionals, public administrations, and other stakeholders who have chosen to undertake large-scale, high-complexity digitisation projects.

From a structural perspective, the Italian guidelines are organised around the main thematic areas relevant to a digitisation project, including administrative, legal, and organisational aspects. The European guidelines, by contrast, adopt a process-oriented structure, articulated into operational phases that accompany and support the implementation of the digitisation project.

The differences become particularly evident in the treatment of the concepts of quality and complexity. While the Italian ICDP implicitly defines quality primarily through technical acquisition parameters, the European guidelines explicitly formalise quality and complexity as interrelated concepts. In this framework, project complexity is understood as a determining factor in the evaluation of final outcomes. The European study introduces a structured taxonomy of complexity, distinguishing between ‘object complexity’ (e.g. geometry, surface reflectance) and ‘process complexity’ (e.g. instrumentation, environmental constraints), and thereby inextricably linking the notion of quality to the intended use of the 3D model¹⁹.

A similar complementarity emerges in the treatment of data enrichment. While the Italian document limits its discussion primarily to metadata,

19. European Commission, *Study on quality in 3D digitisation*, 23-72.

distinguishing between general, descriptive, technical, rights-related, structural, and preservation metadata, and encouraging the adoption of the METS standard; the European guidelines emphasise the importance of both metadata and paradata. In the European framework, paradata is assigned a central role in ensuring transparency, quality, and the reusability of 3D models. Furthermore, the European document promotes metadata schemas such as LIDO, CARARE, and the Europeana Data Model (EDM) to foster interoperability with the Europeana portal.

Differences also emerge in the approach to dissemination. In the Italian guidelines, dissemination is treated primarily as the outcome of the digitisation process and is subordinated to regulatory and organisational constraints. In contrast, the European guidelines frame dissemination as a structural phase within the project lifecycle, closely linked to objectives of access, reuse, and data circulation. Similarly, licensing policies for digital content are addressed in the PND from a predominantly legal and administrative perspective, adopting a precautionary approach oriented towards protection and risk mitigation. Within the European context, by contrast, open licences are regarded as enabling instruments for the full valorisation and reuse of digital data.

Finally, with regard to updates and future perspectives, the Italian guidelines are conceived as a document subject to periodic revision, whereas the European guidelines - although less explicitly oriented towards formal updates - offer a strongly forward-looking vision, oriented towards the integration of emerging technologies such as artificial intelligence, cloud computing, and digital twins, as well as towards new scenarios for the use of digital data.

The comparison between the Italian and European guidelines for the digitisation of cultural heritage outlines a complex and articulated framework, characterised by strong convergence in strategic objectives and significant differentiation at the operational and methodological levels. Both approaches share a commitment to data quality, interoperability, and the adoption of standards as prerequisites for the sustainability and reusability of digital assets. However, while the Italian guidelines define a systemic framework oriented towards governance, role definition, institutional responsibilities, and life cycle management of data within an integrated national context, the *EUreka3D* European guidelines stand out for their high level of technical and scientific specialisation. This is particularly evident in the formalisation of the relationship between quality and complexity, in the systematic documentation of

processes through paradata, and in the definition of metrics and benchmarks for 3D digitisation.

A substantial complementarity thus emerges: the Italian framework provides the organisational and governance infrastructure within which European best practices can be effectively implemented, while the EUreka3D model represents an advanced reference for enhancing the scientific and technical quality of digitisation projects. At the same time, the comparison also highlights a shared limitation, namely the predominant focus on structured cultural institutions, with comparatively limited attention paid to independent professionals and actors who, particularly in the architectural domain, are increasingly responsible for producing the digital information that will constitute the cultural heritage of the future. From this perspective, the full maturation of digitisation processes requires not only the integration of national governance frameworks with advanced European methodologies, but also an expansion of the scope of the guidelines to more explicitly include upstream actors involved in the creation of digital cultural heritage. Finally, an additional critical gap - explicitly acknowledged in the Italian context - concerns the lack of defined technical procedures for the recovery and integration of pre-existing or 'hidden' digitisation outputs, as well as of born-digital cultural assets. Addressing this gap is essential to prevent the loss of already-produced digital heritage and to ensure its long-term preservation and reuse [Fig. 5.11].

Main weaknesses of the digitisation guidelines	1	2	3
	Not addressed to built heritage professionals (e.g., AED firms).	Lack of focus on born-digital materials and previous digitisation campaigns.	Lack of emphasis on the systematic construction of digital and/or hybrid archives.

Fig. 5.11 Key issues and gaps in European and Italian guidelines on cultural heritage digitisation.

05.3 Becoming digital built heritage: the challenges of contemporary architectural archives

The discussion presented thus far primarily concerns cultural heritage Institutions undertaking digitisation campaigns of analogue cultural assets, both movable and immovable, for purposes of preservation, enhancement, and dissemination. However, as highlighted in the previous sections, the digital cultural heritage of the built environment is not limited to digitised materials; it also encompasses born-digital documents preserved within institutions or within the archives of professionals.

Beyond the distinction between digitized and born-digital materials, professional practices operating within the AEC sector (Architecture, Engineering, and Construction) are characterized by a high degree of documentary heterogeneity related to the built environment. Such documentation varies both in typology and in content, according to the tools employed in its production and the specific purposes for which it was generated. Against this backdrop, the following table [Tab. 5.4] offers a concise - though necessarily non-exhaustive - survey of the principal categories of materials typically encountered in professional practices engaged in activities concerning the built environment.

Tab. 5.4 Overview of the main types of documents, content, and associated equipment and tools commonly used in professional practices related to the built environment.

Type of document	Type of content	Equipment and tools
• Textual documents (reports, administrative files, expert opinions, emails, etc.) • Graphic documents (sketches, technical drawings, renderings, presentations, etc.) • Calculation documents (tables, spreadsheets, calculation sheets) • Printed materials (manufacturers' catalogues, journals, article excerpts, brochures, photocopies) • Three-dimensional objects (material samples, maquettes, prototypes, etc.) • Photographic and audiovisual documents • Library materials (books, technical manuals, journal collections)	• Studio management (Administration and accounting, consultancy, etc.) • Contabilità (invoices, contracts, etc.) • Administrative and regulatory documentation (land registry files, site notebooks, permits, etc.) • Design and planning (architectural, urban, landscape, structural, building services, environmental, etc.) • Conservation and restoration • Diagnostics (structural and environmental monitoring, etc.) • Geometric surveying • Expert assessments and evaluations	• Basic equipment (workstations, printers, plotters, scanners, drafting tools, etc.) • Geometric measurement instruments (total stations, laser scanners, measuring tapes, levels, etc.) • Diagnostic measurement instruments (thermal cameras, sound level meters, non-destructive testing tools, sensors, etc.) • Visual acquisition tools (cameras, drones, etc.) • Prototyping tools (3D printers, laser cutters, cutters, etc.) • Visualization tools (AR/VR headsets, monitors, etc.) • Data storage systems (NAS, servers, hardware devices, physical archive, etc.)

As Enrica Bordato emphasised, “the typology, quantity, modes, and order of document production are closely linked to the nature of the client - public or private - the professional domain of the practice, and its organisational structure, which may range from a sole practitioner supported by collaborators to larger associated firms or temporary professional partnerships formed around specific projects. Moreover, while some projects proceed to construction and realisation, others remain unbuilt, including those arising from research-oriented or exploratory design activities”¹.

This structural and procedural diversity has direct implications for the formation, management, and long-term preservation of digital archives produced by contemporary architectural and engineering practices. It also highlights a critical discontinuity between the archival frameworks developed for cultural heritage institutions and the realities of professional archives, which increasingly constitute a significant component of the digital cultural heritage of built environment.

Regarding this latter category, the national and European guidelines examined above show limited direct applicability. These frameworks are predominantly oriented toward cultural heritage institutions rather than private practitioners or technical professionals, and they do not provide a comprehensive or systematic treatment of the creation, management, and long-term preservation of born-digital records, nor of materials generated through earlier digitization initiatives. Furthermore, particularly in the European context, these guidelines tend to prioritize the dissemination and sharing of digital records over the structured formation and maintenance of archival collections. As a result, an overarching and integrated perspective is lacking, one that can account for the full range of materials typically encountered in the hybrid archives of professional practices within the AEC sector.

Although these guidelines provide valuable indications regarding formats and descriptive standards - recommendations that can certainly be adopted by professionals or private entities seeking to create interoperable, accessible, and long-term preservable digital files - the most significant challenges arise during the enrichment phase of both born-digital and digitised data.

1. Enrica Bordato, “Conservare e descrivere gli Archivi del progetto. Esempi dai fondi conservati al Politecnico di Torino,” in *Riordinare e inventariare gli archivi di architettura. Testimonianze del seminario 20-21 settembre 2021*, ed. E. Bodrato, R. Iacobucci (Hapax Editore, 2023), 16.

In the Italian context, metadata creation and enrichment are currently supported by the D.PaC platform, which is offered free of charge to all organisations and institutions participating in the National Recovery and Resilience Plan (PNRR) sub-investment M1C3 1.1.5 “Digitisation of Cultural Heritage”². The platform assists institutions throughout the planning, descriptive, quality-control, and uploading phases of digital resources.

At the European level, although metadata models to be associated with digital resources are provided - most notably through the Europeana Data Model (EDM) - the procedural steps required for metadata enrichment are described only in broad terms. The description of data enrichment procedures appears to be implicitly delegated to specific platforms (themselves developed within European projects, e.g., *Share3D Dashboard*³, *EUreka 3D Data Hub*⁴). These platforms, however, are designed for cultural heritage institutions and are primarily oriented towards publication on online platforms (e.g. *Europeana*).

The situation therefore appears rather unbalanced. From the perspective of cultural heritage institutions, there is an abundance (perhaps even an excess) of tools and guidelines for the digitisation of the cultural heritage they preserve. By contrast, professionals who digitise and produce native-digital resources intended to become digital cultural heritage appear to lack comprehensive and coherent documentation for managing their data, both at the national and supranational levels [Tab. 5.5].

To date, significant attention has been devoted to the recovery of paper-based archives belonging to major architects of the past. In many cases, these archives have been digitised, enabling scholars to study and better understand the most influential professionals of the nineteenth and twentieth centuries⁵. “Archival collections or fonds which now are entering archival institutions sometimes come from firms involved with technical design and construction but often are from architects or architectural firms. The architects whose work is represented in archives may have had brilliant careers or they may be less well known.

2. Istituto centrale per la digitalizzazione del patrimonio culturale – Digital Library, *D.PaC Executive Summary dal Report di inquadramento concettuale. Economic, ecosistema digitale per la cultura* (2025), 5, https://digitallibrary.cultura.gov.it/wp-content/uploads/2025/09/Economic_D.PaC_Executive-summary_v1.0.pdf.

3. Share3D, accessed May 1, 2026, <https://www.share3d.eu/it/>.

4. EUreKA, accessed May 1, 2026, <https://eureka3d.eu/eureka3d-data-hub/>.

5. Stefano Allegrezza, “Gli archivi degli architetti nell’era digitale,” in *Nuovi annali della scuola speciale per archivisti e bibliotecari XXXV* (Leo S. Olschki Editore, 2021): 306.

Digital built heritage	How is it created?	What is the process for becoming digital record and CH?	Who creates it, and which tools are available*?	
			Cultural institutions archives, museums, etc.	Professionals and researchers
Digitised From physical objects to digital objects	New digitisation campaigns	1. Creation	EU & PND guidelines	EU & PND guidelines
		2. Enrichment	EU & PND guidelines	Missing
		3. Archiving	EU & PND guidelines	EU & PND guidelines
		4. Publication	EU guidelines	EU guidelines
	Recovery of previous digitisation campaigns	1. Creation	N/A	N/A
		2. Enrichment	Missing	Missing
		3. Archiving	EU & PND guidelines	EU & PND guidelines
		4. Publication	EU guidelines	EU guidelines
Born-digital Objects existing only in digital format	Outcome of professional or research practice	1. Creation	N/A	Missing
		2. Enrichment	Missing	Missing
		3. Archiving	EU & PND guidelines	EU & PND guidelines
		4. Publication	EU guidelines	EU guidelines

Legend

N/A means not applicable; **Missing** indicates that there are no specific tools for this topic; [Guidelines](#) means that the available tools are not specific to this topic but can still be used.

* In accordance with the latest Italian and European institutional guidelines.

Their impact may have been as teachers of generations of students, or as masters who trained disciples in their ateliers. In every case, they will have tried to respond to requirements of their times and will have left their mark on the field of architecture, on the cultural life of their era, on the visible environment, and on the lifestyles of their contemporaries and of successive generations. Whether architectural records were created by well-known architects or came from the drafting tables of the less-known, care of these documents will present similar problems for archivists”⁶.

Nevertheless, far less attention has been paid to the safeguarding of archival heritage produced within contemporary architectural practices⁷. As Albena Yaneva observes, “while the fate of established archives has been the subject of multiple studies, architectural scholars have rarely touched on the mechanisms of constructing these archives and the process of archiving as keys for understanding how historical sources in

Tab. 5.5 Overview of the main tools supporting the creation, enrichment, storage, and publication of the digital built heritage. The table highlights the weaknesses and gaps in the current state of practice.

6. Cécile Souchon, “Introduction,” in *A guide to the archival care of Architectural Records 19th-20th centuries*, ed. ICA (2000), 17.

7. Allegrezza, *Gli archivi degli architetti nell’era digitale*, 306.

architecture are established”⁸. She further notes that “analysis of what it means to be an archivist of architecture tends to come from the archivists themselves, rather than from professional architects or researchers interested in empirically examining the practices of archiving”⁹.

Over the past three decades, however, architectural practices have demonstrated a growing and deliberate interest in their archives. With the introduction of digital technologies into design practice in the 1980s, many architects developed an increased awareness of their professional legacy. As a result, offices and large firms began to invest systematically in the organisation, cataloguing, and management of their archival materials¹⁰.

These efforts by architectural practices have been supported and encouraged by sustained scholarly debate over the past two decades, accompanied by numerous research projects at both European and international levels¹¹. “These initiatives have sought to enhance knowledge of contemporary architectural archives and to raise awareness of the risks they face. Among the most significant initiatives was the *GAU:DI* project (Governance, Architecture and Urbanism: a Democratic Interaction), funded by the European Community under the *Culture 2000* programme for the periods 2002-2004 and 2006-2008. The project involved several European institutions and aimed to promote institutional collaboration and foster greater understanding of contemporary architecture. Within this framework, the international working group Architecture Archives in Europe (AAE) was established in 2002. Its objectives were twofold: first, to develop a tool for coordinating and increasing the visibility of institutions responsible for collecting and preserving architectural archives across Europe; and second, to produce guidance aimed at raising awareness among architectural practices regarding the proper management and preservation of their archives, offering practical solutions to everyday challenges. To this end, the group produced a multilingual guide (published in English, French, Italian, German, Dutch, and Finnish) entitled “Guidelines to Managing Architectural Records”. Developed through the collaboration of architects,

8. Yaneva Albena, *Crafting History: Archiving and the Quest for Architectural Legacy* (Cornell University Press, 2020), 8, <https://doi.org/10.1515/9781501751837>.

9. Albena, *Crafting History*, 8.

10. Albena, *Crafting History*, 8.

11. Stefano Allegrezza, “Architecture, engineering and design archives in the digital era: state of the art, challenges and future perspectives,” *APXEOH* 5, no. 5 (2022): 17, <https://u-pad.unimc.it/handle/11393/347971>.

historians, archivists, IT specialists, and researchers, the guide combined theoretical reflections on archival management with methodological recommendations, particularly addressing the emerging challenges associated with the preservation of digital technical documentation¹².

Beyond Europe, the United States has also shown significant interest in the challenges surrounding the creation, management, and long-term preservation of architects' digital archives. Between 2002 and 2007, the *DAArch* (Digital Archive for Architecture)¹³ research project, commissioned by the Art Institute of Chicago, focused on developing methods for the management and preservation of born-digital architectural documentation. This work resulted in the OAIS-compliant¹⁴, open-source *Digital Archive for Architecture System* (DAAS). It was followed by the *MIT-led FACADE* project (2007-2009)¹⁵, which investigated strategies and best practices for the long-term preservation and access of CAD and 3D architectural models, highlighting the rapid obsolescence of many digital models produced in the 1990s and leading to the development of a prototype digital repository based on DSpace¹⁶.

Related initiatives have also emerged elsewhere. In Canada, the Canadian Centre for Architecture launched the long-term research programme *Archaeology of the Digital*¹⁷ in 2012, which combined historical inquiry, exhibitions, and archival strategies to address the acquisition and preservation of digital architectural materials. In Australia, the *ADAR* and *ADAR:NF* (Archiving digital architectural records: towards a national framework) projects (2015-2018) resulted in the development of a national framework for archiving digital architectural records, emphasising the importance of guidelines jointly developed by archivists and architects¹⁸.

Despite these efforts, the current situation remains far from encouraging. What is still largely lacking is widespread awareness of the significance of what is being produced today, namely the cultural heritage of tomorrow. As Maria Guercio already observed in 2008, "the lack

12. Allegrezza, *Gli archivi degli architetti nell'era digitale*, 281-283.

13. "DAArch: Digital Archive for Architecture," SourceForge, accessed May 1, 2026, <https://sourceforge.net/projects/daarch/>.

14. Open Archival Information System.

15. MacKenzie Smith, *Future-proofing architectural computer-aided design: MIT's facade project* (Editions InFolio, 2008), <http://hdl.handle.net/1721.1/46329>.

16. Allegrezza, *Gli archivi degli architetti nell'era digitale*, 284-287.

17. "Archaeology of the Digital," Canadian Centre for Architecture, accessed May 1, 2026, <https://www.cca.qc.ca/en/events/3333/archaeology-of-the-digital>.

18. Allegrezza, *Gli archivi degli architetti nell'era digitale*, 287-288.

of recognition, on the part of producers, of the archival nature of these digital memories generated in the course of everyday activities is bound to have serious negative consequences, both in terms of ensuring effective ‘conservation-oriented’ protection of these sources and with regard to the broader possibility of developing systematic initiatives and clearly defined, recognizable, and assessable models of preservation practices”¹⁹.

“The creation, management, and long-term preservation of digital records require architects, heritage authorities, and civil society to address challenges that are fundamentally different from those encountered in the past. Digital documents require robust and effective preservation strategies that must be implemented from the moment of their creation. The challenge of long-term digital preservation therefore depends not only on technical solutions, but also on the awareness, among archival producers, of both the critical issues and the potential of digital tools. Moreover, it is essential that producers of design archives recognise the value of properly preserved archives for sustaining technical knowledge, fostering the professional development of those working within architectural practices, and enhancing the effectiveness of communication with both public and private clients”²⁰.

“The memory of things has weight,” remarks architect Renzo Piano in the documentary dedicated to his archive [Fig. 5.12]. “In particular, an archive associated with a professional practice such as an architectural studio constitutes a repository of heterogeneous materials that reflect the architect’s identity, intellectual outlook, and design methodology. Beyond the logic of ordering and classification, however, this type of archive also functions as a dynamic assemblage capable of triggering new lines of inquiry, constructing interpretative pathways, and fostering curiosity, doubt, and uncertainty, thereby generating interpretations and bringing historical content to the attention of future generations”²¹. Within this perspective, the archive is no longer understood as a mere by-product of design activity, but rather as a primary instrument for

19. Maria Guercio, “Gli archivi come depositi di memorie digitali,” *Digitalia* III, no. 2 (2008): 50, <https://digitalia.cultura.gov.it/article/view/280>.

20. “ANAI - Costituzione del Gruppo di lavoro sugli archivi digitali degli architetti – ADA,” Associazione Nazionale Archivi Italiani, last modified September 30, 2021, https://anai.org/webarchiving/ANAI_2010-2023/sito/anai_cms/cmsf45e.html?numDoc=1756&munu_str=.

21. “Il potere dell’archivio. Renzo Piano Building Workshop”, Molteni&C, last modified September 14, 2018, <https://www.molteni.it/it/news/the-power-of-the-archive-renzo-piano-building-workshop>.



Fig. 5.12 The Power of the Archive. Renzo Piano Building Workshop activating memory, a film by Francesca Molteni, curated by Fulvio Irace with the Renzo Piano Foundation and the Renzo Piano Building Workshop.

[“The Power of the Archive,” Fondazione Renzo Piano, last modified October 1, 2018, <https://www.fondazionerenzopiano.org/en/news/il-potere-dellarchivio/>]

reconstructing the intellectual, technical, and cultural processes that shape both the built and the unbuilt environment.

It should be emphasised that architectural archives constitute one of the most complex and heterogeneous documentary ecosystems within the broader field of cultural heritage. As architectural practice inherently combines aesthetic, technical, regulatory, and relational dimensions, it generates an extraordinary variety of materials²²: drawings, sketches, technical boards, calculations, reports, contracts, photographic and audiovisual records, physical models, material samples, and, increasingly, born-digital documents produced through multiple software platforms and stored on diverse media²³. These archives result in the sedimentation of documents heterogeneous in content, function, form and mate-

22. Marco Carassi, ed. *Riordinare e inventariare gli archivi di architettura* (Hapax, 2023), 16.

23. Alben, *Crafting History*, 7-8.

rial, whose order and composition vary according to the type of commission, the organisational structure of the studio, and the life cycle of each project, from conceptual research to construction and, in many cases, to unrealised proposals²⁴.

“In addition - argues Stefano Allegrezza -, in the current AEC archives there are ‘new’ kinds of documents, such as e-mails, messages exchanged through instant messaging systems (WhatsApp, Telegram, WeChat, etc.) or through social media²⁵ (Facebook, LinkedIn, etc.), which are increasingly replacing the methods traditionally used to communicate with the interlocutors (collaborators, clients, institutions, etc.). These are new kinds of documents, which certainly require considerable commitment and specialized skills for their preservation, although little thought has yet been given to them. There is no doubt that AEC archives of the future - indeed: of the present - will consist of digital material”²⁶. This documentary multiplicity makes architectural heritage particularly fragile, both from a physical and a semantic point of view, and demands advanced strategies of conservation, interpretation, and long-term accessibility. Indeed, “Digital archives created by architects exhibit all the complex issues typically associated with digital archives in general, together with several additional criticalities specific to this sector. There are, of course, differences between large firms, medium-sized practices, small offices, and studios in which a single architect works independently; nevertheless, certain common characteristics can be observed”²⁷. Allegrezza identifies the following recurring issues²⁸:

1. The lack of a logical and correct from an archival point of view sorting criterion in the phase of creation of the archive;
2. The absence of rules governing the naming of digital files and file versions;
3. A tendency toward indiscriminate accumulation;
4. The lack of systematic sorting and discarding practices;
5. The ‘scattering’, namely the distribution of documents and folders across multiple storage systems, platforms, and services;

24. Carassi, *Riordinare e inventariare gli archivi di architettura*, 16.

25. About social media as a new form of archives see also Jovana Tošić, “Continuity or Discontinuity of Architectural History: Digital Repositories and Social Media as Archives,” in *Proceedings of “Architecture Archives of the Future”*, Delft-Rotterdam, November 2023 (2023), 128-135; Jovana Tošić, “Digital Mini-Archives: Social Media Users as Curators of an Architectural Utopia,” *AM Journal of Art and Media Studies*, no. 34 (2024): 27-38, <https://doi.org/10.25038/am.v0i28.562>.

26. Allegrezza, *Architecture, engineering and design archives in the digital era*, 17.

27. Allegrezza, *Gli archivi degli architetti nell'era digitale*, 294.

28. Allegrezza, *Architecture, engineering and design archives in the digital era*, 23-27.

6. A general lack of awareness regarding the challenges of digital preservation;
7. Issues related to the transmission of the so-called ‘digital heritage’, including the transfer of authentication credentials (usernames and passwords).

Beyond the criticalities directly related to the creation and management of architectural archives, there are additional challenges - already discussed in previous sections - connected to technological development. Among these, the issue of file formats constitutes one of the most complex and structurally critical challenges in the long-term preservation of digital architectural archives. Format obsolescence, closely tied to the rapid evolution of proprietary software, hardware infrastructures, and operating systems, represents a primary risk to the continued accessibility, intelligibility, and authenticity of born-digital design records. In contrast to other documentary domains characterised by a relatively limited number of dominant formats, the situation within AED archives is considerably more complex²⁹. “In fact, it is not uncommon for an architectural practice to use several dozen different software applications and, consequently, dozens if not hundreds of different electronic formats. The presence of such a high number of electronic formats significantly complicates the management of the studio’s digital archive, since to counteract the obsolescence of electronic formats and to ensure the long-term preservation of documents, they must undergo periodic processes of format migration. In addition to their sheer number, the electronic formats used in digital architectural archives are often proprietary, which certainly constitutes an obstacle to the preservation of documents produced in these formats”³⁰ [Fig. 5.13].

Within this framework, the adoption of open standards represents a fundamental prerequisite for ensuring interoperability, long-term accessibility, and effective collaboration within digitally based design and documentation processes. Open standards are developed within international standardization frameworks through the activities of technical committees, which bring together experts, institutions, and stakeholders to define shared specifications aligned with evolving technological and professional requirements. In the construction and built environment sector, a central role is played by buildingSMART International, which

29. Allegrezza, *Architecture, engineering and design archives in the digital era*, 27.

30. Allegrezza, *Gli archivi degli architetti nell’era digitale*, 300.

Main issues in the creation and long-term preservation of contemporary AED archives	1 The lack of archival criterion in the phase of creation of the archive.	2 Absence of standardized file-naming and versioning practices.
	3 Tendency toward indiscriminate accumulation.	4 Lack of systematic sorting and discarding practices.
	5 "Scattering": dispersion of records across multiple storage systems.	
6 Lack of awareness regarding the challenges of digital preservation.	7 Lack of awareness regarding the transmission of the 'digital heritage'.	8 Technological obsolescence of file formats.

Fig. 5.13 Main challenges in the creation and long-term preservation of contemporary AEC archives, highlighting organizational, technical, and cultural issues affecting digital records.

develops and maintains open standards - most notably IFC - along with related specifications that support structured and reliable data exchange. At the national level, standardization activities in Italy are carried out by the subcommittee UNI/CT 033/SC 05, “BIM and digital management of construction information processes”, which comprises more than one hundred participants, including construction companies, designers, professional associations, software vendors, and public authorities³¹. This subcommittee primarily translates and implements the standards developed by the technical committee of the European Committee for Standardization³² dedicated to Building Information Modelling (CEN TC 442) and by the technical committee of the International Organization for Standardization responsible for standards in building construction

31. UNI - Ente Italiano di Normazione, *Guida alle norme per le costruzioni digitali. La parte 0 della UNI 11337*, March, 2024, <https://www.uni.com/wp-content/uploads/BrochureBIM2024-1.pdf>.

32. CEN, accessed May 1, 2026, <https://www.cencenelec.eu/>.

and civil engineering works (ISO TC 59)³³.

The use of open standards does not imply the abandonment of proprietary software solutions; rather, it requires ensuring that digital documents can be exported and preserved in non-proprietary formats. This approach effectively mitigates vendor lock-in, facilitates cross-platform and cross-disciplinary collaboration, and supports compliance with regulatory and institutional requirements, thereby contributing to the sustainability, integrity, and continuity of digital information throughout the entire lifecycle of the built asset. The “Linee guida per la digitalizzazione del patrimonio culturale” state that formats intended for long-term preservation must be lossless and uncompressed, preferably in a raw format. The use of lossy copies, possibly compressed - such as JPEG files for images - is mainly intended for online publication³⁴.

The following table presents the main open and proprietary formats currently used for the principal types of digital documents [Tab. 5.6].

Tab. 5.6 Overview of the main open and proprietary file formats currently used for different types of digital documents, with indications of their characteristics and suitability for long-term preservation.

[“Format Descriptions,” Library of Congress, https://www.loc.gov/preservation/digital/formats/fdd/browse_list.shtml; “File format,” The National Archives, <https://www.nationalarchives.gov.uk/PRONOM/Format/proFormatSearch.aspx?status=new>]

File type	Name / Extension	Description	Open format
Text file	DOCX	The Office Open XML-based word processing format using .docx as a file extension has been the default format produced for new documents by versions of Microsoft Word since Word 2007. The format was designed to incorporate the full semantics and functionality of the binary .doc format produced by earlier versions of Microsoft Word.	no
	ODT	The OpenDocument Text Document Format is a format for editable textual documents. It is one of several sub-types in the ODF family for particular content categories. Designed to be a native format for word-processing applications, the format is sometimes called ODT after its usual file extension.	yes
	PDF	PDF represents formatted, page-oriented documents. These documents may be structured or simple. They may contain text, images, graphics, and other multimedia content, such as video and audio. There is support for annotations, metadata, hypertext links, and bookmarks.	yes (since 2008)
	PDF/A	PDF/A is a family of ISO standards for constrained forms of PDF intended to be suitable for long-term preservation of page-oriented documents for which PDF is already being used in practice.	yes

33. “ISO/TC 59 Buildings and civil engineering works,” ISO, accessed May 1, 2026, <https://www.iso.org/committee/49070.html>.

34. Istituto centrale per la digitalizzazione del patrimonio culturale – Digital Library, *Linee guida per la digitalizzazione*, 25.

File type	Name / Extension	Description	Open format
Spreadsheet	XML	Extensible Markup Language is a simple, very flexible text format derived from SGML (ISO 8879). XML documents fall into two broad categories: data-centric and document-centric.	yes
	XLSX	The Open Office XML-based spreadsheet format using .xlsx as a file extension has been the default format produced for new documents by versions of Microsoft Excel since Excel 2007. The XLSX format uses the SpreadsheetML markup language and schema to represent a spreadsheet 'document'.	no
	CSV	It is a simple format for representing a rectangular array (matrix) of numeric and textual values. It is a delimited data format that has fields/columns separated by the comma character and records/rows/lines separated by characters indicating a line break.	yes
	ODS	The OpenDocument Spreadsheet Document Format (ODS), Version 1.2 is an XML-based format for editable spreadsheet documents. It is one of several subtypes in the ODF family for particular content categories.	yes
Presentation	PPTX	The Office Open XML-based presentation format using .pptx as a file extension has been the default format produced for new documents by versions of Microsoft PowerPoint since PowerPoint 2007. The format was designed to incorporate the full semantics and functionality of the binary .ppt format (MS-PPT) produced by earlier versions of PowerPoint.	no
	ODP	The OpenDocument Presentation Document Format is a format for editable documents that are presentations based on sequences of 'slides'. The format is sometimes called ODP after its usual file extension. It is one of several subtypes in the ODF family for particular content categories.	yes
	HTML	HyperText Markup Language (HTML) is the primary markup language used for creating pages and applications on the World Wide Web. HTML files are textual files, viewable and editable in plain text editors.	yes
Raster images	PSD	Adobe Photoshop Document files are raster image files, which include support for image manipulation such as layers, masks, transparency, text, alpha channels, clipping path, additional color settings, and a variety of other Photoshop-specific elements.	no
	PNG	The Portable Network Graphics is an extensible file format for the loss-less, portable, well-compressed storage of static and animated raster images. Indexed-color, grayscale, and truecolor images are supported, plus an optional alpha channel.	yes

File type	Name / Extension	Description	Open format
	TIFF	A tag-based file format for storing and interchanging raster images. TIFF serves as a wrapper for diverse bitstream encodings for bit-mapped (raster) images. The different encodings may represent distinct compression schemes and different schemes for color representation (photometric interpretation).	yes
	JPEG	JPEG stands for Joint Photographic Experts Group, an international organization that standardized the concept of lossy compression during the late 1980s and early 1990s. It uses DCT (Discrete Cosine Transform) compression technique used for images and audio. The standard of lossy compression is able to remove some visual data invisible to human eye which averages out colour variation and reduces the file size.	yes
Vector images	AI	Adobe Illustrator's file format that includes both a pdf copy of the illustration and a postscript copy.	no
	SVG	Scalable Vector Graphic is a language for describing two-dimensional graphics in XML, maintained under the auspices of the World Wide Web Consortium (W3C).	yes
	EPS	The Encapsulated PostScript File Format was developed in the late 1980s by Adobe Systems Incorporated to facilitate the incorporation of illustrations into textual documents for printing. The EPS format is particularly suited to vector graphics or to graphics that combine vector graphics with raster data, sometimes referred to as 'metafiles'.	yes
Point cloud	RCS	An RCS file are indexed point cloud scan files used by Autodesk ReCap.	no
	PLY	It is a simple format for describing an object as a polygonal model. The format originated at the Stanford Computer Graphics Laboratory in the 1990s, where it was used for models derived from a 3D laser triangulation scanner.	yes
	E57	ASTEM E57 3D file format, built using a combination of binary and XML, is an open-source, fully documented, data file exchange format for 3D imaging data. E57 files are capable of storing 3D point data, point data attributes, and 2D imagery, as well as having a defined extension for addressing future aspects of 3D imaging.	yes
	LAS	LAS is a file format for the interchange of 3-dimensional point cloud data. Although developed primarily for exchange of lidar point cloud data, this format supports the exchange of any 3-dimensional x,y,z tuple data.	yes
	XYZ	The XYZ Point Cloud format is a simple, text-based data dictionary format for recording points in 3D space or point cloud data. Stored values are aligned with the Cartesian coordinate system (x,y,z).	yes

File type	Name / Extension	Description	Open format
2D/3D models	DWG	DWG is the proprietary native file format for AutoCAD, one of the most popular computer-assisted design (CAD) packages. The format is maintained by Autodesk. DWG is a compact binary format that stores and describes the content of 2D and 3D design data and metadata.	no
	DXF	DXF is an exchange format for content of AutoCAD Drawing Files (DWG). The DXF format specification is maintained and has been openly published by AutoDesk.	yes
	STEP	It is an ISO standard for the computer-interpretable representation and exchange of product manufacturing information.	yes
	OBJ	The Wavefront OBJ format is a format for defining the 3D geometry for the surface of one or more objects. The format was first used by Wavefront Technologies around 1990.	yes
	STL	The STereoLithography file format is an openly documented format for describing the surface of an object as a triangular mesh, that is, as a representation of a 3-dimensional surface in triangular facets. The STL format was widely adopted in the 1990s and referred to as a de facto standard for rapid prototyping.	yes
BIM	RVT/RFA/RFT/ RTE	RTE (template) files and RVT (project) files are actual Revit projects. RFA (family) files and RFT (family template) files are family files that can either be loaded into a project or saved externally.	no
	PLN/PLA	Files with the .pln extension are the standard working format of Archicad (by Graphisoft), whereas files with the .pla extension are the Archicad archive file type, that bundles together all components, linked images and textures into a single package.	no
	IFC	Industry Foundation Classes is an openly documented standard for the exchange of data about a building or facility and its construction or maintenance, data structured as a building information model (BIM).	yes
	BFC	BIM Collaboration Format is an international openBIM standard, developed and maintained by buildingSMART International. BCF is available in many BIM software tools. There are two different ways to utilise BCF – via a file-based exchange or via a web service.	yes

However, an even more serious issue is emerging on the horizon. “There is a real risk that archival institutions will receive digital archives that are poorly organized or already affected by technological obso-

lescence, leaving little possibility for effective action. In some cases, these archives may never be transferred at all, because they have been permanently lost. It is therefore necessary to move beyond a passive approach - based solely on waiting for digital archives to be deposited - and to adopt a proactive one. Long-term preservation of digital architectural archives can only be achieved by raising awareness among architects, as the creators of these records, and by encouraging them to adopt appropriate and effective strategies from the very beginning of the archival process³⁵.

In response to this urgent need, and following the impetus provided by numerous design professionals, the Associazione Nazionale Archivistica Italiana (ANAI) established a working group in January 2021 with the aim of developing guidelines for the management of design firms' archives, both digital and hybrid. In February 2023, the group published the "Linee guida per la formazione, gestione, conservazione degli archivi digitali e ibridi degli studi di progettazione"³⁶, with the aim of providing guidance for the establishment of structured and well-organized archival systems.

The stated objective is to "provide design professionals (engineers, architects, designers, etc.) with suggestions and guidance to manage the complexity of their archives, which are still largely 'hybrid', as they consist of written documents produced on different media (analog and digital), using diverse technologies and characterized by highly heterogeneous features that are often difficult to manage effectively and in a way that is truly useful for professional practice. The guidelines are intended to focus primarily on the moment when the archive is formed, a phase that has become even more strategic with the widespread adoption of digital documents: preservation itself depends on the choices made at the time individual documents are created, on their proper management from the outset, and on selective appraisal, which now takes place much earlier than in the past"³⁷.

The prerequisites for establishing an archive that functions both as an efficient working tool and as a key element of professional identity are primarily organizational. This is especially crucial in contexts where

35. Allegrezza, *Gli archivi degli architetti nell'era digitale*, 307-308.

36. ANAI, *Linee guida per la formazione, gestione, conservazione degli archivi digitali e ibridi degli studi di progettazione* (2023), https://www.anai.org/wp-content/uploads/2023/04/ANAI_Linee_guida_ADISPRO.pdf.

37. ANAI, *Linee guida*, 5.

multiple people with different roles, skills, and employment relationships work on the same project. It is therefore essential that the studio's principals, who must also interact with public regulatory authorities, make certain preliminary decisions and adopt rules that are subsequently shared with all participants. The [Fig. 5.14] shows the main best practices to be implemented prior to the formation of the archive. The ANAI document specifically addresses some fundamental aspects concerning digital documents and the folders in which they are stored. With reference to architectural, engineering, and design practices, the guidelines focus on the following key issues:



Fig. 5.14 Best practices for the formation of contemporary AEC archives, as outlined in the ANAI guidelines, highlighting key organizational, technical, and preservation strategies to be implemented from the earliest stages of archival creation.

1 • The location and naming conventions for documents and folders to ensure their unique identification

The core documentary unit around which the archive should be organized is the project file, within which all documents related to a specific project - whether administrative, financial, or in nature - must be systematically collected and managed. In this respect, it is essential to avoid the separate handling of documents related to the same project, for instance by organizing them according to different media or formats (e.g., photographs with photographs, emails with emails, and technical drawings with technical drawings) or by allowing them to be dispersed across multiple devices. All data should instead be centralized within a single archival system that nonetheless enables network-based document sharing within an integrated, system-oriented framework.

In a digital environment, each document must be uniquely identifiable in order to be cited without ambiguity and must be stored in a logical location that allows for efficient retrieval. To achieve such logical organization, it is advisable to adopt a classification plan that clearly structures individual project files and their corresponding sub-files [Fig. 5.15].

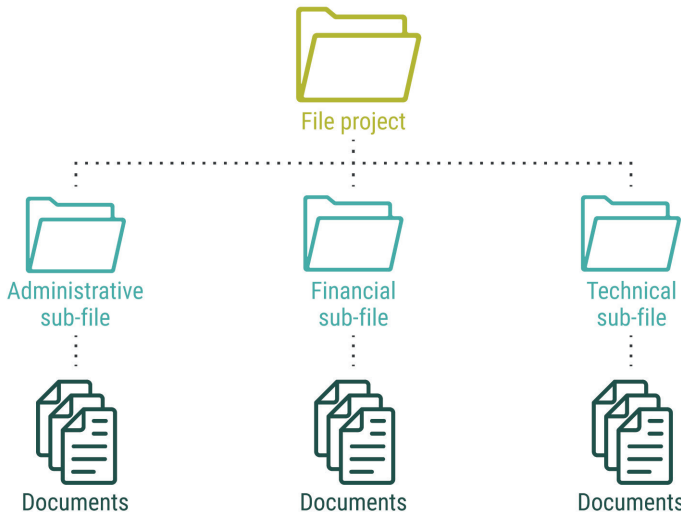


Fig. 5.15 Example of a classification plan. The project file includes all documents - technical, administrative, financial, and others - produced during the design process. Individual documents, regardless of their nature or medium, are logically organized within the relevant sub-file to which they pertain.

Given the need to identify every element of the archive, it is therefore crucial to establish clear and well-defined rules for file naming and to apply them consistently and rigorously. The ANAI guidelines identify the following principles in this regard³⁸:

38. ANAI, *Linee guida*, 11-17.

1. *Use meaningful but concise file names.*

incorrect	correct
Sec_ver	Section_vertical
Mpl_pa	Masterplan_park

2. *Avoid spaces in file names by adopting the following alternatives:*

i. Capital letters for word initials	LineeGuidaAnai
ii. Underscore	Linee_guida_anai
iii. ash	Linee-guida-anai

3. *Avoid special characters in file names.*

Forward slash	/	Asterisk	*
Backslash	\	Double quotation marks	“
Question mark	?	Single quotation marks	‘
Colon	:	Greater-than symbol	>
Vertical slash		Less-than symbol	<

4. *Avoid unnecessary repetition and redundancy.*

incorrect	correct
C:\Projects\Projects_built\Project_Trento2026\Project_delivered.pdf	C:\Projects\Built\Trento2026\Project_delivered.pdf

5. *Do not omit leading zeros (001, 002, 003, ...).*

organised but not correctly	correctly organised
1_Call_for_proposal.pdf	01_Call_for_proposal.pdf
10_Final_report.pdf	02_Urban_context_analysis.pdf
11_Structural_testing.pdf	10_Final_report.pdf
2_Urban_context_analysis.pdf	11_Structural_testing.pdf

6. *Indicate chronological references correctly.* To ensure the chronological ordering of digital documents within a folder, it is recommended to include the date directly in the file name, adopting the “back-to-front” format established by ISO 8601³⁹, which provides recommendations for numerical date and time representations.

correct			
YYYYMMDD	YYYY-MM-DD	YYYY_MM_DD	YYYY.MM.DD
20241230	2024-12-30	2024_12_30	2024.12.30

39. “ISO 8601. Date and time format,” ISO, accessed May 1, 2026, <https://www.iso.org/iso-8601-date-and-time-format.html>.

7. *Use prefixes and suffixes consistently*, for example, to indicate the version of a document or the individual responsible for modifications.

organised but not correctly	correctly organised
Draft_project_park.pdf	Project_park_draft.pdf
Final_project_park.pdf	Project_park_final.pdf
Annex_1_Call report.pdf	Call_report_annex_1.pdf
Annex_2_Call report.pdf	Call_report_annex_2.pdf

8. *Avoid the use of articles, prepositions, and conjunctions (e.g., the, a, an, etc.).*

2 • Maintaining control over the firm's documentary production

The ANAI guidelines underscore the importance for design practices of maintaining continuous intellectual control over the documents they produce, and provide a set of practical recommendations for the creation and organization of the project file. In particular, they emphasize the importance of preparing a tabular register (such as a Word table, an Excel spreadsheet, or an Access database) listing all projects and the documents associated with each of them. This project file register enables the rapid and efficient retrieval of individual documents, facilitates the monitoring of deadlines and procedures, and supports the step-by-step tracking of the activities required to complete a project.

In this respect, although the guidelines do not explicitly propose it, such a register could be used to enrich the listed documents with metadata and paradata. The addition of metadata and paradata would enhance search and retrieval capabilities within the archive, while also allowing for a more comprehensive and accurate description of the materials being preserved.

Should there be a need or an intention to make documents publicly available, several online platforms offer significant alternatives for the enrichment and dissemination of archival materials. Among these, Zenodo⁴⁰ may be cited as a valuable example [Tab. 5.7]. Zenodo is a general-purpose open-access research repository managed by CERN, where a wide range of research outputs can be enriched with metadata and shared by users.

40. Zenodo, accessed May 1, 2026, <https://zenodo.org/>.

Metadata management using a tabular register

Objective	Control, retrieval, and internal management of project documents.
Method	In the tabular structure, each document corresponds to one row, and each metadata element is recorded in a separate column.

	A	B	C	D	E	F	G	H	I	J	K	L
1	Project ID	Project File	Document ID	Content	Creator	Contributor	Format	Date created	Date modified	Version	Rights	Access
	030_A	030_A_2024_Trento_Moser_house	01_plan50_2003	Building plan at 1:50 scale, produced in 2003	Acquired from the client	Acquired from the client	PDF/A	2004	2004	v1.0	© Studio XYZ	Restricted
2	030_A	030_A_2024_Trento_Moser_house	02_survey_2024_MR	Survey carried out by Mario Rossi and Anna Verdi in 2024	Rossi, Mario	Verdi, Anna	DWG	2024-01-30	2024-02-15	v1.2	© Studio XYZ	Restricted
3												
4												
5												

Metadata management with Zenodo

Objective	Preservation, citability, and public access.
Method	Each Zenodo record corresponds to a single archived output.

Basic information

Digital Object Identifier

Do you already have a DOI for this upload? ☐ Yes, I already have one ☒ No, I need one

10.5281/zenodo.18852124

Reserve a DOI by pressing the button (so it can be included in files prior to upload). The DOI is registered when your upload is published.

Resource type

Dataset

Title

Toponymy in Nineteenth-Century Trento: A FAIR Dataset of Historical Evolution of Urban Toponyms in the Piazza del Duomo Area

+ Add titles

Publication date

2026-03-03

In case your upload was already published elsewhere, please use the date of the first publication. Format: YYYY-MM-DD, YYYY-MM, or YYYY. For intervals use DATE/DATE, e.g. 1939/1945.

Authors/Creators

Maragno, Anna (University of Trento)

Research group

+ Add author

Published

Save draft

Preview

Publish

Share

Visibility

Files only

Public

Restricted

Public

The record and files are publicly accessible.

Options

Apply an embargo

Record or files protection must be restricted to apply an embargo.

Discard changes

Delete record

Tab. 5.7 Top: example of metadata management using a tabular register for internal use. Down: an example using Zenodo, a platform primarily employed for the publication of data.

Prior to publication, Zenodo offers the possibility of hosting closed or restricted content, allowing research artefacts to be securely captured and stored while the research is still ongoing, thus ensuring that no materials are lost before their eventual open dissemination. Another fundamental aspect to consider in the overall management of the archive concerns version control. Until a project is definitively clo-

sed, it is necessary to retain not only the initial version of each document but also all subsequent versions. Each version should be assigned a unique file name in order to clearly convey both the chronological sequence of revisions and the responsibilities of the individuals involved in the editing process. It is therefore advisable to adopt simple, well-defined versioning rules, namely standardized conventions for naming successive versions of a document. The guidelines recommend including the version number directly in the file name, using suffixes such as 'v' or 'ver' (for version) or 'r' or 'rev' (for revision).

Typically, version numbers consist of at least two components (e.g., v1.0). The decimal component should be incremented to indicate minor modifications (e.g., v1.1), while the integer component should be increased to reflect substantial changes or a complete revision of the document (e.g., v2.0)⁴¹.

3 • Archive preservation

During design activities, a large number of instrumental and transitory documents are produced and accumulated, whose long-term preservation is unnecessary and can even be detrimental to building and consolidating a useful and usable archive. The disposal of documents that are no longer needed is a crucial step for the proper maintenance of the archive, especially in a digital environment, where production methods facilitate the multiplication of copies and intermediate versions.

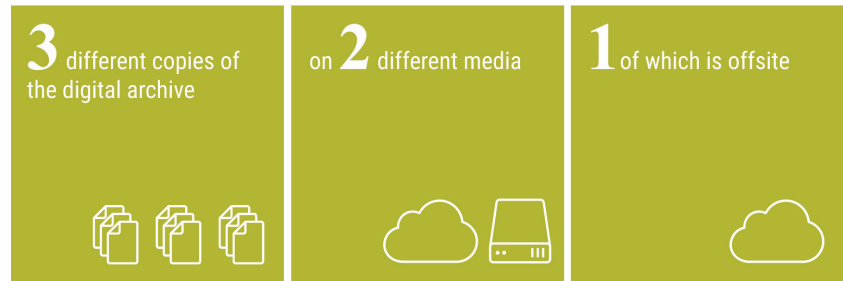
To ensure that the archive functions as an effective working tool, the studio must implement a correct organization of documents and a rigorous selection process, so that the documentation required for various activities can be easily located.

The analysis carried out for the purposes of selection should focus on the intermediate stages of individual deliverables. Such documentation can be discarded with caution if it has no correspondence with the realized work and contains no significant annotations - while, of course, considering any potential historical interest that such documents may have acquired or could acquire over time.

However, disposal is not limited to technical, administrative, or accounting documents. Email correspondence is probably the area in which the advantage of organizing and selecting materials during the process, rather than retrospectively, becomes most evident.

41. ANAI, *Linee guida*, 17-21.

In addition to reorganization and disposal, the preservation of a digital archive requires periodic backups. The guidelines recommend, in this regard, the principle of redundancy, that is, maintaining more than one copy of the digital archive according to the “3-2-1” rule [Fig. 5.16], which consists of keeping at least three copies of the digital archive; using at least two different technologies (e.g., one copy on a physical hard drive and another in the cloud); keeping at least one geographically separate copy (e.g., at another location or in the cloud)⁴².



However, what has been discussed so far does not constitute a sufficient condition to ensure the long-term preservation of the digital archive. As noted in the preceding sections, the technological obsolescence of electronic formats and storage media is arguably the greatest obstacle in the context of digital preservation.

In this regard, the ANAI guidelines recommend a series of activities and best practices, including paper printing, the technological maintenance of PCs and software, emulation, and, finally, direct refreshing onto up-to-date storage media, as well as migration, that is, the conversion of documents into modern formats⁴³.

4 • Planning the future of the archive

The archive undoubtedly constitutes a form of self-representation for the studio and the professionals who work within it. To avoid dissipating this patrimony and to prevent years of effort and labor from being lost to oblivion, it is essential that professionals contemplating the cessation of their activity reflect on the future of their archive and consider its appropriate placement. Awareness of the contribution that each professional has made to cultural heritage through their projects underlies

42. ANAI, *Linee guida*, 23-26.

43. ANAI, *Linee guida*, 26-27.

the decisions regarding the ultimate destination of the archive. Larger studios, in terms of scale and activity, may opt for the establishment of a foundation, whereas in other cases it is necessary to identify a conservation institution to which the archive can be formally entrusted⁴⁴.

Design outputs represent a valuable source of inspiration and conceptual insights for subsequent projects, with some reaching a level of significance that allows them to serve as general case studies. Beyond acting as the professional showcase of the studio, the archive can also function as a resource for scholarly research, the curation of exhibitions, and the production of catalogs and monographs.

Particularly in the case of large studios, the use of the archive should be regulated to prevent undesirable or embarrassing situations and, on occasion, even legal disputes. The regulations adopted by the studio should specify the possible uses of the archive both by internal personnel and external researchers. Even in smaller studios, it is advisable to establish minimal regulations to govern access, considering⁴⁵:

- The fragility of certain documents;
- The need to respect the confidentiality of individuals and the studio, which requires the studio owner to clearly indicate documents temporarily excluded from consultation;
- The existence of copyright and intellectual property rights.

Taken as a whole, the ANAI guidelines present a comprehensive and forward-looking approach to document management in design studios, grounded in the integration of archival principles, professional requirements, and technological innovation. The archive is conceived not merely as a repository of documents, but as a strategic resource that supports the design process, safeguards the studio's institutional memory, and ensures the preservation and transmission of the cultural heritage generated through its work. Within this framework, the guidelines emphasize the archive's dual role as both a practical tool for ongoing professional activity and a custodian of knowledge with enduring cultural value.

Considering the discussion so far, it is clear that architectural memory in the digital age depends on the ability of both creators and institutions to recognise digital objects as potential future cultural heritage. While this awareness has been widely adopted within cultural heritage insti-

44. ANAI, *Linee guida*, 27.

45. ANAI, *Linee guida*, 29.

tutions - as evidenced by the proliferation of projects, guidelines, and best practices supporting digitisation - the same cannot yet be said for professionals in the Architecture, Engineering, and Construction sector. Drawing on the ANAI guidelines, this chapter has examined the processes through which contemporary architectural archives, particularly those that are born-digital or hybrid, can be understood and managed as future digital heritage. By outlining best practices in appraisal, organization, description, and long-term preservation, it has highlighted the necessity of addressing archival concerns at the moment of creation rather than retrospectively. The transition from active records to cultural heritage is neither automatic nor guaranteed; it depends on conscious choices, shared standards, and the recognition of digital architectural documentation as an archival asset with enduring value.

The analysis has shown that effective preservation strategies require close collaboration between architects, archivists, and institutions, as well as the adoption of structured workflows, interoperable formats, and sustainable preservation infrastructures. In this sense, best practices function not merely as technical recommendations but as instruments for fostering awareness and responsibility among producers of architectural records. Ultimately, ensuring that contemporary architecture can 'become' digital heritage means embedding archival thinking within professional practice, thereby safeguarding the documentary evidence of today's design culture for future research, interpretation, and public access.

06

*The Imaginary Map: a digital
public platform to explore
Trento's built heritage*



DE LA SOIE

Chapter 06 • *The Imaginary Map*: a digital public platform to explore Trento's built heritage

The chapter presents *The Imaginary Map*, a web-based platform dedicated to the history of Trento's built heritage. Inspired by André Malraux's concept of the *Musée imaginaire*, the platform functions as a hybrid and open system that brings together heterogeneous data - archival, bibliographic, iconographic, and geometric - within a unified, semantically structured environment. The integration of historical research and digital survey data enables the creation of a comprehensive dataset that supports both scholarly investigation and public dissemination.

Designed for a wide range of users, including researchers, cultural institutions, and professionals, the platform ensures usability, accessibility, and long-term preservation through the adoption of open standards and tools such as Zenodo. By combining rigorous data management with an intuitive interface, *The Imaginary Map* acts as both a research support tool and a public resource, fostering new forms of interaction with built heritage and contributing to the development of an interconnected digital cultural ecosystem.

06.1 The web platform project in the research context: research gap, aim, target users, tools and methods

In light of the reflections developed thus far on the memory of built heritage, both historical and contemporary, and across its many dimensions, it becomes essential to translate into practice those principles and best practices that have so far remained confined to the theoretical realm.

Throughout this dissertation, the need to construct digital records - whether digitized or born-digital - endowed with the value of sources has been repeatedly emphasized. Such records should be understood as digital resources equipped with structured descriptions, capable of generating meaning and participating in processes of access, interpretation, and valorisation¹. A fundamental requirement for these digital records to be fully recognized as digital cultural heritage is the application of the FAIR principles in their structuring and the LOD fundamentals in their publication. In this way, each digital record becomes accessible, searchable, and interoperable, and is integrated into a coherent, interlinked, and semantically enriched framework².

However, what has emerged in recent years is an overwhelming proliferation of digitization projects and digital repositories on the web. Although often driven by commendable intentions, many of these initiatives lack the resources necessary to ensure long-term sustainability or geographical expansion. In other cases, their effectiveness is constrained by methodological or technological limitations, as well as by a lack of standardisation³. As a result, the web appears saturated with numerous initiatives that are not always truly beneficial for researchers and historians of built heritage, contributing instead to fragmentation and informational noise.

For scholars approaching research on built heritage, it would therefore be extremely valuable to have a tool capable of guiding investigation

1. Istituto centrale per la digitalizzazione del patrimonio culturale - Digital Library, *Economic. Ecosistema digitale per la cultura. Report di inquadramento concettuale* (2025), 34-35, https://digitallibrary.cultura.gov.it/wp-content/uploads/2025/09/Ecomiic_Report-di-inquadramento-concettuale_v1.0.pdf.

2. Istituto centrale per la digitalizzazione del patrimonio culturale - Digital Library, *Economic*, 34-36.

3. Anthony Cassar, Drew Baker, and Marinos Ioannides, "From Digital Twin to Memory Twin: A Holistic Framework for Cultural Heritage Documentation, Interpretation, and Adaptive Reuse," *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.* XLVIII-M-9-2025 (2025): 203, <https://doi.org/10.5194/isprs-archives-XLVIII-M-9-2025-203-2025>.

from its earliest stages. Such a tool should not generate further noise or introduce additional isolated resources into the web; rather, it should function as a catalyst for what already exists and is publicly available online, while also directing users toward the physical locations where specific information can be accessed.

At the same time, a platform structured in this way could also serve as a repository for born-digital records, such as the outputs of geometric survey campaigns, ensuring that newly produced data are integrated within the same coherent documentary and semantic framework.

In this sense, the objective is not to add yet another fragmented initiative to the digital landscape, but to provide an orienting and aggregating infrastructure capable of connecting, contextualizing, and enhancing both existing and newly generated resources. The ultimate goal is to create a hybrid and open system that brings together, within a unified environment, all available resources and information related to a specific built asset, enabling them to communicate and interact within a shared and interconnected framework.

Building upon these reflections, and inspired by the concept of *Le Musée imaginaire* by André Malraux - understood not as a physical museum, but as a mental and cultural space where works enter into new forms of dialogue - the project *The Imaginary Map. Experience Trento's history through interactive maps* was conceived: a public digital platform dedicated to the history of the built heritage of Trento across the centuries.

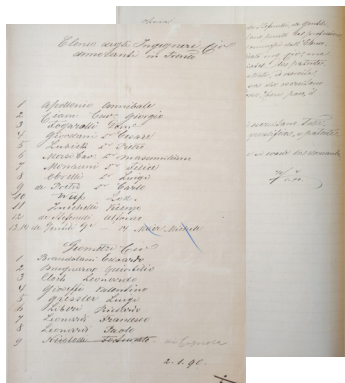
The methodological framework of this project is based on the integration of two distinct yet complementary data streams. On the one hand, extensive historical research provides essential insights into the evolution of Trento's built heritage, drawing on archival documentation, bibliographical references, and iconographic sources⁴. On the other hand, the survey campaign conducted on the Duomo square, palazzo Pretorio and its surroundings supplies precise geometric measurements and qualitative characteristics, establishing a solid empirical foundation for the site's digital representation⁵. By combining these two sources, the project brings together qualitative historical narratives and quantitative spatial data, resulting in a comprehensive and coherent dataset designed for effective digital dissemination.

4. See chapter 06.2 of the present thesis.

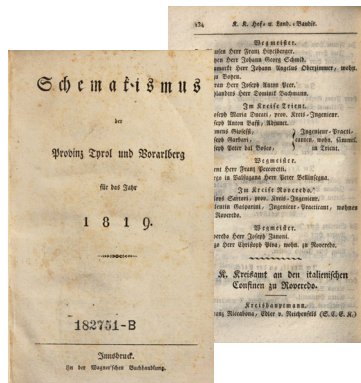
5. See chapter 06.3 of the present thesis.

Physical or digitised sources

Manuscripts



printed documents



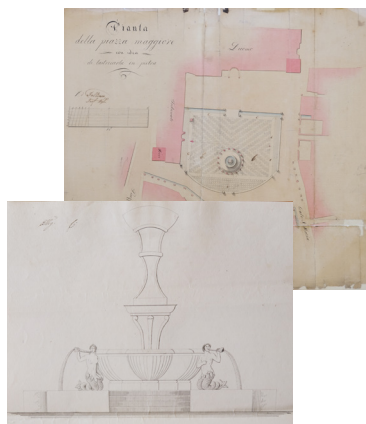
maquettes and objects



lithographs and prints



hand-drawings

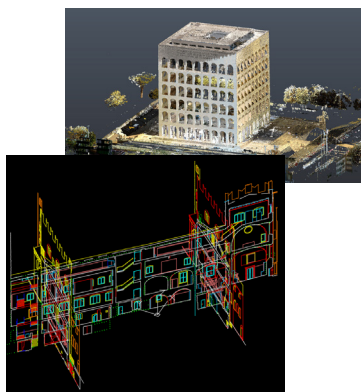


photographs

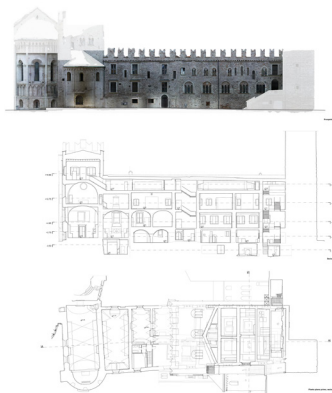


Born-digital sources

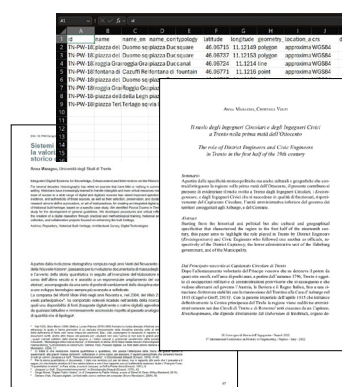
3D digital models



2D digital representation



digital documentation



The fragmentary and heterogeneous nature of the documents consulted during the historical and archival research on Trento's built heritage has highlighted the need for a research support tool, aimed at guiding the initial phase of studies for those approaching the history of Trento [Fig. 6.1]. Indeed, existing resources are often scattered, lack standardization, and rarely provide interactive or easily accessible platforms for data exploration. Addressing this research gap is essential to enhance the usability, visibility, and impact of historical datasets, and it can also serve as a vehicle for disseminating updated geometric data on the current state of the built environment. Ultimately, the project aims to develop an integrated digital system for the dissemination of historical and geometric data, conceived as authoritative digital records.

The system is designed to ensure the long-term accessibility, reliability, and interoperability of data, allowing users to engage with the content not merely as isolated information but as structured and validated digital sources. By adopting a comprehensive approach, the project ensures that both the historical and geometric dimensions of the heritage are represented in a manner consistent with contemporary standards of digital scholarship [Fig. 6.2].

The intended beneficiaries of the platform encompass a broad spectrum of stakeholders:

- *Researchers and students*: who require structured, interoperable datasets for academic analysis, comparative studies, and educational purposes.
- *Cultural institutions*: including museums, archives, and local heritage organizations, which can integrate the platform into their digital services to enhance public engagement.
- *Professionals*: such as urban planners, architects, and conservation specialists, who benefit from reliable historical and geometric data for decision-making and project planning.

The diverse target user base informs the design decisions of the platform, ensuring usability, accessibility, and applicability across multiple domains of heritage research and management. The creation and dissemination of the platform rely on a suite of complementary tools:

- *Digital system creation*: Implemented using Python, HTML, and JavaScript, allowing the development of interactive and responsive web maps capable of visualizing both thematic and spatial data.
- *Data management*: Employing Zenodo for archiving and ensuring

Fig. 6.1 Main type of physical, digitised and born-digital sources about built heritage.

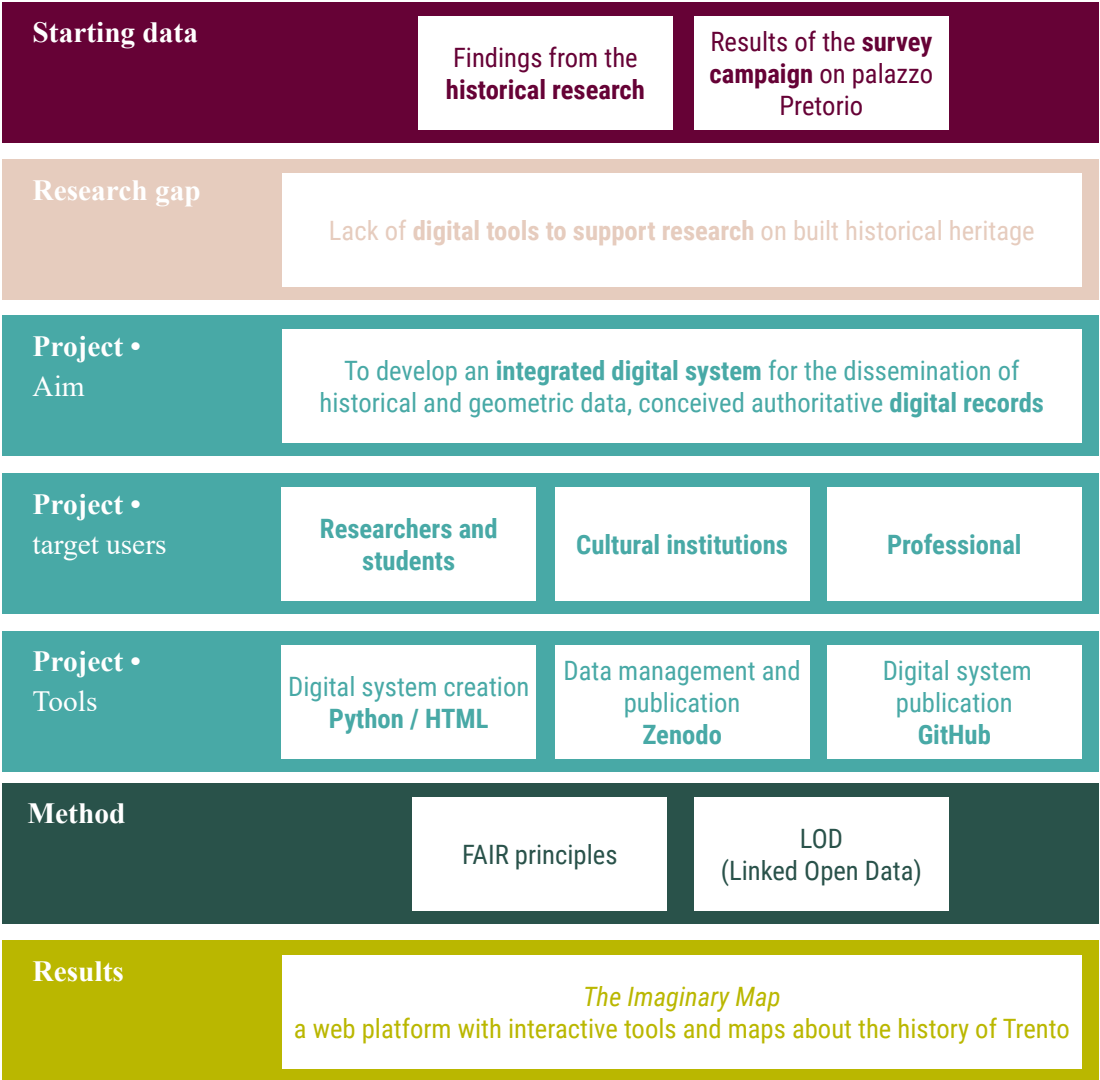
persistent, citable, and FAIR-compliant datasets, thus maintaining scientific reliability and openness.

- *Digital system publication*: The platform is intended for web-based deployment, ensuring wide accessibility to the public and stakeholders; current implementation strategies are focused on sustainability and user-friendly interfaces.

The platform development adheres to contemporary best practices in digital heritage research:

- FAIR principles (Findable, Accessible, Interoperable, Reusable) are applied to all datasets, ensuring that data is not only accessible but also machine-readable and integrable with other digital resources.

Fig. 6.2 Conceptual framework of *The Imaginary Map* project.



- LOD (Linked Open Data) methodologies are implemented to facilitate semantic interoperability, enabling the integration of the platform's datasets with external open data resources and supporting advanced queries and connections across heritage information systems.

The culmination of the project is *The Imaginary Map* [Fig. 6.3], a web platform featuring interactive thematic maps on the history of Trento. The platform allows users to explore the city's historical evolution spatially and temporally, integrating geometric survey data with archival research.

By combining rigorous scholarly data with an intuitive, interactive interface, the platform serves as both a research tool and a public-facing educational resource, bridging the gap between scholarly work and cultural dissemination.

Above all, *The Imaginary Map* functions as an aggregator of digital records on the history of Trento, bringing together resources already available on the web and integrating them with new digital sources, thereby supporting and guiding historical and documentary research.

The platform can be accessed through the following link or by scanning the QR code below:

<https://annamaragno.github.io/the-imaginary-map-Trento-history/>

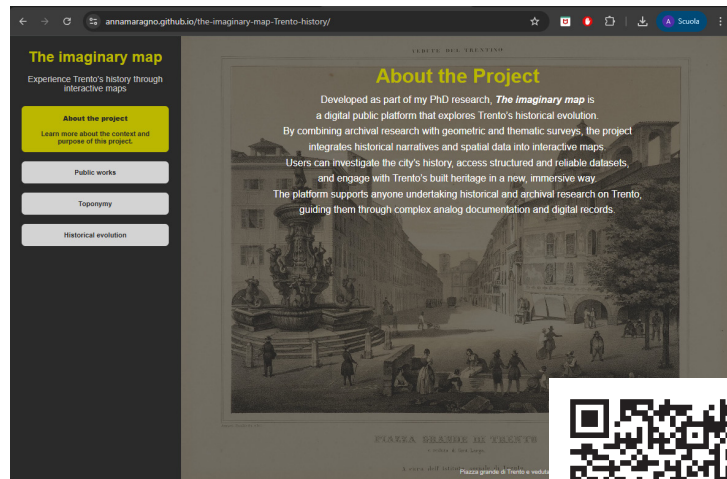


Fig. 6.3 Homepage of *The Imaginary Map* web platform.

06.2 Historical data acquisition: documentary research on Trento's urban transformations in the 19th century and the role of engineers

As Renato Bocchi and Carlo Oradini observed in the introduction to their still essential volume on the history of Trento, published forty years ago, the nineteenth century marked the definitive dissolution of “the closed and crystallised shape of the walled city” and the search for a new urban configuration in the relationship between the historic city, emerging expansions, and the surrounding territory¹. It was during this century that modern Trento took shape, largely through the work of engineers who played a fundamental role both as state officials and as employees of local authorities² [Fig. 6.4].



1 Renato Bocchi and Carlo Oradini, *Le città nella storia d'Italia. Trento* (Laterza, 1983), 5.

2 Anna Maragno and Cristiana Volpi, *Dove Trento si ingegna. Il ruolo degli ingegneri nello sviluppo della città di Trento durante il XIX secolo* (Edizioni Efestò, 2023), 3.

Building upon the framework of the PRIN 2017 research project (Progetto di Ricerca di Interesse Nazionale), the doctoral research aimed precisely to investigate the role played by these figures - often overlooked and at times only temporarily active in the city's history - in shaping Trento's urban development. The study - the results of which have been published in a monograph and several essays³ - reconstructs their competencies and responsibilities within the network of technical offices distributed across the territory according to the complex administrative organisation established by the Habsburg government, with particular attention to urban-scale interventions and renewals.

Methodologically, the research is grounded in an extensive and systematic survey of archival, bibliographic, historiographical, and other documentary sources preserved in local and international archives and libraries. The research was conducted primarily in the following archival and documentary repositories:

- Archivio Diocesano Tridentino (ADTn)⁴;
- Archivio fotografico storico provinciale (AFS)⁵;
- Archivio Provinciale di Trento (APTn)⁶;
- Archivio storico del Comune di Trento (ASCTn)⁷;
- Archivio di Stato di Trento (ASTn)⁸;
- Allgemeines Verwaltungsarchiv, Wien (AVA)⁹;
- Biblioteca Comunale di Trento (BCTn)¹⁰;
- Fondazione Museo storico del Trentino (FMSTn)¹¹;

Fig. 6.4 Evolution of the city of Trento. From top left, to bottom right: Pianta della città e dei dintorni di Trento. Rilevata nell'anno MDCCCXIII sotto la dominazione francese, 1813; Proposta dell'ingegnere Carlo Caminada relativa alla stazione per la progettata ferrovia, 1851; Francesco Ranzi, Pianta di Trento antica e moderna, 1869; Progetto del nuovo quartiere commerciale e industriale in Centa, 1898. Maps show that the city remained largely closed and unchanged within the walls until the mid-nineteenth century.

[From top left, to bottom right: ASCTn 3.8 - IV.65.1891-01; ACTn 3.8 - VII.366.1851-01; BDn, T II h 738; ACTn 3.8 - VII.106.1898-04]

3 Anna Maragno and Cristiana Volpi, "Il ruolo degli Ingegneri Circolari e degli Ingegneri Civici a Trento nella prima metà dell'Ottocento," in *History of Engineering/Storia dell'Ingegneria. Proceedings of the 5th International Conference/Atti del 9° Convegno Nazionale* (Cuzzolin, 2022), 613-626; Maragno and Volpi, *Dove Trento si ingegna*; Anna Maragno and Cristiana Volpi, "Lo sviluppo urbano di Trento dalle origini alla seconda metà dell'Ottocento," in *L'arte in Trentino dal Medioevo al Novecento*, ed. E. Chini, and M. Beato (Antiga edizioni, 2025), 394-403.

4. "Archivio Diocesano Tridentino," Trentino Cultura, accessed May 1, 2026, <https://www.cultura.trentino.it/Luoghi/Tutti-i-luoghi-della-cultura/Archivi/Archivio-Diocesano-Tridentino>.

5. "Archivio fotografico storico provinciale," Trentino Cultura, accessed May 1, 2026, <https://www.cultura.trentino.it/Luoghi/Tutti-i-luoghi-della-cultura/Archivi/Archivio-fotografico-storico-provinciale>.

6. "Archivio provinciale di Trento," Trentino Cultura, accessed May 1, 2026, <https://www.cultura.trentino.it/Luoghi/Tutti-i-luoghi-della-cultura/Archivi/Archivio-provinciale-di-Trento>.

7. "Archivio storico," Biblioteca Comunale di Trento, accessed May 1, 2026, <https://bibcom.trento.it/Archivio-storico>.

8. "Archivio di Stato di Trento," Ministero della Cultura, accessed May 1, 2026, <https://archiviodistatotentino.cultura.gov.it/>.

9. "Allgemeines Verwaltungsarchiv," Austrian State Archives, accessed May 1, 2026, <https://www.statearchives.gv.at/tasks-and-organisation/allgemeines-verwaltungsarchiv-finanzen-und-hofkammerarchiv.html>.

10. Biblioteca Comunale di Trento, accessed May 1, 2026, <https://bibcom.trento.it/>.

11. Fondazione Museo storico del Trentino, accessed May 1, 2026, <https://museostorico.it/>.

Urban scale	Architectural scale	People
Traditional sources		
Archivio Diocesano Tridentino Archivio fotografico storico provinciale Archivio storico comune di Trento → Protocolli di Consiglio del Magistrato politico-economico → Protocolli di sessione del Consiglio comunale → Esibiti → Patrimonio comunale → Regolamenti comunali Archivio di Stato → Capitanato Circolare → Sezione Luogotenenza → Serie Carte e Piante Fondazione Museo storico del Trentino, Archivio iconografico Museo Diocesano Tridentino Tiroler Landesarchiv	Archivio Diocesano Tridentino Archivio fotografico storico provinciale Archivio storico comune di Trento → Protocolli di Consiglio del Magistrato politico-economico → Protocolli di sessione del Consiglio comunale → Esibiti → Patrimonio comunale → Contratti rogito terzi → Progetti di edilizia privata città → Progetti piccoli lavori di edilizia privata → Regolamenti comunali Archivio di Stato → Capitanato Circolare → Sezione Luogotenenza Biblioteca Comunale di Trento → Fondo manoscritti → Fondo Dal Bosco Museo Diocesano Tridentino Tiroler Landesarchiv	Archivio Diocesano Tridentino Archivio storico comune di Trento → Protocolli di Consiglio del Magistrato politico-economico → Protocolli di sessione del Consiglio comunale → Esibiti → Patrimonio comunale → Progetti di edilizia privata città → Progetti piccoli lavori di edilizia privata Archivio di Stato → Capitanato Circolare → Sezione Luogotenenza Biblioteca Comunale di Trento → Fondo manoscritti → Fondo Dal Bosco Museo Diocesano Tridentino Tiroler Landesarchiv
Digital tools and sources		
Archivio storico comune di Trento → Cartografia Storica della città di Trento [https://archiviostorico.bibcom.trento.it/fonds/4617] Biblioteca Digitale Trentina → Iconografia [https://bdt.bibcom.trento.it/] HISTORICALkat [https://historicalkat.provincia.tn.it/#/it/welcome]	BeWeB → Beni architettonici [https://beweb.chiesacattolica.it/?l=it_IT] Biblioteca Digitale Trentina → Iconografia [https://bdt.bibcom.trento.it/]	BeWeB → Beni architettonici → Persone [https://beweb.chiesacattolica.it/?l=it_IT] Biblioteca Digitale Trentina → Iconografia [https://bdt.bibcom.trento.it/] Museo Diocesano Tridentino → Nati in Trentino [https://www.natitrentino.mondotrentino.net/] Biblioteca Civica di Rovereto (Rovereto Digital Library) → Dizionario dei trentini illustri [https://digitallibrary.bibliotecacivica.rovereto.tn.it/communities/0da9ab99-6bdc-4205-817d-c33294ac61b4]

- Museo Diocesano Tridentino (MDTn)¹²;
- Tiroler Landesarchiv, Innsbruck (TLA)¹³.

Main documentation was consulted at the Archivio storico del Comune di Trento, with particular attention to building permits, urban improvement projects, and correspondence between civic authorities and engineers. A significant amount of iconographic documentation was also consulted in the “Carte e piante” collection of the Archivio di Stato di Trento. These physical archives were complemented by online catalogues and digital repositories, including the *Biblioteca Digitale Trentina* and the webpage *Beni ecclesiastici in web* (BeWeB) [Tab. 6.1].

With the aim of clarifying the role of engineers in the urban evolution of Trento, the research was conducted at multiple levels of detail and along several lines of inquiry [Fig. 6.5].

To begin with, the 19th-century urban layout of Trento was studied by analyzing the city's evolution over the centuries. Based on historical cartography and iconography¹⁴ - where still available - and with reference to key studies on the city's history¹⁵, graphic reconstructions of Trento's development over time were created. These are synthetic representations of the city, from its foundation in the 1st century BCE to the second half of the 19th century, when, following the diversion of the course of the Adige river, it gradually took on the configuration that still characterizes it today. The maps aim to highlight the most impor-

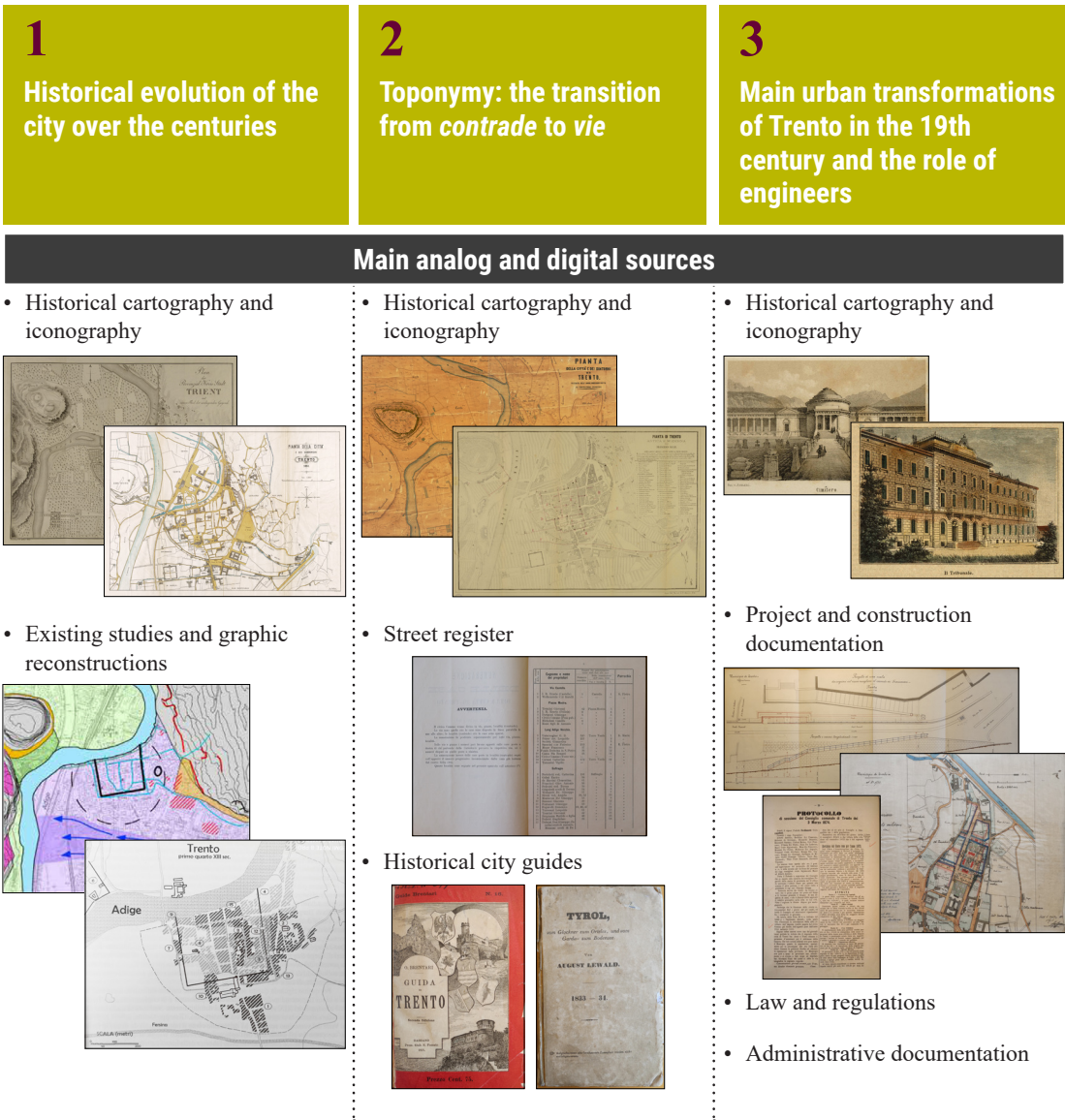
12. Museo Diocesano Tridentino, accessed May 1, 2026, <https://www.museodiocesano.tridentino.it/>.

13. “Tiroler Landesarchiv,” Land Tirol, accessed May 1, 2026, <https://www.tirol.gv.at/kunst-kultur/landesarchiv/>.

14. Giovanni Andrea Vavassore, *Tridentum Trient*, 1562 (British Library, Londra); Ludovico Sordani, *pianta prospettica di Trento*, 1660 ca. (Tiroler Landesarchiv, Innsbruck); Mappa della città di Trento, 1813 (BDTn, TG 1 a 1); Ph. Miller, *Plan der Provinzial Kreis Stadt Trient mit einem Theil der umliegenden Gegend*, 1822 (BDTn, TP e 187); Carlo Caminada, *Pianta della città di Trento e delle sue vicinanze, con tre proposte per il posizionamento della stazione*, 1851 (ASCTn, 3.8 - VII.366.1851); *Mappe catastali asburgiche d'impianto di Trento*, 1855 (Provincia autonoma di Trento, Esposizione storica del libro fondiario e del catasto di Trento); Carlo Perini, *Pianta della città di Trento*, 1868 (BDTn, T II k 136); Francesco Ranzi, *Pianta di Trento antica e moderna*, 1869 (BDTn, T II h 738); Francesco Ambrosi, *Pianta di Trento*, 1881 (BDTn, TG 2 f 23); Annibale Apollonio, *Pianta della città e dei sobborghi di Trento*, 1883 (BDTn, TG 2 a 06); Ottone Brentari, *Pianta di Trento*, 1890 (BDTn, T II k 1238); Annibale Apollonio, *Pianta della città e dei sobborghi di Trento*, 1891 (BDTn, TG 2 a 11); Annibale Apollonio, *Pianta della città e dei sobborghi di Trento*, 1902 (BDTn, TG 2 a 12).

15. Michele Bassetti, “*L'acqua disfa li monti e riempie le valli... Il ruolo dei processi fluviali nell'evoluzione del paesaggio urbano di Trento*,” in *Archeologia delle Alpi. Studi in onore di Gianni Ciurletti*, ed. F. Nicolis and R. Oberosler (Provincia Autonoma di Trento, 2018), 79-132; Cristina Bassi, “*Tridentum città romana. Osservazioni cronologiche sulla fondazione*,” in *Da Camunni a Romani. Archeologia e storia della romanizzazione alpina, atti del convegno (Breno-Civitate Camuno, 10-11 ottobre 2013)*, ed. S. Solano (Edizioni Quasar, 2017), 175-195; Bocchi and Oradini, *Le città nella storia d'Italia. Trento*; Emanuele Curzel, *Trento* (Fondazione Centro italiano di studi sull'alto medioevo, 2013).

Tab. 6.1 List of the main traditional and digital resources consulted during the historical and documentary research. For the investigation of architecture, the city, and the key figures involved, various archives and online resources were consulted.



tant phases of urban development, as well as the most significant architectural works and infrastructures that shaped the appearance of Trento during the historical periods considered¹⁶ [Fig. 6.6].

The research then focused on the nineteenth century, examining the evolution of the toponymy of streets, city gates, and neighborhoods. Through the study of historical cartography, historical city guides, and

Fig. 6.5 Documentary resources (both analog and digital) consulted for the three research areas: the urban evolution of the city across the centuries, the development of toponymy in the nineteenth century, and the city’s evolution along with the role of engineers.

16. About the historical evolution of Trento see also: Maragno and Volpi, “Lo sviluppo urbano di Trento dalle origini alla seconda metà dell’Ottocento”.

the street registers periodically compiled by the municipal administration, it was possible to identify a crucial shift in the system: namely, the transition from the use of the term *contrada* to *via*. This represents a significant change, reflecting the erasure of the boundary between 'inside' and 'outside' the city center following the demolition of the civic walls, alongside the renewed aspirations for modernity pursued by the administrations of the time.

This change was accompanied by transitions in other denominations. For example, the term *androne* had previously been used to indicate most of the city's narrow and winding alleys, often interspersed with connecting bridges between adjacent houses; *fossati* referred to small lanes characterized by the presence of a water channel; and *Vo* (or *passaggi del Vo*) designated the narrow passages leading from the main street to the Adige river¹⁷. Analysis of nineteenth-century historical maps provides a clear picture of this transition, which appears to have taken place between the 1870s and 1880s.

A similar transition is also evident in the house surveys and numbering documents of Trento from 1871¹⁸ and 1877¹⁹, which seem to confine the period of the formal shift from *contrada* to *via* to these years. In the subsequent 1890 document, the change appears to have been definitively consolidated, as the preface specifies the new definitions of the two terms: "*Vie* are those where the houses are arranged in parallel lines; *località (contrade)*²⁰ are those where the houses are scattered"²¹ [Fig. 6.7]. Finally, a survey was conducted on the major urban transformations that reshaped Trento during the nineteenth century, particularly following the straightening of the Adige river (1853-1859), which initiated the expansion of the old city. To the north, following the construction of the railway station (1855-1856)²², the administration realised the urbanization of the Centa district and the layout of the gardens (1869-1879)²³.

17. Aldo Bertoluzza, *Aria di Trento. Contrade, vicoli, androne, fossati, vo, antiche fiere e mercati* (Dossi, 1990), 10; Lamberto Cesarini Sforza, "Piazze e strade di Trento, 1896," ed. E. Fox, (U.C.T., 1991); Renzo Francescotti, *I rioni di Trento* (U.C.T., 1999), 68; Mauro Lando, *Trento nuova. Le sue strade, le sue storie* (Curcu&Genovese, 2018).

18. Coscrizione delle case del Comune Civico di Trento compilato a cura del cancellista municipale Demetrio Gerloni, Küpper-Fronza, Trento 1871.

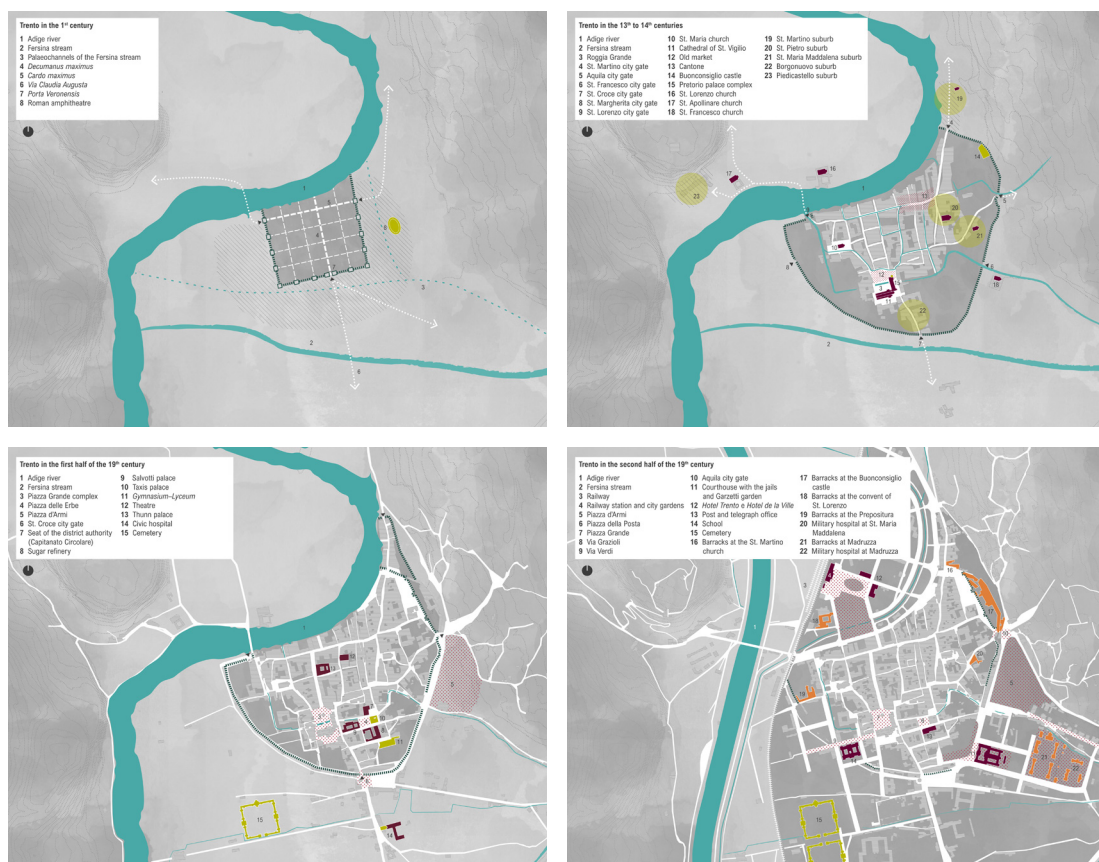
19. Coscrizione delle case del Comune Civico di Trento compilato a cura del dirigente l'uff. di controllo municipale Demetrio Gerloni, Küpper-Fronza, Trento 1877.

20. ASCTn, 3.8 - VII.88.1890.

21. Numerazione delle case della città di Trento nell'anno 1890 per cura del Municipio di Trento, 1890 (ASCTn, 3.8 - VII.88.1890).

22. ASCTn, 3.8 - VII.366.1851; ASCTn, 3.8 - VII.15.1855.

23. ASCTn, 3.8 - VII.148.1863; ASCTn, 3.8 - VII.32.1868; ASCTn, 3.8 - VII.91.1875.



To the west, the Briamasco area development plan (1888)²⁴ included the opening of via Vittoria (today via Verdi). To the south, a new street network was established connecting via Vittoria to the monumental cemetery, which was expanded in 1895²⁵. To the east, in the new Madruzza district²⁶, the central government relised barracks (1886)²⁷, a military hospital (1890)²⁸, the courthouse, and prisons (1881)²⁹, while in the area known as ‘ai Paradisi’, the civic engineer planned via Grazioli to accommodate the town’s bourgeois mansions³⁰ [Fig. 6.8]. More limited and targeted interventions took place within the historic city. Notable example include the covering of the roggia Grande in the-

Fig. 6.6 The main graphic reconstructions of Trento’s urban evolution. From top left, to bottom right: 1st century BCE, 13th-14th century, early 19th century, late 19th century.

[Maragno and Volpi, *Dove Trento si inegna*, 283-291]

24. Luigi Blanco and Elena Tonezzer, ed., *L’invenzione di via Verdi. Una strada di Trento tra Otto e Novecento* (Fondazione Museo Storico del Trentino, 2010).

25. ASCTn, 3.8 - VII.23.1884, ASCTn, 3.8 - VII.52.1897.

26. ASCTn, 3.8 - VII.162.1886.

27. ASCTn, 3.8 - X.40.1880; ASCTn, 3.8 - VII.10.1887.

28. ASCTn, 3.8 - X.40.1880.

29. ASCTn, 3.8 - VII.65.1858.

30. ASCTn, 3.8 - VII.73.1890.

The toponymy of Trento in nineteenth-century cartography				
Today	1891 Annibale Apollonio	1883 Annibale Apollonio	1869 Francesco Ranzi	1851 Carlo Caminada
				
Corso 3 Novembre	Via al Fersina	Stradone di Mattarello	Corso del Fersina	-
Corso M. Buonarroti	-	-	-	-
Largo G. Carducci	Piazza Macello Vecchio	Piazza Macello Vecchio Piazza della Posta Vecchia	-	-
Piazza A. d'Arogno	Piazza dietro il Duomo	Piazza dietro il Duomo	Piazza delle Legne	Piazza delle Legne
Piazza A. Vittoria	Piazza della Posta	Piazza della Posta	Piazza della Posta	-
Piazza C. Battisti	-	-	-	-
Piazza Dante	Piazza della Stazione	Piazza della Stazione	-	-
Piazza della Mostra	Piazza della Mostra	Piazza della Mostra	Piazza della Mostra	Piazza della Mostra
Piazza della Portella	Piazza alla Portella	Portella	-	-
Piazza delle Erbe	Piazza delle Erbe	Piazza delle Erbe	Piazza delle Erbe	Piazza delle Erbe
Piazza di Centa	-	-	-	-
Piazza di Fiera	Piazza di Fiera	Piazza di Fiera	Piazza della Fiera	Piazza di Fiera
Piazza del Duomo	Piazza Grande	Piazza del Duomo	Piazza Grande	Piazza Grande

Fig. 6.7 Excerpt from the table listing the street toponymy of Trento during the nineteenth century.

[Maragno and Volpi, *Dove Trento si ingegna*, 246-249]

Duomo square (1867)³¹ and the construction of the post and telegraph office building (1885-1889) next to the former sugar refinery³².

The documentary reconstruction of nineteenth-century Trento demonstrates that urban transformation was deeply embedded in administrative structures and professional practices. Whether large- or small-scale, all nineteenth-century interventions were examined with the aim of identifying the figures involved in the urban interventions and understanding their respective roles and responsibilities, namely civic engineers (*ingegneri civili*), employed by the the *Magistrato politico-economico* of Trento, and district engineers (*ingegneri circolari*), operating within the *Capitanato Circolare*. Civic and district engineers were central figures in this process, acting within a hierarchical yet dialogical system that connected municipal initiative to imperial regulation. Engineers were

31. ASCTn, 3.8 - VII.64.1867.

32. ASCTn, Capitanato Circolare, Trento, b. 562; BCTn, Fondo Dal Bosco, A/5/a/7; ASCTn, 3.8 - VII.7.1855; ASCTn, 3.8 - XV.15.1883; AVA, f.105; ASCTn, 3.8 - V.109.1885.

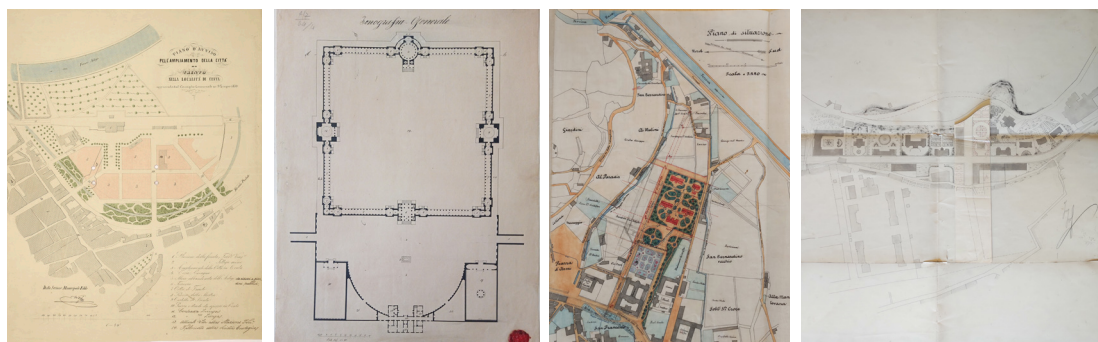


Fig. 6.8 Some of the main urban projects of the second half of the nineteenth century. From left to right: Ludovico Weiss, Piano d'avviso dell'ampliamento della città di Trento nella località di Centa [...]; Giuseppe Pietro Dal Bosco, Disegni del nuovo cimitero di Trento; Annibale Apollonio, Progetto di massima d'un ospedale militare da erigersi a Trento; Ludovico Weiss, Nuova via ai Mulini.

[ASCTn, 3.8 - VII.148.1863; BCTn, Fondo Dal Bosco, A/7/b/4; ASCTn, 3.8 - X.40.1880; ASCTn, 3.8 - VII.73.1890]



Fig. 6.9 Contea principesca del Tirolo e Vorarlberg, divisione politica, 1815.

[BDTn, GG 1 atc 30]

examined through correspondence, project and construction documentation, contemporary regulations and laws, in order to understand their education, duties, responsibilities, role, and career development. To this end, it was necessary to analyze these figures in relation to the political and administrative context of the time.

Throughout the nineteenth century, Trento was part of the Habsburg Monarchy, within the County of Tyrol [Fig. 6.9]. The Napoleonic interlude (1805-1814) introduced administrative and cadastral reforms, but it was with the Restoration and the 1814 reorganisation that the Austrian administrative structure was firmly re-established.

The “Notificazione” of 1814 reorganised the territory into *circoli* (districts), assigning to each a *Capitanato circolare* headed by a district captain and supported by technical personnel, including engineers³³ [Fig. 6.10].

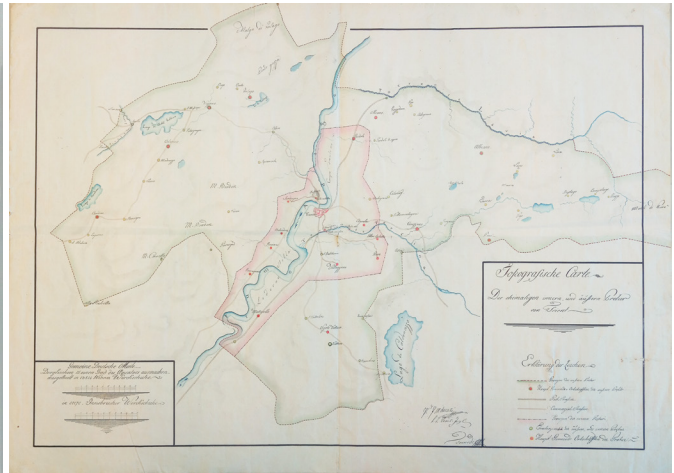
33. Maragno and Volpi, *Dove Trento si inegna*, 7-8.

Fig. 6.10 The political and administrative structure of Trento in 1814.



Fig. 6.11 Left: Gian Antonio Caminada (civic engineer), *Profilo al lungo del Canale da A in G* [...], 1830; right: Gian Maria Ducati (district engineer), *Carta topografica dell'ex pretura di Trento*, (1819-20?).

[ASTn, Carte e piante, no.50; ASTn, Carte e piante, no. 33]



According to the “Notificazione” of 1814, the district engineer oversaw road construction, hydraulic works, and bridges, ensuring that projects were appropriate, efficient, and economically executed. The office required advanced education, examinations in multiple technical areas,

and extensive apprenticeship³⁴. Civic engineers, in contrast, could initially be appointed with lower qualifications, sometimes resulting in the employment of individuals with limited expertise relative to the responsibilities assigned³⁵.

The 1839 designation of Giovanni Rossetti (1810-?)³⁶ as civic engineer formalized the role and expanded duties, which included the supervision of municipal buildings, churches, cemeteries, streets, fountains, public promenades, fire-fighting equipment, and the review of private building projects, with attention to public aesthetics³⁷. Civic engineers were assisted by a chief foreman and occasionally by apprentices, and district engineers were formally barred from intervening in municipal technical matters.

After 1850, following the suppression of the *Capitanato Circolare*³⁸, state intervention became increasingly confined to sectors considered strategically significant from a military and institutional perspective. Concurrent political reforms fostering greater local autonomy, reflected in the promulgation of municipal statutes, strengthened the decision-making role of the civic engineer in urban matters³⁹.

In 1863, the municipality established a building section tasked with maintenance, construction oversight, planning, and approval of municipal projects. Subsequent regulations (1870, 1896) further professionalized the office, establishing clear qualifications for engineers, inspectors, and assistants, while expanding duties to include urban planning, public health infrastructure, street cleaning, and supervision of private building proposals.

The study of these key figures in shaping the ‘modern city’ produced a complete list of all civic and district engineers who worked in Trento during the nineteenth century [Tab. 6.2 and 6.3], which complements the historical and documentary reconstructions of the major projects in

34. “Notificazione dell’i.r. Commissione aulica plenipotenziaria riguardante l’organizzazione provvisoria delle autorità politiche, e la determinazione dei principj generali per l’amministrazione interinale della parte italiana, ed illirica del Tirolo”, in *Raccolta delle leggi provinciali pel Tirolo e Vorarlberg per l’anno 1814*, v. I (Rauch, 1822), 156, 158, 166.

35. ASCTn, 3.8 – XI.1042.1839.

36. ASCTn, 3.8 - XI.1021.1840.

37. ASCTn, 3.8 – XI.3440.1843.

38. After this date, Offices for public constructions (*Uffici per le pubbliche costruzioni*) were established in the territories of the *Circoli* to manage public building works (“Dispaccio del Ministero del commercio, dell’industria e delle pubbliche costruzioni del 25 dicembre 1849,” in *Bollettino provinciale delle leggi e degli atti del Governo pel Tirolo e Vorarlberg* XIII (1850), 106-108).

39. Organamento del dicastero Magistratale, e considerazioni che ne avvalorano il progetto, presentato il 20 aprile 1863 e allegato ai protocolli di sessione del Consiglio comunale di Trento (ASCTn, 3.5).

which they played a leading role. Among these projects, the renewal of the Duomo square and its surroundings stands out as particularly emblematic, both for its socio-cultural significance and for the number of engineers involved in its transformation. For this reason, this site was chosen as a case study for the development of the integrated digital system *The Imaginary Map*.

Tab. 6.2 List of the principal engineers active in the *Magistrato politico-economico* of Trento.

[Maragno and Volpi, *Dove Trento si ingegna*, 61]

Main civic engineers in Trento during the 19th century		
Name	timeframe	role
Annibale Apollonio	1878 - 1891	hydraulic engineer
	1891 - 1911	civic engineer
Gian Antonio Caminada	1813 - 1839	civic engineer
Paolo Leonardi	1843 - 1870	civic engineer
Giovanni Rossetti	1840 - 1843	civic engineer
Ludovico Weiss	1870 - 1891	civic engineer

Tab. 6.3 List of the principal engineers active in the *Capitanato Circolare* of Trento up to 1850.

[Maragno and Volpi, *Dove Trento si ingegna*, 26-31]

Main engineers of the <i>Capitanato Circolare</i> in Trento until 1850		
Name	timeframe	role
Giuseppe Pietro Dal Bosco	1826 - 1836	assistant district engineer (<i>ingegnere aggiunto</i>)
Giuseppe Maria Ducati	1821 - 1822	district engineer
	1823 - 1840	district engineer and road commissioner (<i>commissario stradale</i>)
Dominikus Lachmann	1824 - 1838	roadmaster (<i>maestro stradale</i>)
	1839 - 1848	assistant district engineer (<i>ingegnere aggiunto</i>)
Joseph v. Leutner	1841 - 1848	assistant district engineer (<i>ingegnere aggiunto</i>)
Leonhard Liebener	1834 - 1838	assistant district engineer (<i>ingegnere aggiunto</i>)
Floriano Menapace	1839 - 1840	assistant district engineer (<i>ingegnere aggiunto</i>)
	1841 - 1849	district engineer
Joseph Meusburger	1849	assistant district engineer (<i>ingegnere aggiunto</i>)

06.2.1 In-depth study & experiences

The 19th-century renewal of the Duomo square in Trento

Research title	Historical and documentary research on Trento urban transformations and the role of engineers in the nineteenth century.
Coordinator	Cristiana Volpi ((DICAM, University of Trento).
Timeframe	November 2021 - December 2023
Dissemination	Cristiana Volpi and Anna Maragno, “Al servizio del Municipio. Il ruolo degli ingegneri civici a Trento nell’Ottocento Cristiana Volpi e Anna Maragno, Università di Trento,” oral presentation at <i>Patrimoni comunali e identità civiche nei comuni montani: una prospettiva di lungo periodo</i>, Fondazione Bruno Kessler, Trento, October 18-19, 2024. Anna Maragno and Cristiana Volpi, <i>Dove Trento si ingegna. Il ruolo degli ingegneri nello sviluppo della città di Trento nel corso del XIX secolo</i> (Edizioni Efesto, 2023). Anna Maragno and Cristiana Volpi, “Il ruolo degli Ingegneri Circolari e degli Ingegneri Civici a Trento nella prima metà dell’Ottocento,” in <i>History of Engineering/Storia dell’Ingegneria. Proceedings of the 5th International Conference/Atti del 9° Convegno Nazionale</i> (Cuzzolin, 2022): 613-626.

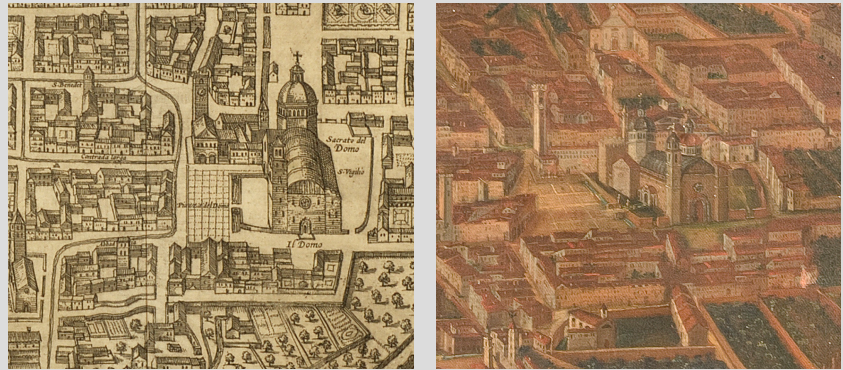
The renewal of the Duomo square

As the seat of religious, civic, and commercial functions, the Duomo square has represented the focal point of urban life since Late Antiquity. Based on documentary and iconographic sources¹, the spatial configuration of piazza Grande (now piazza Duomo) appears, from its very origins, to have been clearly divided into two distinct sectors: a religious one, adjoining the northern façade of the cathedral, and a civic one, opening toward the city’s principal *contrade* [Fig. 6.12]. The boundary between these two spatial and functional domains was marked by the presence of the roggia Grande, the most significant of the canals that ran extensively through the city until the nineteenth century.

Prior to the nineteenth century, the principal interventions affecting this urban space date back to the 1530s, when Bernardo Cles (1485-

1. Michelangelo. Mariani, *Trento con il Sacro Concilio et altri notabili. Description’ Historica. Libri tre. Con un Ristretto del Trentin Vescovato; l’Indice delle Cose notabili, et le figure in rame*, (1673, ripr. anastatica 1989), 14.

[BDT_n, TI 1 e 047;
MDT_n]



At the dawn of the nineteenth century, however, the appearance of piazza Grande and the areas surrounding the cathedral, such as Adamo d'Aragno square, does not seem to have differed significantly from that depicted in seventeenth- and eighteenth-century engravings, except for a pronounced state of neglect and deterioration. This condition was partly due to the gradual raising of the ground level of the square, caused by the long-standing presence of cemeteries adjacent to the northern and southern sides of the church [Fig. 6.13].

[BDTn, TC I a 002;
BDTn, TI 1 f 151]



- 309

The first concrete initiative aimed at reorganizing piazza Grande dates to the 1820s and forms part of a broader and more structured program for the renewal of the city's squares and streets⁵. At the local level, this program was coordinated by the district engineer Giuseppe Maria Ducati (1778-1858) and the civic engineer Gian Antonio Caminada (1776 ca.-1845).

In November 1828, work began on lowering the ground level of the former religious sector of the square⁶, but progress was slow: by December 1830, excavation had affected only a few meters between the sacristy entrance and the northern entrance⁷. During this period, Caminada was tasked with studying and drafting a plan for managing water drainage in the former cathedral cemetery [Fig. 6.14]. This plan, ultimately concerning the entire square, was implemented only between the autumn of 1832 and the spring of 1833⁸. Following the ground-lowering works, in April 1833 the civic engineer was commissioned to survey the new level of piazza Grande. On this basis, the assistant engineer Giuseppe Pietro Dal Bosco (1798-1880) was to determine the 'appropriateness' of renewing the paving⁹.

The events surrounding this episode highlight the often tense relations between the two local offices responsible for urban and building matters: on the one hand, the technical office of the *Capitanato Circolare*; on the other, that of the *Magistrato politico-economico* of Trento. Caminada's rather rough and approximate leveling proposal provoked a strong reaction from Dal Bosco, who, upon reviewing the submitted drawings, declared:

«Debbesi poi meravigliarsi, come al Sig. Ingegnere Civico [...] sia sfuggito di omettere simili dettagli suggeriti dalla convenienza e dall'arte molto più che il medesimo dovrebbe in simile materia già essere quanto basta istruito almeno per pratica, e che egli stesso dovrebbe conoscere quali esperimenti si debbano prendere a si fatte importanti operazioni. Rincesce quindi doversi ritardare l'esecuzione, ed opinare che l'Inclito Capitanato Circolare voglia respingere l'elaborato al Lod. Magistrato Civico coll'ordine di farlo in regola riformare»¹⁰.

5. ASCTn, 3.8 - XI.60.1829.

6. ADTn, 1828, book B (285), no. 3630.

7. ASTn, Carte e piante, no. 50.

8. ASCTn, 3.8 - XI.65.1833.

9. ASTn, Capitanato Circolare, Trento, b. 538.

10. "It is indeed surprising that the Civic Engineer [...] should have overlooked such details, which are dictated by both practical considerations and professional expertise, and which he ought, in a matter of this kind, to be sufficiently acquainted with - at least through experience. He should himself be aware of the procedures required for undertaking such important operations. It is therefore regrettable that the execution must be delayed, and it is to be expected that the Illustrious Cap-

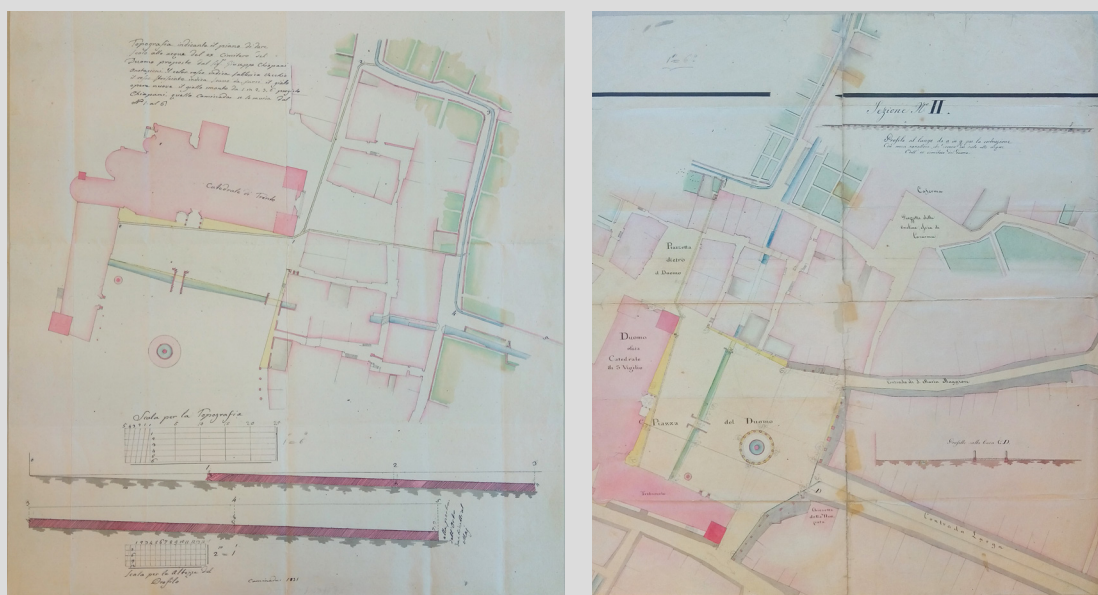


Fig. 6.14 Left: Gian Antonio Caminada, *Topografia indicante il piano di dare scolo alle acque del ex Cimitero del Duomo* proposto dal sig. Giuseppe Chiapani, 1831; right: Sezione n. II – Profilo al lungo da A in G per la costruzione dei nuovi canalloni, che devono dar scolo alle acque dell'ex Cimitero del Duomo.

[ASTn, Carte e piante, no. 50]

The matter was resolved a few months later, on 18 July, with the submission of revised leveling drawings, this time compliant with the requirements of the *Capitanato Circolare*'s technical office.

Despite the large number of projects for the renewal of piazza Grande, it is not possible to identify with certainty either the final version or the author of the plan submitted in the autumn of 1833 to the *Direzione provinciale delle pubbliche costruzioni* in Innsbruck for final review¹¹ [Fig. 6.15]. Equally controversial is Dal Bosco's decision, in December of the same year - while the *Direzione provinciale*'s evaluation was already underway - to propose a variant of the project to the *Magistrato politico-economico*. This variant included a paved area of white and red stone slabs around the Neptune Fountain¹² [Fig. 6.16]. Despite initial concerns about costs, the proposal was approved on 10 July 1834, to be financed through "voluntary contributions"¹³.

Construction, which began only in May 1835, was completed in January 1840, approximately twelve years after the initial excavations¹⁴.

itanato Circolare will return the proposal to the Honourable Municipal Authority with instructions that it be properly revised" (ASTn, Capitanato Circolare, Trento, b. 538).

11. ASCTn, 3.3, Protocollo del Consiglio del Magistrato politico-economico di Trento dei 26 ottobre 1833.

12. ASCTn, 3.3, Protocollo del Consiglio del Magistrato politico-economico di Trento dei 20 dicembre 1833.

13. ASCTn, 3.3, Protocollo del Consiglio del Magistrato politico-economico di Trento dei 10 luglio 1834.

14. ASCTn, 3.8 - XI.307.1840, p. no. 78, January 7, 1840.



Fig. 6.15 Trento, Pianta della piazza Grande con progetto di riforma della medesima.

[BCTn, Fondo Dal Bosco, A/5/a/4]

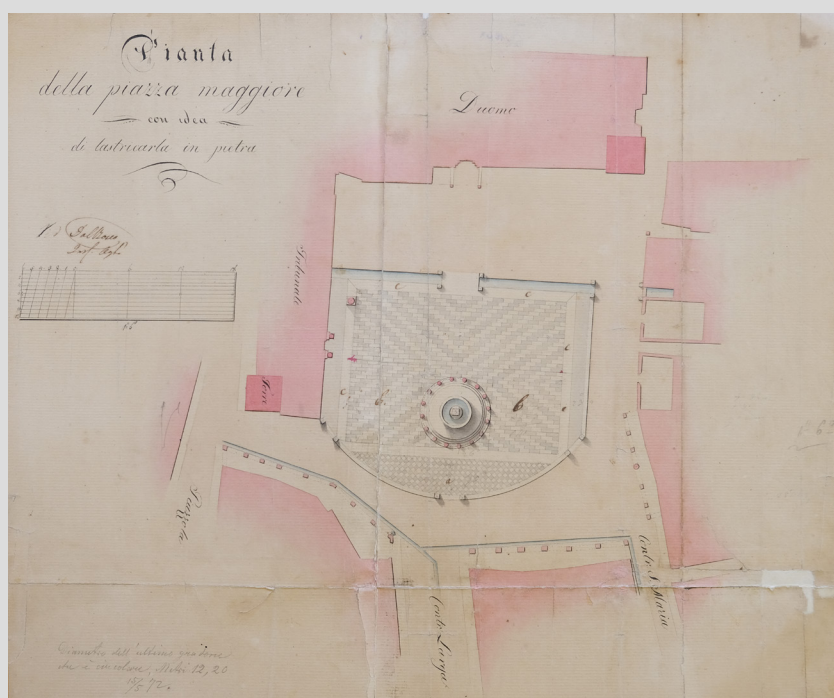


Fig. 6.16 Giuseppe Pietro Dal Bosco, Pianta della piazza Maggiore con idea di lastricatura in pietra, [1833-35?]

[ASCTn, 3.8 - XI.363.1843]

However, the absence of documentary and iconographic evidence suggests that the stone paving around the Neptune Fountain was never actually realized. It is likely that Dal Bosco's transfer in 1837, or the need to complete the project, led the *Magistrato* to abandon the plan to raise funds for the stone paving.

The square underwent further interventions only from the mid-nineteenth century onward, notably with the construction in 1850 of a fountain

near casa Rella¹⁵. The project, initially entrusted to the civil engineer Carlo Caminada (son of Gian Antonio)¹⁶, who proposed economically unfeasible solutions, was soon reassigned to the civic engineer Paolo Leonardi (1810-1891). He developed two “extremely simple” designs: one incorporating the Trentino eagle from the well of the small square of San Pietro, and another surmounted by a cast-iron sculpture depicting the Bowl of Aesculapius¹⁷. On 26 March 1850, the Civic Council unanimously approved a third solution proposed by Leonardi, combining the use of the Trentino eagle from the first design with the simplicity, sobriety, and cost-effectiveness of the second [Fig. 6.17].

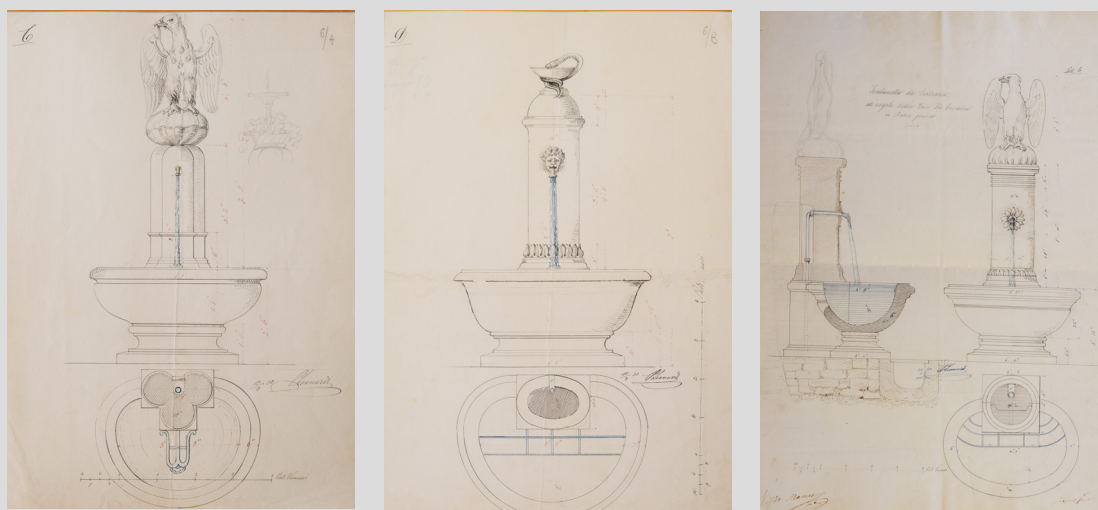


Fig. 6.17 Paolo Leonardi, Fontanella da collocare all’angolo della Casa Fu Ceschi in Piazza grande, 1850.

[ASCTn, 3.8 - XI.308.1850]

In the following years, one intervention above all was destined to transform the centuries-old structure of the square: the covering of the roggia Grande. Its approval in January 1867 definitively sanctioned the burial of the canal and, with it, the physical and visual unification of the two sectors of the square¹⁸. However, the intervention appears to have been motivated less by a desire for ‘unification’ than by the intention to render the canal unusable for laundry purposes¹⁹. Indeed, the initial project, devised by Leonardi in June 1867, envisaged only a partial covering of the canal with stone slabs, while leaving some sections open

15. The designation ‘casa Rella’ refers to the two arcaded houses at the entrance of present-day Via Belenzani, particularly renowned for their richly frescoed façades. Over the centuries, however, these buildings have been known by various names, including ‘case al Duomo’ and ‘Cazuffi’.

16. ASCTn, 3.8 - XI.308.1850.

17. ASCTn, 3.8 - XI.308.1850.

18. ASCTn, 3.5, Protocollo del Consiglio comunale di Trento dei 19 gennaio 1867.

19. ASCTn, 3.8 - VII.64.1867.

and enclosing them with “stone posts fitted with iron bars and chains”²⁰ [Fig. 6.18 a].

Leonardi’s proposals, along with a second project by the engineer and architect Tamanini²¹, were suspended in September 1867, when the City Council decided instead to cover the Roggia Grande with vaulting and paving²². It remains unclear what occurred between September 1867 and November 1869, when the Municipal Council resolved to complete the covering of the canal in the Duomo square with stone slabs²³ [Fig. 6.18 b].

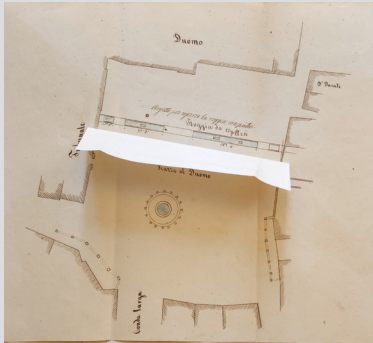


Fig. 6.18 Left: (a) Paolo Leonardi, Progetto di copertura della roggia in piazza del Duomo, 1867; right: (b) C. Bernard, Albert Toller, Der Dom in Trient (Nordwest-Seite), 1884.

[ASCTn, 3.8 - VII.64.1867; BDTn, T II k 1706]

The renewal of the Adamo d'Arogn square

In the early 1840s, piazza della Legna (now piazza Adamo d'Arogn) was in a state of deterioration, with an uneven surface and no paving. In 1841, the civic engineer Giovanni Rossetti prepared a project to lower and pave the square and the area in front of the cathedral, also proposing a system of connections with the street behind it through steps and railings²⁴ [Fig. 6.19].

Although the project was approved and construction began, the works were delayed by conflicts between municipal technicians and those of the *Capitanato Circolare*. In 1942, the district engineer Floriano Menapace proposed several modifications, particularly concerning the design of the steps and the railing, which were opposed by Rossetti, who defended the functionality and aesthetic coherence of his original plan. After a series of revisions and disputes, a final solution was reached

20. ASCTn, 3.8 - VII.64.1867, p. no. 2847.

21. ASCTn, 3.8 - VII.64.1867, p. no. 2847, July 11, 1867).

22. ASCTn, 3.5, Protocollo di sessione del Consiglio comunale di Trento del 12 settembre 1867.

23. ASCTn, 3.8 - VII.64.1867.

24. ASCTn, 3.8 - XI.363.1843, Giovanni Rossetti, Analisi dei prezzi unitari dei varj materiali e lavori occorrenti nell'abbassamento e lastricato della Piazza della Legna e Piazzetta Terlagio [...], February 24, 1842.

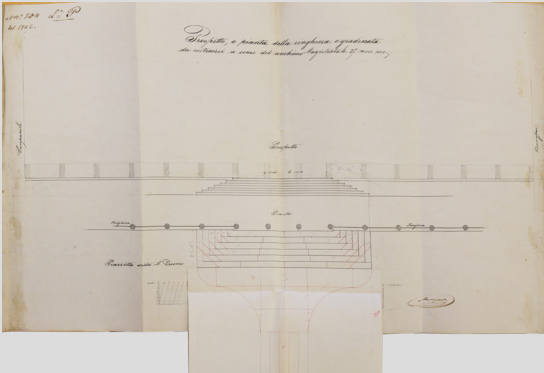
Fig. 6.19 Giovanni Rossetti, Floriano Menapace, Planimetria della Piazza delle Legne, e della Piazza Terlago aderenti alla Cattedrale di questa Città con Progetto di Abbassamento, 1841.

[ASCTn, 3.8 - XI.363.1843]



Fig. 6.20 Left: Floriano Menapace, Prospetto, e pianta della ringhiera e gradinata da costruirsi a senso del conchiuso Magistratale 27 mese corr., 1842 (?); right: Basilio Armani, Duomo di Trento, 1868.

[ASCTn, 3.8 - XI.363.1843; BDTn, T II k 0136]



thanks to the superior intervention of the *Fabbriceria della chiesa Cattedrale*, which determined the alignment of the railing²⁵ [Fig. 6.20]. The works were completed in 1842.

Further interventions in the area took place only in the 1880s, as part of a broader phase of urban expansion promoted by the municipal administration under the leadership of Podestà Paolo Oss Mazzurana²⁶. A new street, via Alessandro Vittoria (now Via Verdi) was opened in connection with the development of the Briamasco area²⁷. This led to significant demolitions, including medieval buildings and sections of the city walls, ultimately resulting in the permanent disappearance of piazza Terlago, located in front of the western entrance of the Duomo.

25. ASCTn, 3.8 - XI.363.1843, p. no. 2574, June 5, 1842.
 26. Luigi Blanco, "Un Comune 'imprenditore'. Trento nell'età di Paolo Oss Mazzurana," in *L'invenzione di via Verdi. Una strada di Trento tra Otto e Novecento*, ed. L. Blanco and E. Tonzzer (Fondazione Museo Storico del Trentino, 2010), 16-17.
 27. ASCTn, 3.5, Protocollo di Sessione di Sessione del Consiglio comunale di Trento dei 25 gennaio 1884.

06.3 Geometric data acquisition: survey of palazzo Pretorio and the Duomo area

Alongside the historical and documentary research on the Duomo area, some urban survey campaigns were carried out between 2022 and 2024. A first architectural survey campaign focused on Palazzo Pretorio, a site of major importance for the political and religious life of the city over the centuries, while a second acquisition campaign - this time at the urban scale, as discussed in chapter 4 - was conducted in the main squares surrounding the Duomo.

The research on palazzo Pretorio [Fig. 6.21] started in 2021 by the Museo Diocesano Tridentino in collaboration with the Department of Literature and Philosophy and the Departments of Civil, Environmental and Mechanical Engineering (DICAM) of the University of Trento, the Biblioteca Comunale, the Archivio Storico del Comune di Trento, and the Superintendency of Cultural Heritage. The investigation was aimed at reconstructing and interpreting the various transformations of the building over time by means of an accurate digital survey, the study of construction stratifications, and the analysis of archival sources¹.



Fig. 6.21 Left: view of the west façade of palazzo Pretorio from the Duomo; right: view of the square from the Duomo.

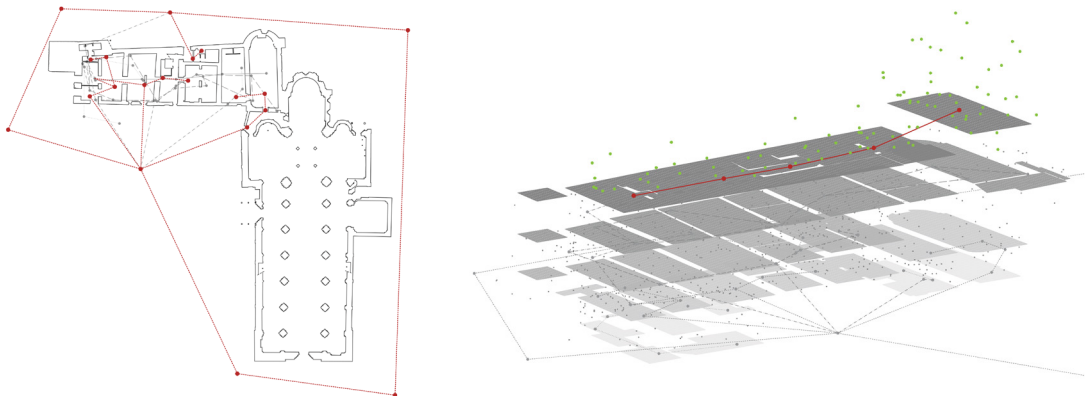
1. Giovanna A. Massari, "Rilievo geometrico e rappresentazione digitale," in *Palazzo Pretorio. Da residenza vescovile a sede del Museo diocesano tridentino: una storia plurisecolare*, ed. M. Anderle, F. Cagol, E. Possenti, and A. Quendolo (Publistampa Edizioni, 2024), 58-81.

"The data acquisition campaign at Pretorio palace involved the dialogue between several traditional and digital survey methods², intending to produce a 3D geometric model useful for historical and archaeological investigations of the building". The objective was to develop a comprehensive and multi-source dataset capable of supporting different levels of representation and analysis, from 2D drawings to advanced 3D and parametric models.

"The progressive introduction of technologically advanced instrumentation has not changed, over the years, the essence of surveying activity. Its primary purpose remains to discretise continuous, identifying the salient, evident, and remarkable points of reality, and reproducing, with a limited number of signs, the object of study. From this perspective, range-based and image-based techniques are not aimed at merely replicating reality but rather at acquiring a greater quantity and density of data. Therefore, the construction of a reference system – through a topographic network – is mandatory and allows a dialogue between surveying solutions, the correlation between acquired data, and ultimately the reconstruction of geometric figures in a representation model [...]. The topographic network, consisting of 54 polygonal vertices and approximately 1,500 object points, served as the framework for referencing data obtained through range-based and image-based methods. Consequently, natural points were identified before the photo and laser-scanning operations and markers were affixed, which were then acquired with the total station Topcon GPT 1001 [Fig. 6.22]"³.

Fig. 6.22 Left: plan of the topographic network on the ground floor; right: axonometric view of the topographic network on the third floor and the approximately 1,500 object points.

[Massari, "Rilievo geometrico e rappresentazione digitale," 62]



2. The described experience took place in the LAMARC Laboratory of Architectural Modelling and Analysis Representation and Communication of the University of Trento (scientific coordinator G.A. Massari).

3. Ambra Barbini, Francesco Giampiccolo, Anna Maragno, Giovanna A. Massari, and Cristina Pellegatta, "Innovation and tradition: integrated practices in the architectural survey of Pretorio palace in Trento," *SCientific RESearch and Information Technology Ricerca Scientifica e Tecnologie dell'Informazione*, v. 14, i. 1 (2024): 47, <http://dx.doi.org/10.2423/i22394303v14n1p45>.

In parallel, a range-based and image-based digital survey was carried out, generating large amounts of 3D data and enabling an accurate simulation of reality. The external façades and interior spaces across the building's five floors were surveyed using a static laser scanner (Faro Focus S120), resulting in a total of 138 scans of the interiors and 34 of the exteriors. Acquisition parameters were set to a resolution of $\frac{1}{4}$, quality 2×, and 10,240 points per 360°. In areas that were difficult to access, the laser scanner was complemented by tablet-based surveying using an iPad Pro equipped with a LiDAR sensor, enabling the documentation of confined or cluttered spaces such as narrow hatches and attics.

The TLS data were recorded and processed in Faro Scene, where scans were aligned and georeferenced to the topographic network with an error margin of less than 1 cm. The point clouds were then processed in CloudCompare to remove noise and redundant data for graphic restitution. Finally, the cleaned datasets were exported in .e57 format, converted into .rcp using Autodesk ReCap, and imported into AutoCAD for the production of the main architectural drawings, including plans and sections [Fig. 6.23].

Photogrammetry was used to survey the building's exterior and the interior sacristies, focusing on painted surfaces and exposed masonry. Data were acquired using a DJI Mavic 2 Pro UAS and a Microgeo 3Deye system equipped with a Sony Alpha 6000 DSLR mounted on a 9-metre telescopic pole. A total of 390 images were captured indoors and 690 outdoors, then processed in Agisoft Metashape to generate dense point clouds with an accuracy comparable to laser scanning (approximately 2 mm/pixel) [Fig. 6.24]. The resulting point clouds were used to produce façade orthomosaics with resolutions up to 1 mm/pixel and were systematically organised to ensure data traceability and interoperability. Between April and September 2022, a traditional survey campaign was also carried out, providing a valuable complement for the correct understanding of the building and its components. This phase of the research involved students from the third-year course "Architectural Survey with Design Workshop" at the University of Trento⁴. For the acquisition phase, "various analogue and electronic tools have been made available, such for example self-levelling crossline laser and traditional levels to define horizontal and/or vertical planes, carpenter squares and plumb lines to verify perpendicularity between elements, and measu-

4. Massari, "Rilievo geometrico e rappresentazione digitale," 64-65.

Fig. 6.23 The point cloud management phase; clockwise direction: recording, editing, converting, and modelling/ drawing.

[Barbini et al.,
"Innovation and
tradition," 49]

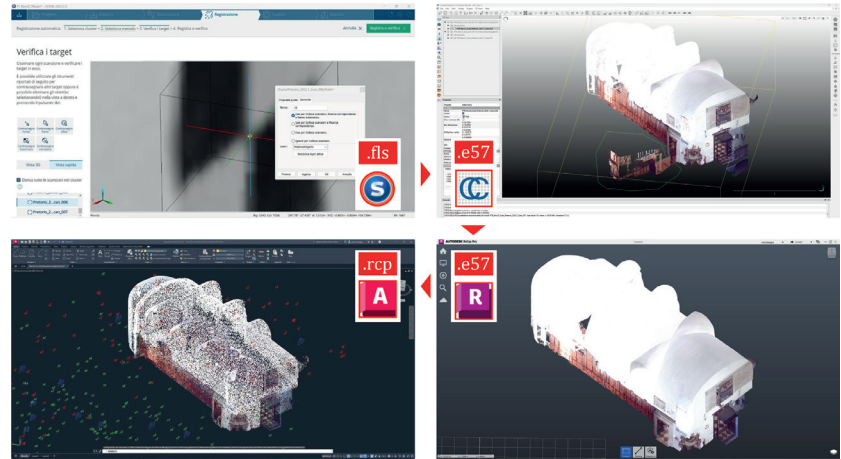
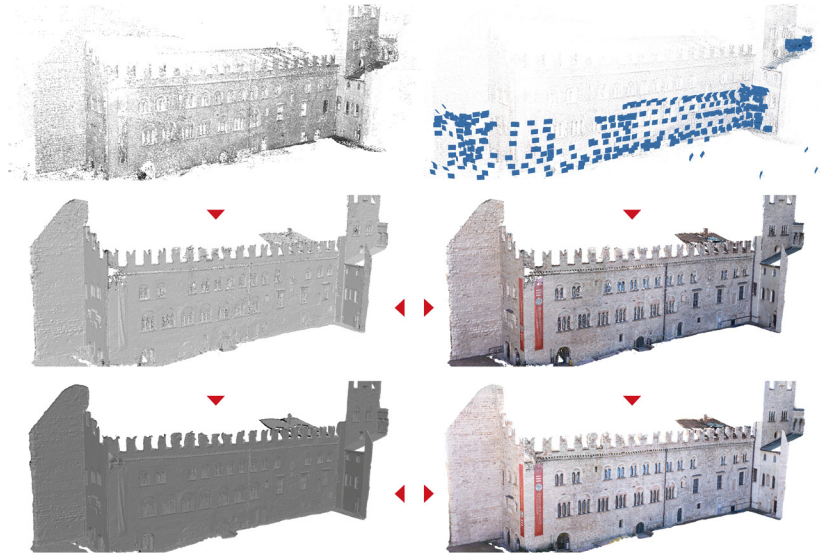


Fig. 6.24 From top to bottom: sparse cloud (stand-alone, left; with photographs, right), dense cloud (not coloured, left; coloured, right), surface model (mesh, left; textured mesh, right).

[Barbini et al.,
"Innovation and
tradition," 49]



ring tape rulers to acquire linear measurements, needle profilograph for detail elements and DSLR camera for digital photographs [...]. The synthesis of survey data was obtained through the development of a 3D through-section model, based on the representation, for each surveyed space, of at least one horizontal and vertical section intersected orthogonally with each other in a 3D virtual modelling space. This model serves not only as a comparison tool to validate all the collected data but also for the integration of further data”⁵.

The study produced two complementary 3D models: a plane-based

5. Barbini et al., “Innovation and tradition,” 53.

digital restitution model and a semantic HBIM model. Both organise survey data into structured systems for interpreting and communicating architectural knowledge, though with different aims. The 3D plane-based model, developed in a CAD environment, integrates data from laser scanning, photogrammetry, and traditional surveys to reconstruct the building through coordinated horizontal and vertical sections. Built at a 1:1 scale, it formalises the interpretative drawing process and produces standard architectural outputs (plans, sections, elevations). In this approach, graphic representation is central: drawing acts as a synthesis of knowledge and a neutral outcome of different survey techniques, regardless of the acquisition method [Fig. 6.25].

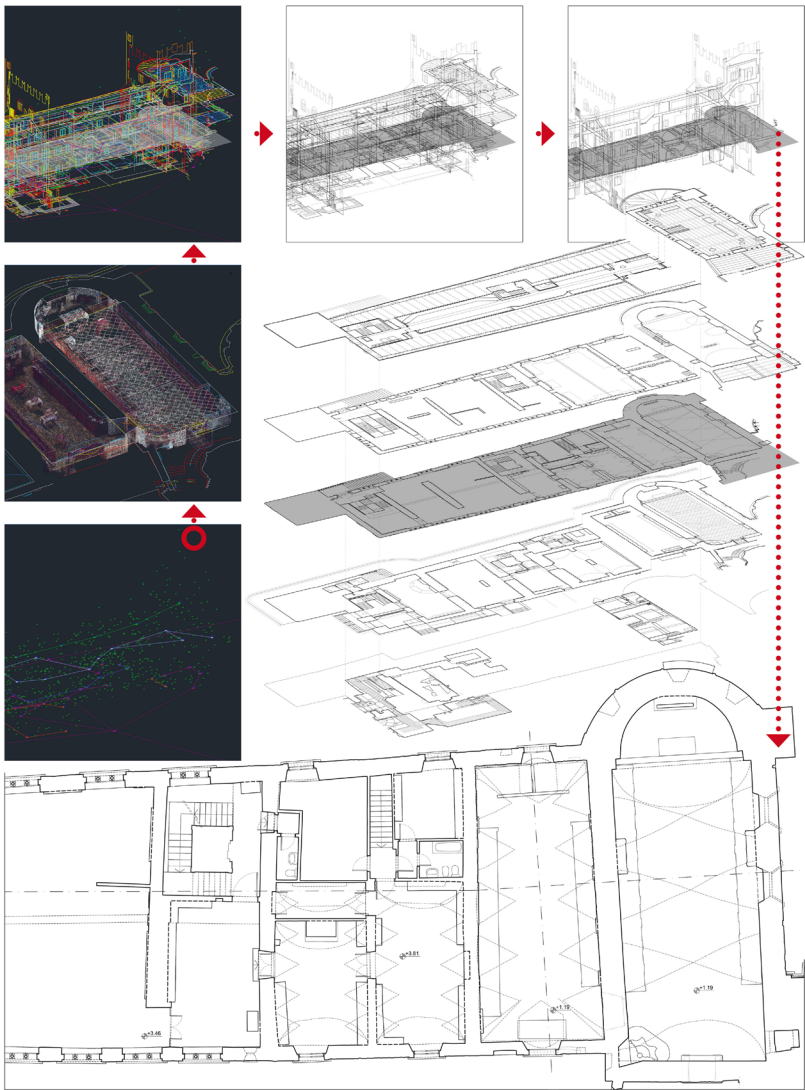


Fig. 6.25 The construction process of the 3D digital model by planes: from the topographical points to the line drawing.

[Barbini et al., "Innovation and tradition," 56]

The HBIM model, instead, focuses on semantic enrichment using Autodesk Revit and a selected portion of the building. Starting from point clouds, it decomposes the structure into parametric elements (walls, floors, openings, vaults), with more complex geometries derived from point-cloud sections and auxiliary drawings. Additional parameters (e.g., Modelling Source) ensure transparency and traceability of the data, while the model is designed to evolve with further research contributions [Fig. 6.26].

Despite their differences, both models integrate measurement, interpretation, and representation, confirming that graphic communication remains the final and unifying stage of the survey process.

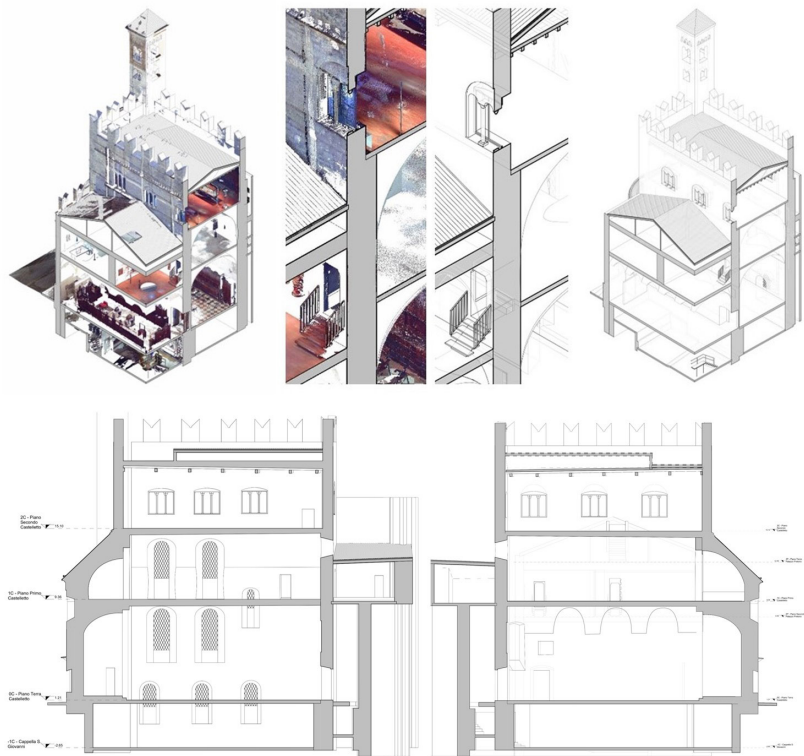


Fig. 6.26 From top to bottom: Heritage Building Information Model development based on the point cloud from digital 3D survey, extraction of vertical section and visualisation of information associated with single components.

[Barbini et al., "Innovation and tradition," 58]

The second survey campaign, aimed at collecting geometric data for the project's case study, was carried out at the urban scale in the area surrounding the Cathedral, specifically in Duomo square and Adamo d'Arogno square.

As discussed in Chapter 4 of this thesis, the urban survey campaign was conceived as an experimental activity to test low-cost image-based and range-based instruments, namely a spherical camera (Ricoh Theta V) and a tablet equipped with a LiDAR sensor (Apple iPad Pro). The

workflow was defined as ‘low-cost’ not only due to the affordability of the sensors compared to TLS systems, but also because it required reduced time and resources during data acquisition, and relied largely on open-source software or tools with free/educational licenses, producing open file formats⁶.

Data acquisition and processing followed two distinct procedures, reflecting different survey objectives [Fig. 6.27]. The spherical camera was used to capture large portions of space through video acquisition. After stitching the videos using the RICOH THETA desktop application, they were imported into Agisoft Metashape Professional, where they were split into frames. The spherical photogrammetry workflow then followed standard procedures for HDR panoramic images: camera calibration, image alignment, and dense point cloud generation at high accuracy. The resulting models were scaled using the bar scale method, based on known distances between reference points.

The LIDAR-equipped tablet was instead employed for detailed surveys of small urban elements, such as fountains, stairways, and railings. Data acquisition was performed using the 3D Scanner App, with advanced LIDAR settings and high-resolution mode. Scans were carried out by slowly moving around the objects at a distance of approximately 1.3-1.5 metres, avoiding redundant coverage. The application also enabled automatic processing, including texturing, and allowed export of coloured point clouds in formats compatible with open-source software such as CloudCompare.

Fig. 6.27 Low-cost digital survey campaign. Left: use of the Ricoh Theta V for acquiring Duomo square; right: use of the Apple iPad Pro for acquiring the staircase in Adamo d’Arogno square.

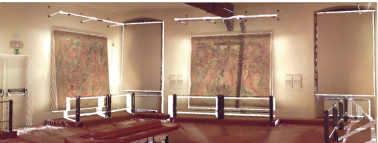
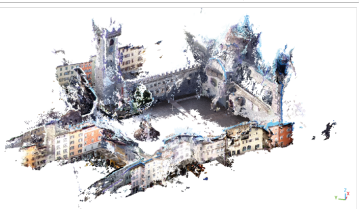
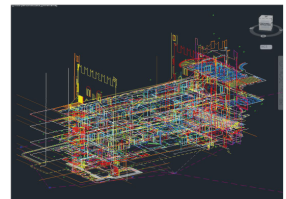
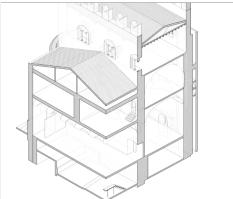


6. Chiara Chioni, Anna Maragno, Angelica Pianegonda, Marco Ciolli, Sara Favargiotti, and Giovanna A. Massari, “Low-Cost 3D Virtual and Dynamic Reconstruction Approach for Urban Forests: The Mesiano University Park,” *Sustainability* 15, no. 19 (2023), <https://doi.org/10.3390/su151914072>.

In parallel with these experiments, the entire area was also surveyed using a mobile mapping system (MMS), specifically the Lixel X1 laser scanner, in a single acquisition carried out along a continuous path at a slow and constant speed.

In conclusion, the results of the survey campaign of palazzo Pretorio that can be shared as digital resources through *The Imaginary Map* include the 2D vertical and horizontal sections of the building, façade orthomosaics, the 3D point cloud model, the 3D model by planes, and the parametric HBIM model. By contrast, the outcomes of the urban survey campaign consist of 3D point cloud models at different levels of detail [Fig. 6.28].

Fig. 6.28 Overview of all outcomes of the survey campaigns on Pretorio palace and the Duomo area that can potentially be shared through the project's web platform.

Digital survey of palazzo Pretorio			Digital survey of Duomo area		
range-based tools	image-based tools		range-based tools	image-based tools	
Faro Focus S120	DJI Mavic 2 Pro	3D eye system	iPad Pro with LIDAR sensor	Lixel X1	Ricoh Theta V
main outcomes: potential digital resources for <i>The Imaginary Map</i>					
2D sections		2D orthomosaics (detail and architectural scale)		3D point cloud model (detail and urban scale)	
					
3D point cloud model					
3D model by planes		3D parametric model			
					

06.4 Data processing and management: from digital resources to digital records through FAIR principles and LOD methodologies

The historical information and geometric data - respectively derived from documentary research and from the survey campaign - constitute the core body of knowledge upon which *The Imaginary Map* project is developed. These materials represent the primary dataset, the raw evidence from which the narrative of nineteenth-century Trento has been constructed. At the same time, their analysis, structuring, and dissemination have acted as a guiding framework for the entire project, shaping both its conceptual orientation and its methodological approach.

In their initial form, the data can be considered raw. In order to qualify as digital records, according to the definition provided in chapter 05 of this thesis, they must be systematically structured and enriched through detailed descriptive information¹. Only through this process digital resources can acquire documentary value, thereby becoming potential historical sources for the built heritage.

The description of the data has been carried out on two complementary levels. On the one hand, individual data items were described where possible; on the other hand, the data were organized and documented at the dataset level according to the main research directions, namely the historical evolution of Trento across the centuries, the transformation of toponymy during the nineteenth century, and the main urban transformations of the city, including the role of engineers in this process.

The resulting datasets have been designed according to FAIR principles, ensuring long-term accessibility, interoperability, and reusability through standardized metadata and open dissemination practices. In parallel, their publication strategy adopts Linked Open Data (LOD) principles, enabling semantic integration and interconnection of data through explicit modeling of entities and relationships [Fig. 6.29].

Publishing datasets within a combined FAIR and LOD framework significantly enhances their scientific and technological value beyond traditional open data approaches. While FAIR principles ensure that data are Findable, Accessible, Interoperable, and Reusable through persistent

1. Istituto centrale per la digitalizzazione del patrimonio culturale - Digital Library, *Economic. Ecosistema digitale per la cultura. Report di inquadramento concettuale* (2025), 34-35, https://digitallibrary.cultura.gov.it/wp-content/uploads/2025/09/Ecomomic_Report-di-inquadramento-concettuale_v1.0.pdf.

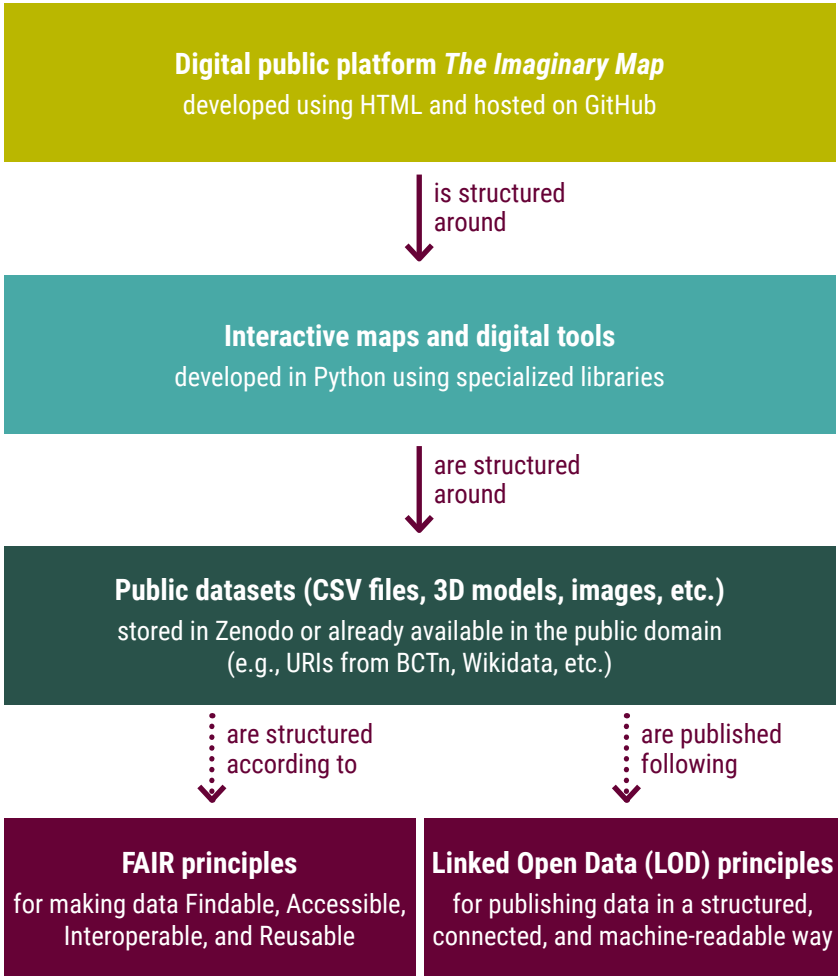


Fig. 6.29 Diagram of the project structure from a data organization perspective.

identifiers, rich metadata, and standardized formats, LOD introduces a deeper semantic layer that enables the explicit representation of entities, relationships, and contextual information using shared vocabularies and ontology-based structures. By assigning dereferenceable URIs to entities and expressing relationships through RDF-based models, the dataset becomes part of the broader Web of Data, enabling integration with external knowledge graphs such as Wikidata, GeoNames, and other domain-specific resources. This level of semantic interoperability supports advanced forms of cross-dataset querying, dynamic linking, and automated data enrichment, thereby reducing the complexity and cost of data integration².

2. Tatiana Petrova, Boris Bliznioukov, Aleksandr Puzikov, and Radu State, “From Semantic Web and MAS to Agent AI: A Unified Narrative of the Web of Agents,” *ArXiv*, no. 2507 (2025),

Moreover, the combined adoption of FAIR and LOD principles enhances machine-actionability, allowing computational systems not only to access and retrieve data, but also to interpret and reason over their semantic structure, thus supporting inference and knowledge discovery. To ensure the highest possible compliance with FAIR principles, the datasets were made publicly available through Zenodo, a general-purpose repository that allows users to share a wide range of research outputs³. Zenodo stores data in the Data Centre of CERN and is developed and operated by CERN and OpenAIRE to support Open Science. Each upload is assigned a Digital Object Identifier (DOI), making it citable and traceable, and datasets can be easily updated thanks to a built-in versioning system. The platform is also closely integrated with GitHub⁴, which was used in this thesis to share the code of the web platform *The Imaginary Map*. GitHub is a cloud-based service that enables users to store, share, and collaboratively develop code through repositories, facilitating change tracking, code review, and teamwork via the open-source version control system Git⁵.

The datasets published on Zenodo served as the foundation for creating interactive narratives about the history of Trento, each focused on a different theme. In line with the principles of Digital Public History, an interactive experience was developed for each topic to explore and deepen specific aspects of the data. The three datasets underlying these narratives are [Fig. 6.30]:

- *Historical Evolution of Trento: Graphic Reconstructions of the City's Development Through the Centuries* (<https://doi.org/10.5281/zenodo.18710761>);
- *Toponymy in Nineteenth-Century Trento: A FAIR Dataset of Historical Evolution of Urban Toponyms in the Piazza del Duomo Area* (<https://doi.org/10.5281/zenodo.18852124>);
- *Public Works in Nineteenth-Century Trento: A FAIR Dataset of Urban Interventions in Piazza del Duomo and Its Surroundings* (<https://doi.org/10.5281/zenodo.18493752>).

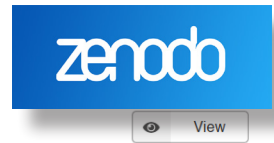
These datasets are discoverable even in the absence of a DOI through the search and metadata infrastructure provided by Zenodo. They can be

<https://doi.org/10.48550/arXiv.2507.10644>.

3. "About Zenodo," Zenodo, accessed May 1, 2026, <https://about.zenodo.org/>.

4. GitHub, accessed May 1, 2026, <https://github.com/>.

5. "About GitHub and Git," GitHub, accessed May 1, 2026, <https://docs.github.com/en/get-started/start-your-journey/about-github-and-git>.



✓ March 3, 2026 (v1) Dataset Open

View

Toponymy in Nineteenth-Century Trento: A FAIR Dataset of Historical Evolution of Urban Toponyms in the Piazza del Duomo Area

Maragno, Anna

This dataset collects the historical names of streets and squares in the piazza del Duomo area in Trento (Italy) during the 19th century. The dataset allows for the analysis of how toponymy has evolved in response to political and urban changes - from the Napoleonic era and the...

Uploaded on March 3, 2026

0 0

✓ February 20, 2026 (v1) Drawing Open

View

Historical Evolution of Trento: Graphic Reconstructions of the City's Development Through the Centuries

Maragno, Anna

This dataset provides a comprehensive digital collection of original graphic reconstructions illustrating the urban evolution of Trento (Italy) across the centuries. The collection spans from the Roman foundation (1st century AD) to the major urban transformations of the late 19th...

Uploaded on February 20, 2026

8 103

✓ February 5, 2026 (v1) Dataset Open

View

Public Works in Nineteenth-Century Trento: A FAIR Dataset of Urban Interventions in Piazza del Duomo and Its Surroundings

Maragno, Anna

This dataset provides a specialized digital inventory of historical public works and urban interventions exclusively centered on Piazza Duomo in Trento (Italy) and its immediate surroundings. Rather than a general survey of the entire city, this collection focuses on the micro-historical...

Uploaded on February 5, 2026

32 65

Fig. 6.30 Dataset visualization on Zenodo. Anna Maragno's dashboard presents the three contents, each with a preview.

retrieved by querying the dataset title, relevant keywords, or fragments of the description, as well as through associated author or institutional names. In addition, Zenodo enables metadata-based filtering using thematic terms and supports discovery via disciplinary communities and curated collections that group related research outputs. These combined functionalities ensure that the datasets remain findable and accessible even without direct reliance on persistent identifiers.

The most comprehensive and wide-ranging dataset is *Public Works in Nineteenth-Century Trento*. The dataset is structured as a multi-layered digital object, designed to bridge the gap between traditional archival heuristics and contemporary requirements for Open Science. Rather than a monolithic file, the repository comprises an integrated ecosystem of files, each serving a specific epistemic and technical function within the FAIR framework.

The composition of the dataset supported the development of the interactive historical narrative, namely the creation of an explorable map focused on public works carried out in the case study area during the nineteenth century.

The foundational layer consists of the *trento_public_works_original.csv* file. This ‘master data’ represents the primary digitization of archival records, capturing the granularity of 19th-century urban interventions - such as the leveling of piazza del Duomo or the canalization of the roggia Grande - in a human-readable tabular format. To ensure transparency, this file maintains a direct link to the original archival signatures (e.g., ASCTn, ASTn) and bibliographical sources [Fig. 6.31 a]. According to LOD principles, the people involved and the locations subject to public intervention have been enriched with links, where possible, to open datasets already accessible on the Web (e.g., Wikidata, the Digital Library of Rovereto, etc.). This approach enhances connectivity between different resources and helps avoid ‘noise’ in web-based historical searches.

Parallel to this, the *trento_public_works_cidoc_crm.csv* serves as a conceptual bridge. By remapping original headers to the CIDOC Conceptual Reference Model⁶ (ISO 21127:2023) nomenclature (v7.1.1), this file documents the semantic translation process, providing a ‘flat’ but semantically informed view that remains accessible to researchers unfamiliar with graph-based technologies. This version is designed for the Semantic Web and Linked Open Data integration [Fig. 6.31 b].

The core of the dataset’s interoperability is embodied in the *trento_public_works.ttl* file. Using the RDF (Resource Description Framework) Turtle syntax, the urban history of Trento is transformed into a Knowledge Graph⁷. In this environment, historical entities are no longer isolated entries but nodes identified by persistent URIs [Fig. 6.31 c]. By implementing the CIDOC CRM event-centric model, the dataset establishes

6. “The CIDOC Conceptual Reference Model (CRM) is a theoretical and practical tool for information integration in the field of cultural heritage [...]. The CIDOC CRM thus consists of the CRMbase standard which provides the basic classes and relations devised for the cultural heritage world. This base ontology is complemented by a series of modular extensions to the basic model. Such extensions are designed to support different types of specialized research questions and documentation such as bibliographic documentation or geoinformatics” (CIDOC CRM, accessed May 1, 2026, <https://cidoc-crm.org/>).

7. “The Resource Description Framework (RDF) is a general-purpose language for representing information in the Web. This document defines a textual syntax for RDF called Turtle that allows an RDF graph to be completely written in a compact and natural text form, with abbreviations for common usage patterns and datatypes” (“RDF 1.2 Turtle,” W3C Working Draft, accessed May 1, 2026, <https://www.w3.org/TR/rdf12-turtle/>).

formal relationships between physical objects (E22 Man-Made Object), the historical activities that produced them (E7 Activity), and the professional actors involved (E39 Actor). Furthermore, the integration of external authorities - specifically the Getty Art & Architecture Thesaurus (AAT) for urban typologies and Wikidata for prosopographical data - elevates the dataset to the 5-star Linked Open Data standard, enabling cross-domain federated queries.

To guarantee the long-term sustainability and findability of the digital object, the dataset utilizes the *mets.xml* file. This file follows the METS (Metadata Encoding and Transmission Standard) schema to provide a sophisticated structural map of the repository [Fig. 6.31 d]. It encapsulates descriptive metadata (via the MODS schema), technical specifications, and the logical relationships between the CSV and RDF components.

Finally, the *README.md* file acts as the critical apparatus of the digital edition, providing the necessary historical context and usage instructions. This tiered architecture ensures that the research is not only discoverable by search engines but remains semantically meaningful for future computational analysis in the fields of Urban History and Digital Heritage [Fig. 6.31 e].

In addition to historical data, the dataset *Public Works in Nineteenth-Century Trento* also includes several digital resources resulting from surveying campaigns conducted in the area of the Duomo and palazzo Pretorio. Among the various outputs of these surveys, two types of files were selected as representative examples for public dissemination [Fig. 6.32]:

- four technical drawings representing the main vertical and horizontal sections and façade orthomosaics of palazzo Pretorio in .pdf format (*tavola_01_palazzo_Pretorio.pdf*, *tavola_02_palazzo_Pretorio.pdf*, *tavola_03_palazzo_Pretorio.pdf*, *tavola_04_palazzo_Pretorio.pdf*);
- two 3D point cloud models of the Casa Cazuffi-Rella fountain (1850) and the staircase leading to Adamo d'Arogno square (1841–1842). These models are provided in .glb format, a compact, efficient, and web-friendly implementation of the glTF (GL Transmission Format) standard. The .glb format encapsulates geometry, materials, textures, and scene information within a single binary file, simplifying distribution and ensuring consistency across platforms (*model_Cazuffi_Rella_fountain.glb*, *model_double_staircase_della_Legna_square.glb*).

trento_public_works_original.csv

https://zenodo.org/records/18493752?preview_file=trento_public_works_original.csv

It contains historical names (Italian/English), precise coordinates, and the professional figures involved (engineers, architects). It is a ‘flat’ descriptive file optimized for human readability and standard GIS software. Where possible the names of people and places were linked to existing external datasets.

Fig. 6.31 (a) preview of the *original.csv* file.

trento_public_works_cidoc_crm.csv

https://zenodo.org/records/18493752?preview_file=trento_public_works_cidoc_crm.csv

It is a semantically enriched file mapped to the CIDOC Conceptual Reference Model (ISO 21127:2023). This version is designed for the Semantic Web and Linked Open Data integration.. This file serves as a bridge for researchers who require structured data for statistical or GIS analysis without the complexity of RDF processing.

Fig. 6.31 (b) preview of the *cidoc_crm.csv* file.

trento_public_works.ttl

This is the core of the dataset, expressed in RDF/Turtle format. This file transforms isolated records into a network of knowledge, utilizing the CIDOC CRM (v7.1.1) ontology to model complex events, actors, and temporal spans.

Fig. 6.31 (c) preview of the *.ttl* file.

mets.xml

https://zenodo.org/records/18493752?preview_file=mets.xml

Implemented using the Metadata Encoding and Transmission Standard (METS) and the Metadata Object Description Schema (MODS), this file functions as a structural ‘map’ of the dataset, describing the technical architecture of a complex digital object. It encodes both the hierarchical structure and the descriptive metadata in a machine-readable XML format, ensuring that repository harvesters can interpret and process the dataset as a coherent entity.

Fig. 6.31 (d) preview of the *.xml* file.

README.md

https://zenodo.org/records/18493752?preview_file=README.md

Serving as the primary entry point, this file provides the intellectual and methodological context. It defines the provenance of the data (Maragno and Volpi, *Dove Trento si ingegna*), describes the licensing (CC BY 4.0), and provides the ‘data dictionary’ necessary for human interpretation of the semantic mappings.

Fig. 6.31 (e) preview of the *.md* file.

	A	B	C	D	E	F	G	H	I	J	K	L
1	Id	name	name_en	typology	latitude	longitude	geometry_type	location_accuracy	crs	date_start	date_end	date_star
2	TN-PW-1828-001	piazza del Duomo	Duomo square	square	46.06715	11.12149	polygon	approximate	WGS84	1828	1833	circa
3	TN-PW-1833-001	piazza del Duomo	Duomo square	square	46.06737	11.12153	polygon	approximate	WGS84	1833	1840	exact
4	TN-PW-1835-001	roggia Grande	roggia Grande	canal	46.06724	11.1214	line	approximate	WGS84	1835	1836	exact
5	TN-PW-1850-001	fontana di casa Ca: Cazuffi Rella fountai	fontain	fontain	46.06771	11.1216	point	approximate	WGS84	1850	1850	exact
6	TN-PW-1860-001	piazza del Duomo	Duomo square	square	46.06737	11.12153	polygon	approximate	WGS84	1860	1860	exact
7	TN-PW-1867-001	roggia Grande	Roggia Grande	canal	46.06724	11.1214	line	approximate	WGS84	1867	1869	exact
8	TN-PW-1841-001	piazza della Legna	della Legna square	square	46.06688	11.12222	polygon	approximate	WGS84	1841	1842	exact
9	TN-PW-1888-001	piazza Terlago	Terlago square	square	46.06689	11.12096	polygon	approximate	WGS84	1888	1889	circa
10												

	A	B	C	D
1	E22_Man-Made_Object_ID	P102_has_title	P2_has_type_AAT	E53_Place_WK
2	https://doi.org/10.5281/zenodo.18493752#TN-PW-1828-001	piazza del Duomo	http://vocab.getty.edu/aat/300008304	POINT(11.12149 46.06715)
3	https://doi.org/10.5281/zenodo.18493752#TN-PW-1833-001	piazza del Duomo	http://vocab.getty.edu/aat/300008304	POINT(11.12153 46.06737)
4	https://doi.org/10.5281/zenodo.18493752#TN-PW-1835-001	roggia Grande	http://vocab.getty.edu/aat/300133792	POINT(11.121396 46.06724)
5	https://doi.org/10.5281/zenodo.18493752#TN-PW-1850-001	fontana di casa Cazuffi Rella	http://vocab.getty.edu/aat/300006179	POINT(11.121601 46.06771)
6	https://doi.org/10.5281/zenodo.18493752#TN-PW-1860-001	piazza del Duomo	http://vocab.getty.edu/aat/300008304	POINT(11.12153 46.06737)
7	https://doi.org/10.5281/zenodo.18493752#TN-PW-1867-001	roggia Grande	http://vocab.getty.edu/aat/300133792	POINT(11.121396 46.06724)
8	https://doi.org/10.5281/zenodo.18493752#TN-PW-1841-001	piazza della Legna	http://vocab.getty.edu/aat/300008304	POINT(11.12222 46.06688)
9	https://doi.org/10.5281/zenodo.18493752#TN-PW-1888-001	piazza Terlago	http://vocab.getty.edu/aat/300008304	POINT(11.12096 46.06689)
10				

```

16
17 <https://doi.org/10.5281/zenodo.18493752#object/TN-PW-1828-001>
18 a crm:E22_Man-Made_Object ;
19 crm:P102_has_title "piazza del Duomo"@it ;
20 crm:P2_has_type <http://vocab.getty.edu/aat/300008304> ;
21 crm:P108i_was_produced_by <https://doi.org/10.5281/zenodo.18493752#activity/>
22 crm:P53_has_former_or_current_location <https://doi.org/10.5281/zenodo.18493752#object/TN-PW-1828-001>
23 dct:isPartOf <https://doi.org/10.5281/zenodo.18493752> .
24

```

This XML file does not appear to have any style information associated with it. The document tree is shown below.

```

<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<met:met xmlns:met="http://www.loc.gov/METS/" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:mods="http://www.loc.gov/mods/v3" xmlns:xlink="http://www.w3.org/1999/xlink"
  OBJID="doi:10.5281/zenodo.18493752" TYPE="Dataset" xsi:schemaLocation="http://www.loc.gov/METS/
  http://www.loc.gov/standards/mets/mets.xsd http://www.loc.gov/mods/v3
  https://www.loc.gov/standards/mods/v3/mods-3-7.xsd">
  <metHdr CREATEDATE="2026-02-09T11:20:00">
    <agent ROLE="CREATOR" TYPE="INDIVIDUAL">
      <name>Anna Maragno</name>
      <note ORCID: 0009-0009-0709-3055</note>
    </agent>
  </metHdr>
  <dmdSec ID="DMD1">
    <xmldWrap MDTYPE="MODS">

```

README: Public works in 19th-century Trento: a FAIR dataset of urban interventions in piazza del Duomo and its environs

1. Metadata Overview

Dataset Title: Public works in 19th-century Trento: a FAIR dataset of urban interventions in piazza del Duomo and its environs

Persistent Identifier (DOI): [<https://doi.org/10.5281/zenodo.18493752>]

Creators: Anna Maragno [<https://orcid.org/0009-0009-0709-3055>]

[<https://github.com/Annamaragno>]

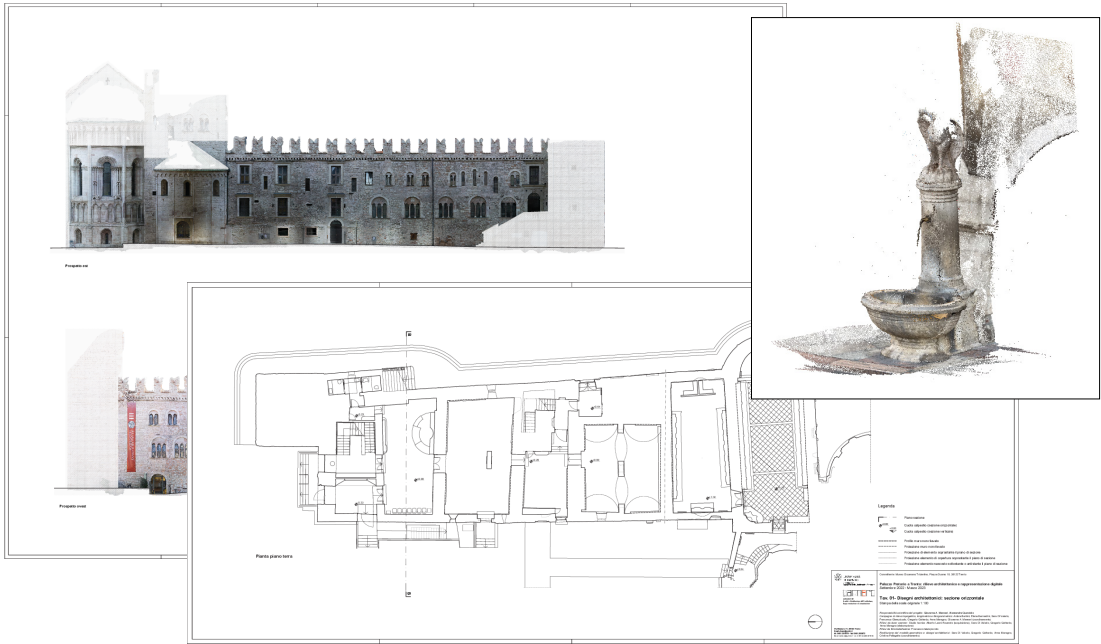
Keywords: Trento, piazza del Duomo, urban history, CIDOC CRM, Historical GIS (H-GIS), Linked Open Data (LOD), METS, EDM compatible.

Language: Italian (original data), English (metadata/descriptions).

License: Creative Commons Attribution 4.0 International (CC BY 4.0).

2. Abstract

This dataset provides a comprehensive record of public works and urban transformations specifically focused on the area of piazza del Duomo in Trento and its surrounding urban



The dataset described above follows, as closely as possible, the principles of Open Science and, although it does not have its own dedicated domain, it is structured according to Semantic Web principles. The [Fig. 6.33] summarizes the key aspects of the dataset's FAIRness. The other two datasets share similar characteristics. The *Historical Evolution of Trento* presents a synthesis of historical cartography and archival research, visualized through eight distinct temporal layers. These correspond to the graphic reconstructions resulting from the historical and documentary analysis discussed in chapter 6.2 [Fig. 6.6]. This dataset was used to create multilayer maps that, through a sliding bar, allow comparison of the city's layout across different historical periods. It includes:

1. *trento_evolution_maps.csv*: a primary descriptive file containing map titles, periods, precise WGS84 coordinates, and direct links to archival sources for each temporal layer.
2. *trento_evolution_maps.json*: a JSON-LD file (Schema.org) designed for search engine optimization and automated metadata harvesting.
3. *trento_evolution_maps.ttl*: the core semantic dataset in RDF/Turtle format, implementing Linked Open Data principles through a resource-property-object structure.
4. *meta.xml*: a Metadata Encoding and Transmission Standard file pro-

Fig. 6.32 Some of the 2D and 3D outputs from the geometric surveys that were selected as representative examples for public dissemination.

viding the structural map, ensuring the collection is machine-readable and ready for professional digital repositories.

5. *Graphic reconstructions (.jpg)*: 8 high-resolution image files representing the urban layout of Trento in the 1st, 3rd-6th, 10th-11th, 13th-14th, 15th-16th, 17th-18th centuries, and the first/second half of the 19th century.
6. *README.md*: methodological documentation providing the intellectual context, technical specifications, and the “Data Dictionary” for interpretation.

Toponymy in the Nineteenth-Century Trento dataset collects the historical names of streets and squares in the Duomo area during the 19th century. The dataset allows for the analysis of how toponymy has evolved in response to political and urban changes - from the Napoleonic era and the Habsburg administration to the contemporary period, and corresponds to the tabular resulting from the historical and documentary analysis discussed in chapter 6.2 [Fig. 6.7].

This dataset was used to create an interactive map that allows users to explore different streets in the historic center and access toponymic information derived from historical cartography. Specifically, the dataset includes:

1. *trento_toponymy.csv*: it contains the cartography name, author, year, and archival reference. For each historical map, the toponyms of seven main streets and squares in the area of the Duomo di Trento are listed.
2. *trento_toponymy.ttl*: this is a Linked Open Data representation in Turtle format, aligned with Schema.org, FOAF, and GeoSPARQL vocabularies.
3. *datapackage.json*: it is a machine-readable metadata file that follows the Frictionless Data standard. It provides a precise technical description of the .csv structure, defining data types (e.g., numbers, URIs, years), the delimiter used (;), etc.
4. *trento_toponymy.json*: this file follows the Schema.org standard. Its purpose is to describe the dataset as a whole for search engines (such as Google Dataset Search) and platforms like Zenodo. It contains ‘high-level’ information: the author, the license, the temporal coverage (1813-2026), and the geographic area.
5. *README.md*: serving as the primary entry point, this file provides the intellectual and methodological context. It defines the provenance of the data and describes the licensing (CC BY 4.0).

Fig. 6.33 (following pages) FAIRness of the *Public Works in Nineteenth-Century Trento* dataset.

FAIRness of the dataset	
F indable	F1. (Meta)data are assigned a globally unique and persistent identifier. F2. Data are described with rich metadata. F3. Metadata clearly and explicitly include the identifier of the data they describe. F4. (Meta)data are registered or indexed in a searchable resource.
A ccessible	A1. (Meta)data are retrievable by their identifier using a standardised communications protocol. A1.1 The protocol is open, free, and universally implementable. A1.2 The protocol allows for an authentication and authorisation procedure, where necessary. A2. Metadata are accessible, even when the data are no longer available.
I nteroperable	I1. (Meta)data use a formal, accessible, shared, and broadly applicable language for knowledge representation. I2. (Meta)data use vocabularies that follow FAIR principles. I3. (Meta)data include qualified references to other (meta)data.
R eusable	R1. (Meta)data are richly described with a plurality of accurate and relevant attributes. R1.1. (Meta)data are released with a clear and accessible data usage license. R1.2. (Meta)data are associated with detailed provenance. R1.3. (Meta)data meet domain-relevant community standards.

The dataset is assigned a DOI (10.5281/zenodo.18493752) via Zenodo, ensuring a permanent and immutable link that supersedes standard web URLs.

Contextual depth is provided through the README.md (historical context) and the mets.xml file, which utilizes the MODS standard for technical and bibliographic descriptions.

The DOI is embedded within all primary files, including the XML header of the mets.xml, Section 1 of the README.md, and as the root URI in the Turtle (.ttl) file.

By utilizing the Zenodo repository, the metadata is automatically harvested by OpenAIRE and exposed via the OAI-PMH protocol, ensuring visibility in global academic search engines.

Data retrieval is facilitated via HTTPS, an open, secure, and universally implemented communication protocol.

The dataset is accessible without financial or software-related barriers.

The dataset is accessible without financial or software-related barriers.

Zenodo ensures tombstone persistence: if data files are deaccessioned, the descriptive metadata in mets.xml and README.md remain accessible to document the dataset's prior existence.

The dataset utilizes international standards for knowledge representation: XML for structural manifests and RDF/Turtle for semantic knowledge modeling.

Rather than using arbitrary labels, the dataset employs standardized ontologies, specifically CIDOC CRM v7.1.1 and the Getty Art & Architecture Thesaurus (AAT).

The dataset establishes “qualified links” to external authority files, such as Wikidata and local digital libraries, integrating the research into the global Linked Open Data (LOD) cloud.

The dataset offers multiple “perspectives” of the same data: the original CSV (archival evidence), the mapped CSV (analytical ease), and the Turtle file (semantic power).

A Creative Commons Attribution 4.0 International (CC BY 4.0) license is explicitly declared across all files, removing legal ambiguity regarding reuse.

Scholarly lineage is documented in the README.md, citing both primary archival sources and the foundational publication (Maragno & Volpi, 2023).

By adhering to Digital Humanities standards (CIDOC CRM) and digital preservation protocols (METS), the dataset is optimized for ingestion into cultural heritage aggregators such as Europeana.

Recalling once again that the aim of *The Imaginary Map* is to provide a platform supporting historical and documentary research on the built heritage of Trento during the nineteenth century, the system is conceived as an aggregator of heterogeneous information.

The data integrated into the platform - used to construct historical narratives through interactive and engaging experiences - partly derive from open data already available in online repositories such as BeWeB and Biblioteca Digitale Trentina. These include cartographic, iconographic, and textual resources.

Additional data are produced ex novo through archival research in physical repositories (e.g., the Archivio storico del comune di Trento and the Archivio di Stato di Trento) and through geometric survey campaigns (e.g., plans and sections, orthomosaics, and 3D models). These materials, which constitute new digital records, are made accessible either directly or indirectly through the web platform.

All these data are ultimately used to develop three final maps, each corresponding to a specific research direction (historical evolution over the centuries, toponymy, and public works). These maps take the form of HTML pages, published in a repository on GitHub and accessible through *The Imaginary Map* interface [Fig. 6.34].

Fig. 6.34 Summary overview of the data used in The Imaginary Map platform. The diagram specifies the formats and sources of these data.

Open data already available online

About built environment	About people
BeWeB, <i>Beni architettonici</i>	BeWeB, <i>Persone</i>
Archivio storico comune di Trento, <i>Cartografia storica della città</i>	Museo Diocesano Tridentino, <i>Nati in Trentino</i>
Biblioteca Digitale Trentina, <i>Iconografia</i>	Biblioteca Civica di Rovereto <i>Dizionario dei trentini illustri</i>

New digital record accessible through the Zenodo dataset (DOI assignment)

evolution_maps	toponymy_maps	public_works_maps
trento_evolution_maps.csv	trento_toponymy.csv	trento_public_works_original.csv
trento_evolution_maps.json	trento_toponymy.ttl	trento_public_works_cidoc_crm.csv
trento_evolution_maps.ttl	datapackage.json	trento_public_works.ttl
mets.xml	trento_toponymy.json	mets.xml
README.md	README.md	README.md
2D graphic reconstructions (.jpg)		2D drawings and orthomosaic (.pdf)
		3D point cloud models (.glb)

New digital record accessible through GitHub Pages

the_imaginary_map.html
public_works_maps.html
toponymy.html

06.5

Data dissemination: development of the web platform

The Imaginary Map

Building on the experience gained in the ‘Information Technology’ course at the Politecnico di Milano, it was decided to disseminate the datasets through the development of a dedicated web page. This led to the creation of *The Imaginary Map*, a Python-based web mapping platform designed to transform heterogeneous historical datasets into interactive geospatial visualizations.

The system integrates archival records, cartographic sources, iconographic materials, and digital surveys into a unified digital environment. The objective is to move beyond static representation of historical data and to construct a dynamic spatial narrative of urban transformation, focusing on the city of Trento across multiple temporal layers.

The system is entirely implemented in Python (interactive maps) and in HTML (web page) [Fig. 6.35] and relies on a set of core technologies:

- *Pandas*¹ for data ingestion, cleaning, and transformation of CSV-based archival datasets;
- *Folium*² for the generation of interactive Leaflet.js-based web maps;
- *HTML/CSS/JavaScript*: for content formatting and interactivity;
- *JuxtaposeJS*: for historical image sliders.

This minimal stack enables a fully reproducible pipeline that converts the structured .csv datasets stored in Zenodo (*trento_evolution_maps.csv*, *trento_toponymy.csv*, *trento_public_works_original.csv*) into interactive HTML maps without requiring manual GIS software.

Fig. 6.40 Graphical overview of *The Imaginary Map* contents.



1. Pandas, accessed May 1, 2026, <https://pandas.pydata.org/>.
2. “Folium,” GitHub, accessed May 1, 2026, <https://python-visualization.github.io/folium/latest/>.

Public works HTML map

1. Data loading and organization

The system begins by loading the dataset *trento_public_works_original.csv* that contains historical and geographical information such as names, dates, coordinates, descriptions, and multimedia references³.

At this stage, the dataset is imported into a tabular structure, similar to a spreadsheet. Each row represents a historical element, such as a building or infrastructure project [Fig. 6.31 a].

```
df = pd.read_csv(
    os.path.join(DATASET_ZENODO_DIR, "public_works_maps", "trento_public_works_original.csv"),
    sep=";",
    encoding="latin1"
)
```

2. Temporal expansion of data

One of the key features of the system is the ability to represent change over time. Since many historical objects exist across multiple years, the dataset is expanded so that each year becomes an individual entry. This transformation allows the map to display historical evolution year by year, enabling a dynamic temporal navigation.

```
righe = []
for _, r in df.iterrows():
    for anno in range(int(r["date_start"]), int(r["date_end"]) + 1):
        nuova_riga = r.copy()
        nuova_riga["Year"] = anno
        righe.append(nuova_riga)
df_anni = pd.DataFrame(righe)
```

3. Creation of the interactive map

The visualisation system is built using Folium, a Python library that generates web maps based on Leaflet.js. The map is centered on the city of Trento, and a neutral background style is chosen to highlight historical elements.

```
m = folium.Map(
    location=[46.06754, 11.12143],
    zoom_start=18,
    tiles="CartoDB positron",
    name="Display public works in progress by year:"
)
```

3. See chapter 06.4 of the present thesis.

A fullscreen control is also added:

```
Fullscreen(position="topleft").add_to(m)
```

4. Visual encoding of historical data

Each object on the map is represented as a circular marker. Different categories (such as roads, buildings, fountains) are visually distinguished using colors. This color system helps users immediately recognize the type of historical element without reading textual descriptions.

```
colori = {
    "square": "darkred",
    "canal": "darkblue",
    "road": "darkgreen",
    "building": "purple",
    "fountain": "green"
}
```

5. Temporal layers and user interaction

To enable chronological exploration, the map is divided into layers, one for each year. Users can toggle these layers to observe changes over time. Only one year is displayed by default, while others can be activated through a layer control interface [Fig. 3.36].

```
fg = folium.FeatureGroup(name=str(anno), show=(anno == anno_default))
folium.LayerControl(collapsed=False).add_to(m)
```

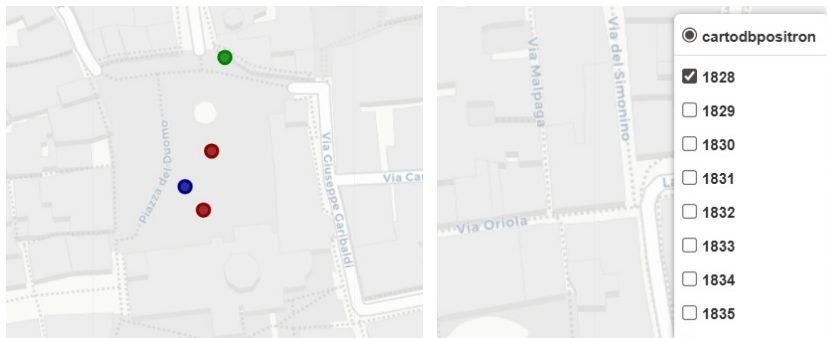


Fig. 6.36 Left: interactive map of public works, displaying markers that pinpoint the location of each individual intervention; right: layer control menu showing multiple years.

6. Interactive Popups: Enriched Historical Information

Each spatial marker contains a structured HTML pop-up combining multiple sources of information. This is one of the most important elements of the system, as it transforms a simple geographic marker into a rich historical record [Fig. 6.37]. The popup includes:

```
html_popup = f"""
<div style="width:460px; font-family:Arial; font-size:12px;">
  <div style="font-weight:bold; font-size:17px;">{name}</div>
  <div style="text-align: justify;">{description}</div>
  <hr>
  <b>Years</b> {years}
  <hr>
  <b>People involved</b><br>
  {person1}<br>
  {person2}<br>
  {person3}
  {historical_image_html}
  {digital_survey_html}
  {archival_section}
  {bibliography_section}
</div>
"""
```

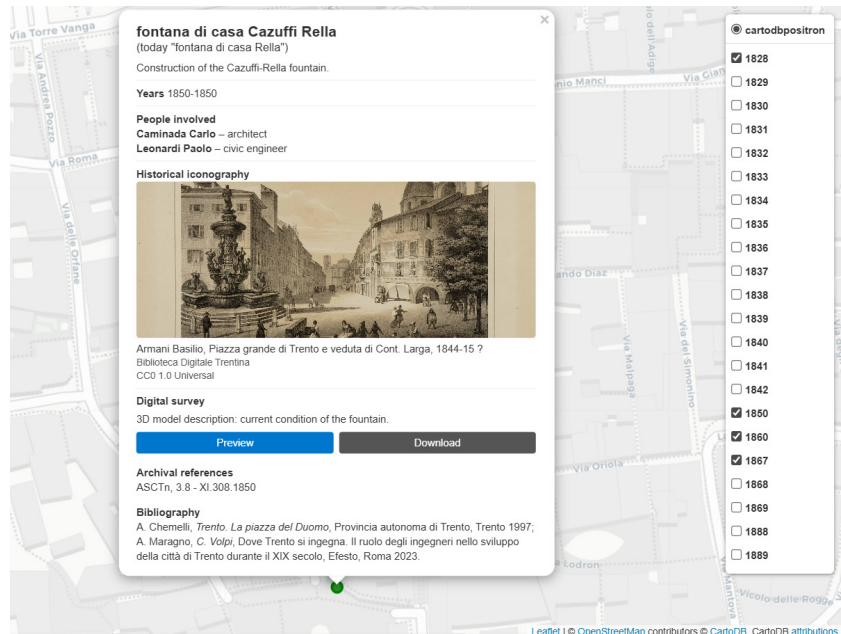


Fig. 6.37 Example of the information and data displayed in the pop-ups

- Name of the object/intervention
- Short historical description
- Time period (start and end dates of the intervention)
- People involved (civic engineers, district engineers, architects, etc.)
- Main archival references
- Main bibliography

- Images and digital resources (historical iconography, 2d digital drawings or 3D digital models, etc.)

7. *Integration of historical iconography*

When available, historical images are embedded directly into the popup. These images are linked to external sources (e.g. Biblioteca Digitale Trentina) and include metadata such as description, platform, and license. This allows users to visually connect the mapped object with its historical representation.

```
historical_image_html = f"""

<div style="font-size:12px;">{image_description}</div>
"""
```

8. *Digital survey section*

A dedicated section integrates advanced documentation such as 3D models and technical drawings. This enhances the platform by bridging historical data with modern surveying techniques.

```
model_3d_content = f"""
<a href="{preview_url}" target="_blank">Preview 3D Model</a>
<a href="{download_url}" target="_blank">Download</a>
"""
```

9. *Output generation: saving the map*

Finally, the map is saved as a standalone HTML file (*map.html*), making it easily accessible through any web browser without requiring additional software.

```
m.save("map.html")
```

Toponymy evolution HTML map

1. *Data loading and organization*

In addition to public works, the system includes a second map dedicated to the evolution of toponymy in the 19th century in Trento. This map focuses on how geographic names change across historical cartography. The system begins by loading the dataset *trento_toponymy.csv*, that is organised in a compact format, where multiple toponyms (place names) are stored within a single row. To make this information usable for mapping, the data is transformed into a long format, where each toponym becomes an individual record associated with geographic coordinates and a specific year.

```
for i in range(1, 8):
    name_col = f"toponymy_{i}"
    lat_col = f"latitude_{i}"
    lon_col = f"longitude_{i}"

    if row[name_col] != "":
        records.append({
            "year": year,
            "name": row[name_col],
            "lat": row[lat_col],
            "lon": row[lon_col]
        })
```

2. *Reconstructing the historical sequence*

Once the data is reorganised, the system groups all names that refer to the same geographic location. This is done using coordinates as a unique identifier. Each location is therefore associated with a chronological sequence of names. These sequences are then sorted by year to reconstruct the historical evolution of each place.

```
history = defaultdict(list)

for _, r in df_long.iterrows():
    key = (r["lat"], r["lon"])
    history[key].append((r["year"], r["name"]))

history[key].sort(key=lambda x: x[0])
```

3. *Visual representation on the map*

Each location is represented by a circular marker. Unlike the public works map, where multiple layers represent different years, the toponymy map uses a single static layer. The temporal dimension is instead embedded within the popup content. The choice of a single color ensures visual consistency and emphasizes that the focus is not on categorisation, but on temporal transformation.

```
folium.CircleMarker(
    location=[lat, lon],
    radius=7,
    color="#BAB700",
    fill=True,
    popup=popup
).add_to(mm)
```

4. The popup as a historical table

The most distinctive feature of the toponymy map is the popup structure. Instead of a descriptive paragraph, each marker opens a table that summarises the evolution of the place name across time [Fig. 3.38]. Each row corresponds to a specific moment in time and includes:

- the year of the map,
- the recorded place name,
- the historical cartographic source,
- the author of the map.

```
<table>
<tr>
  <th>Year</th>
  <th>Name</th>
  <th>Historical reference map</th>
  <th>Author</th>
</tr>
```



Fig. 6.38 Example of the information displayed in the pop-ups

5. Output generation: saving the map

Finally, the map is saved as a standalone HTML file (*toponymy.html*), making it easily accessible through any web browser without requiring additional software.

```
mm.save("toponymy.html")
```

Historical evolution map with JuxtaposeJS

JuxtaposeJS⁴ is used to create sliders that allow users to compare two images by dragging a vertical divider. In this project, the images are historical maps from different periods. The goal is to highlight spatial transformations, make changes immediately visible, and provide an intuitive, visual experience without requiring technical knowledge.

1. Structure of the Slider

Each slider is a standalone HTML page that includes:

- a container element,
- references to two images,
- configuration parameters.

The two images are overlaid, and the user can interactively reveal one or the other.

```
<div id="slider-container"></div>

<script>
new juxtapose.JXSlider('#slider-container',[
{ src: 'map1.jpg', label: 'Roman Trento' },
{ src: 'map2.jpg', label: 'Late antique Trento' }
]);
</script>
```

2. Sequential Historical Narrative

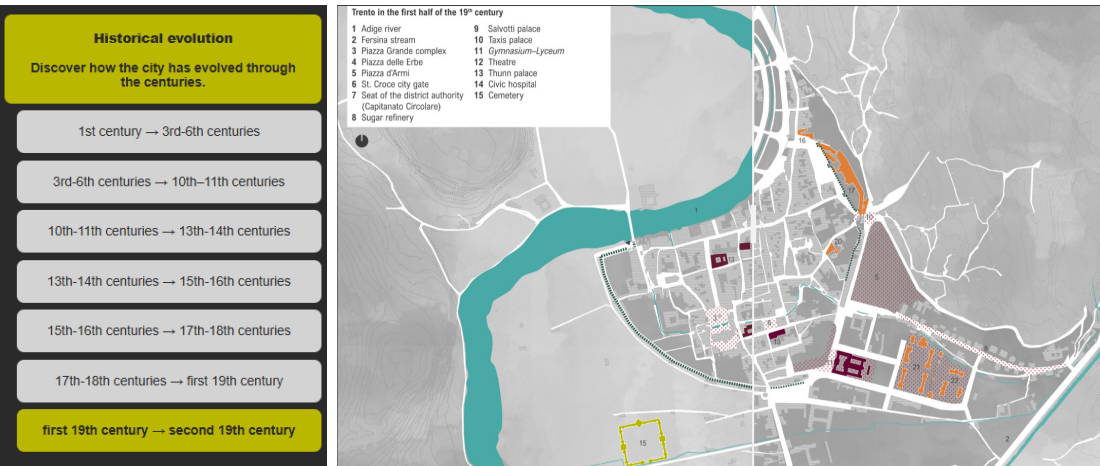
Multiple sliders are created, each comparing consecutive historical periods (e.g. Roman → Late Antique; Late Antique → Early Medieval; Early Medieval → Late Medieval; etc.). This structure creates a step-by-step visual timeline, where each slider represents a transition phase [Fig. 6.38].

3. User Interaction

The interaction is deliberately simple: dragging the slider reveals changes, labels identify the historical periods, and animations make transitions smoother.

```
{ animate:true, showLabels:true, startingPosition:"50%" }
```

4. "Juxtapose helps storytellers compare two pieces of similar media, including photos, and GIFs. It's ideal for highlighting then/now stories that explain slow changes over time (growth of a city skyline, regrowth of a forest, etc.) or before/after stories that show the impact of single dramatic events" ("JuxtaposeJS," Knight lab, accessed May 1, 2026, <https://juxtapose.knightlab.com/>).



The Imaginary Map HTML page

The *Imaginary Map* page is designed as an interactive environment that allows users to explore the historical evolution of the city of Trento through digital maps. Although the underlying code is written using standard web technologies, the system is intentionally designed to remain simple, accessible, and intuitive for non-technical users.

The platform is built using three fundamental web technologies:

- HTML (HyperText Markup Language), which defines the structure of the page;
- CSS (Cascading Style Sheets), which controls the visual appearance;
- JavaScript, which manages interactivity and dynamic behavior.

These three components work together to create a single-page application in which users can navigate different thematic maps without reloading the entire website.

1. Interface layout structure

At a structural level, the interface is divided into two main areas, namely a sidebar (left panel) containing navigation controls, and a main map area (right panel) displaying the selected content [Fig. 6.40]. This simple structure defines the entire layout of the platform: a navigation panel on the left and a visualization area on the right.

```
<div class="container">
  <div class="sidebar">...</div>
  <div class="map-container">...</div>
</div>
```

Fig. 6.39 Example of two overlapping maps and a list of all cartographic comparisons.



Fig. 6.40 Layout of the HTML main page.

2. The sidebar: navigation and user interaction

The sidebar is the primary tool through which users interact with the platform. It contains buttons that allow access to different thematic datasets. A typical button is defined as follows:

```
<button id="publicWorksBtn" data-file="dataset_github/public_works_maps/map.html">
  <strong>Public works</strong><br>
  <span class="extended">Explore the public works carried out in the
city of Trento during the 19th century.</span>
</button>
```

3. The map container and dynamic content loading

The main visualization area uses an `iframe`, which acts as a window that loads external content. This means that each map is stored as a separate file on GitHub and displayed inside the main page when needed.

The dynamic behavior is controlled by a JavaScript function:

```
function loadMap(file, button) {
  loader.style.display = "flex";
  frame.src = file;
}
```

4. Responsive design

The platform is designed to adapt to different screen sizes. For example, on mobile devices the layout changes automatically. This means that the sidebar moves to the top, and the map is displayed below. The result

is a consistent user experience across devices.

```
@media (max-width: 768px) {  
  .container {  
    flex-direction: column;  
  }  
}
```

5. Code availability and online deployment

The source code of *The Imaginary Map* is publicly available through the platform GitHub⁵, which is widely used for sharing, managing, and preserving digital projects [Fig. 6.41].

Publishing the code on GitHub serves several important purposes. First, it ensures transparency, allowing other researchers to understand how the platform is built and how the data is presented. Second, it supports reproducibility, enabling others to reuse or adapt the structure for similar projects. Finally, it contributes to the long-term preservation of the project, as the code remains accessible independently from local storage or institutional infrastructures.

The platform is deployed using GitHub Pages, a service that allows websites to be published directly from a GitHub repository. This means that the project does not require a dedicated server or complex backend infrastructure. Instead, the website is generated from static files (HTML, CSS, and JavaScript) and made accessible online through a public URL:

<https://annamaragno.github.io/the-imaginary-map-Trento-history>

From a technical perspective, the deployment process is relatively straightforward. The developer uploads the project files to a repository on GitHub, and the platform automatically publishes them as a website. Any updates to the code can be made by modifying these files and uploading a new version, which is then immediately reflected online.

From the user's point of view, this approach guarantees easy and open access. No installation or registration is required: the platform can be accessed directly through a web browser. At the same time, researchers and developers can consult the underlying code, download it, or contribute to its improvement, fostering an open and collaborative research

5. GitHub, accessed May 1, 2026, <https://github.com/>. GitHub is the world's largest cloud-based platform for software development, hosting over 420 million repositories and serving more than 100 million developers.

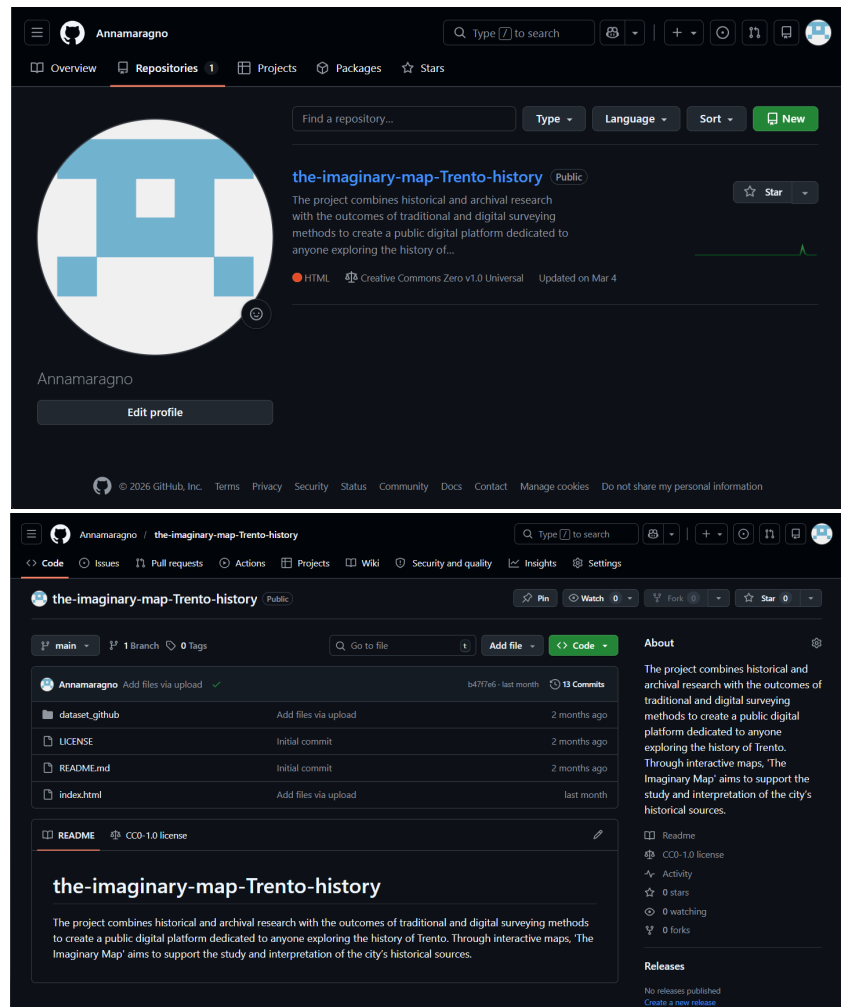


Fig. 6.41 The repository *the-imaginary-map-Trento-history* published on GitHub.

environment.

The platform demonstrates how relatively simple web technologies can be used to create a powerful tool for historical exploration. By combining structured datasets with an intuitive interface, it enables users to engage with complex spatial and historical information in an accessible and interactive way.

The code does not require advanced technical infrastructure, yet it supports a rich user experience through careful design and thoughtful integration of visual and interactive elements.

06.5.1 In-depth study & experiences

User manual

1. Accessing the platform

The Imaginary Map is web-based platform developed as part of Anna Maragno's doctoral thesis, entitled "Shaping the memory of the built heritage: The digital record as new historical source" (University of Trento). This web platform can be accessed easily through any standard browser. No installation, login, or prior technical knowledge is required. To begin exploring the platform, simply open the following link or scan the QRcode:

<https://annamaragno.github.io/the-imaginary-map-Trento-history/>



2. The interface

The interface is organized into two main areas that work together:

- A *sidebar* (a), which functions as a guide and navigation tool. Here the user finds the different thematic sections of the project.
- A *main display area* (b), where maps and content are dynamically visualized based on the user's selection.

3. The homepage: "About the Project" [Fig. 6.41]

When the platform is first opened, users are welcomed by the "About the Project" section. This introductory text explains the goals of the research and the methodological approach behind the platform. Users can return to this section at any time by clicking the "About the project" button in the sidebar.

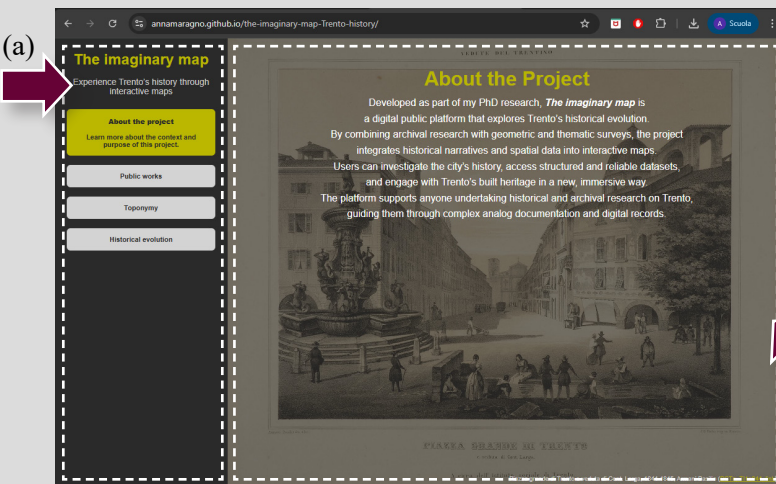


Fig. 6.41 Interface layout. When first opened, users are welcomed by the "About the Project" section. On the left there is the sidebar (a), on the right the main display area (b).

4. Exploring the thematic maps

The core of the platform lies in its interactive maps. Each thematic section corresponds to a specific research focus and dataset stored on Zenodo. By clicking on a button in the sidebar, users activate a map that is loaded instantly in the main display area (b).

4.1 “Public works” button [Fig. 6.42]

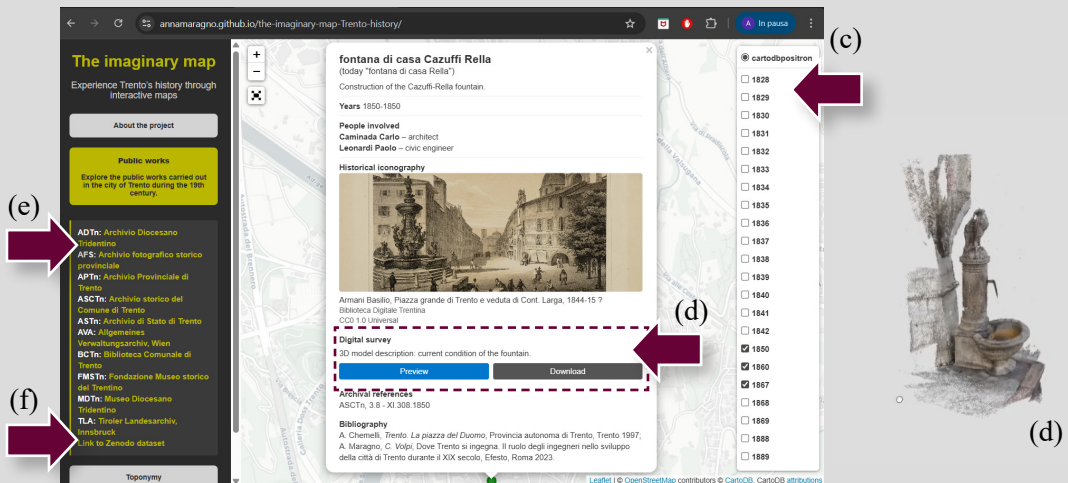
This section allows users to explore the transformations of the urban fabric through public interventions in the 19th century. It provides insight into how infrastructure, planning decisions, and administrative actions shaped the city.

By clicking the “Public works” button, a thematic map appears showing urban and architectural interventions. Using the legend (c) on the right side of the screen, users can select, year by year, all construction sites active during that period. Multiple years can be selected simultaneously to facilitate comparison.

Each circular marker on the map corresponds to a construction site. By clicking on a marker, a pop-up opens with information about the project (start date, end date, professionals involved, archival and bibliographic references, historical iconography, etc.). When available, users can also view and download graphic materials, such as 2D drawings or digital 3D models (d).

On the left, the sidebar displays the legend of the relevant archives and libraries, with links to their respective websites (e). Finally, at the bottom of the legend, a Zenodo link is provided, directing users to the dataset used to build the map (f).

Fig. 6.42 “Public works” section. On the left, the sidebar displays the archive legend (e) and the link to Zenodo (f); on the right, the pop-up with project information (d) and the legend for selecting the reference year (c).



4.2 “Toponymy” button [Fig. 6.43]

The “Toponymy” section focuses on the evolution of place names in the 19th century, offering a valuable perspective on social, political, and cultural changes. By observing how names shift over time, users can trace broader processes such as modernization, administrative reform, and identity construction.

By clicking the “Toponymy” button, a thematic map appears showing circular markers located along the main streets of Trento’s historic center. Clicking on a marker opens a pop-up containing a table that lists, in chronological order, the different names that each street had during the 19th century (g). The table also indicates the historical maps - and their respective authors - from which the names were derived.

In line with a Linked Open Data approach, the names of the maps and their authors are, when possible, connected via links to open digital repositories (e.g. Archivio storico del comune di Trento, Biblioteca Digitale Trentina).

In this section as well, the sidebar includes a link to Zenodo, where the dataset used to build the map is stored (h).

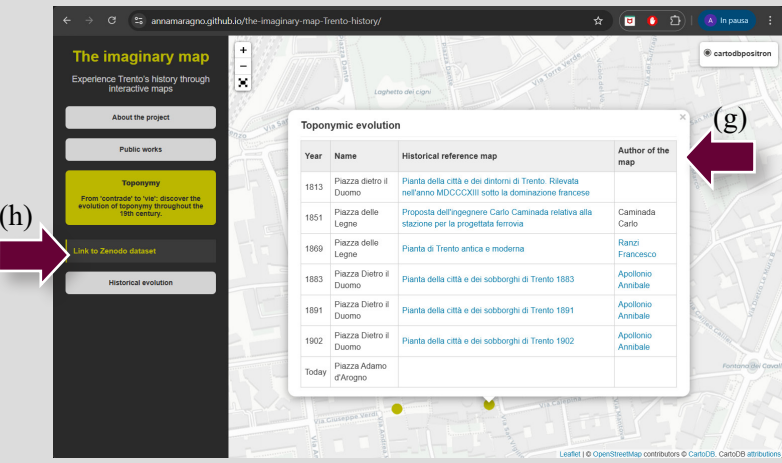


Fig. 6.43 “Toponymy” section. On the left, the sidebar displays the link to Zenodo (h); on the right, the pop-up with the names table (g).

4.3 “Historical evolution” button [Fig. 6.44]

The “Historical map evolution” section offers a diachronic view of the city across multiple centuries. Through a series of chronological maps, users can observe how urban form, spatial organization, and key features have changed over time.

In the sidebar, a menu allows users to select the historical periods corresponding to the graphic reconstructions to be compared (i). By clicking on the desired periods, the corresponding maps appear on the right as

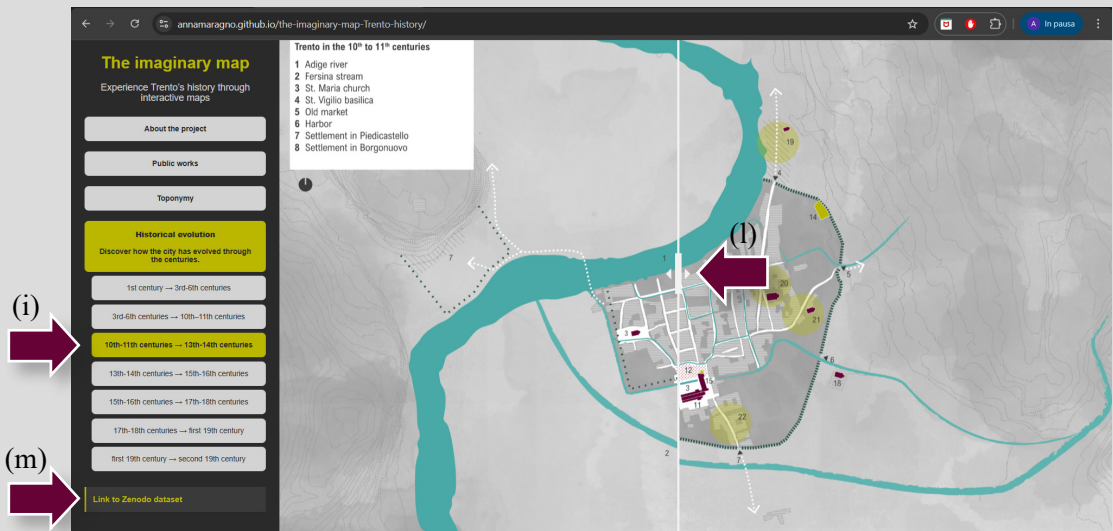


Fig. 6.43 “Historical evolution” section. On the left, the sidebar displays the menu for selecting the historical periods (i) and the link to Zenodo (m); on the right, the maps visualised as overlapped layers and the slider bar (l).

overlapping layers. Using a slider bar (l), users can move from right to left to reveal or hide the underlying map, enabling direct visual comparison between different periods.

Each map includes a legend showing the main places and architectural landmarks of the city, as well as an indication of the north.

In this section as well, the sidebar includes a link to Zenodo, where the dataset used to build the map is stored (m).

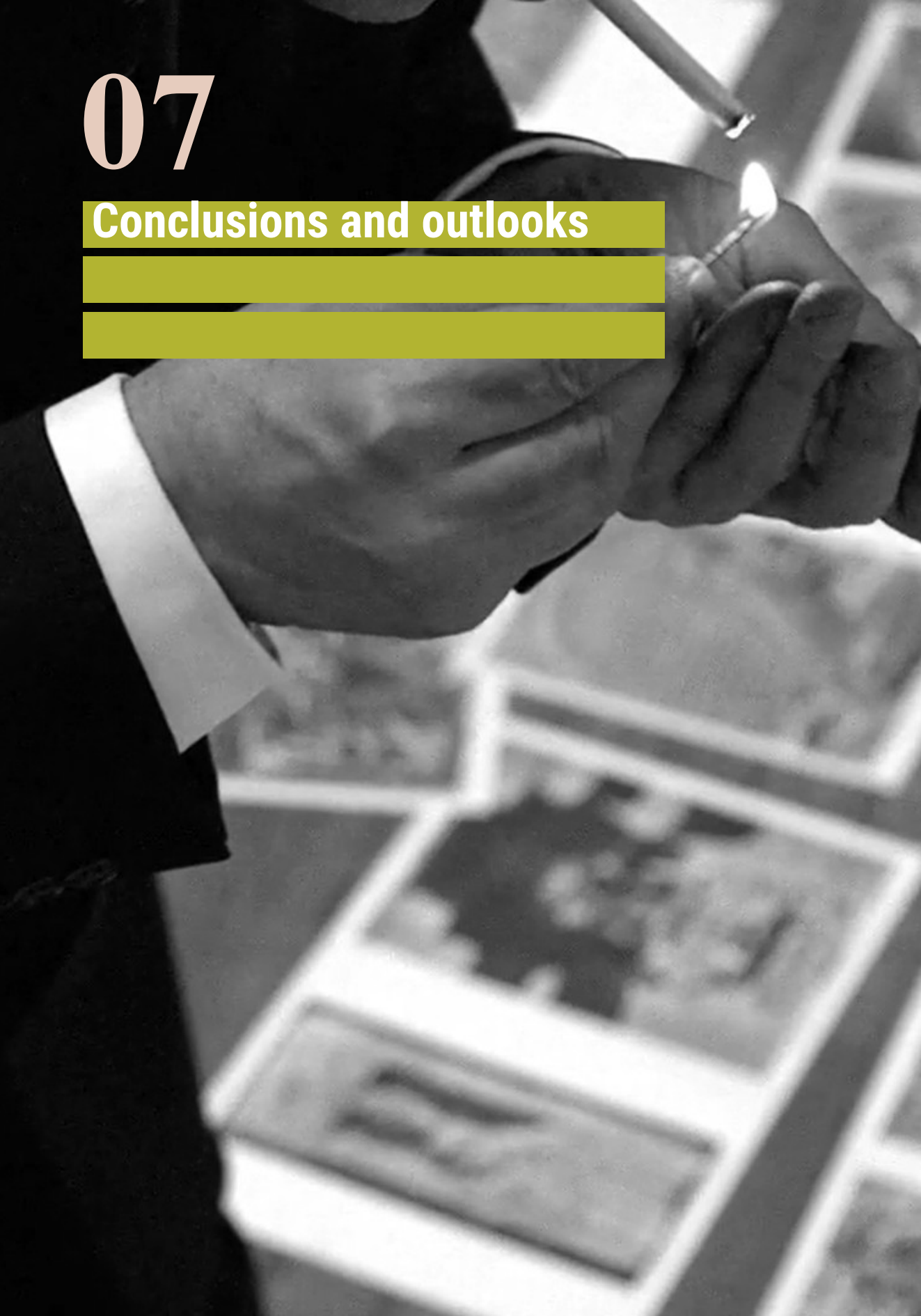
5. Accessibility across devices

The platform is designed to function on a wide range of devices, from desktop computers to smartphones. On smaller screens, the layout adapts automatically, placing the navigation panel above the map.

While all functionalities remain available, a larger screen may provide a more detailed and immersive experience.

07

Conclusions and outlooks



Chapter 07 • Conclusions and outlooks

This concluding chapter revisits the main research questions that have guided this study: how digitized and born-digital materials can reliably transmit historical knowledge over time while ensuring accessibility and long-term preservation; whether contemporary AEC outputs and online built heritage resources can be considered valid historical sources; and how the production of digital resources might be standardized to ensure enduring evidential value.

Building on these questions, the study has shown how the notions of memory, history, and historical sources are continually reshaped by technological change, particularly in the context of rapid digital transformation and the increasing role of artificial intelligence. This evolution raises critical issues related to data overload, technological obsolescence, and the often limited documentary value of digital outputs.

Focusing on AEC archives, the research highlights their complexity and the lack of consistent, field-specific guidance despite existing international frameworks. It therefore points to the need for stronger archival awareness among professionals, closer collaboration between creators and archivists, and the systematic use of metadata, paradata, and open standards.

The chapter ultimately frames these challenges within the broader idea of the ‘validated digital object’, suggesting a shift from reactive preservation to more proactive and structured forms of digital curation.

After this long and intricate journey through memory and the digital future, it is appropriate to return to the beginning - to the research questions that set the path in motion and guided the work to this point.

The initial questions concerned how digitized and born-digital materials can reliably convey historical knowledge over time while ensuring both accessibility and long-term preservation; to what extent the outputs of contemporary AEC practices and online resources on the built heritage hold value as historical sources; and whether it is possible to standardize the creation of digital resources so that they are recognized as having enduring evidential value.

These are fundamental questions when dealing with archives and the built heritage. In addressing them, the discussion began from the very roots of the issue: the concept of memory. As we have seen, memory - together with history and the notion of the historical source - is not fixed, but evolves over time, reflecting broader transformations in society and culture¹.

In recent years, this evolution has accelerated dramatically, driven by the digital transformation of nearly every aspect of daily life, and even more so by the widespread adoption of artificial intelligence across multiple domains². This shift is profound - at times unsettling in its pervasiveness and societal implications. Yet, like earlier revolutions brought about by writing, printing, and photography, it is a transformation that humanity is gradually learning to understand, manage, and harness to meet its needs and ambitions.

Over the past few decades, Europe and the rest of the world have begun to confront this transformation, often through tentative and sometimes uncoordinated efforts, gradually shaping what will become the digital memory of our time. In this context, enriching digital and digitized files with metadata and paradata emerges as one of the most effective strategies for creating resources capable of transmitting historical, cultural, and technical value into the future, rather than continuing to populate physical storage systems and cloud infrastructures with empty, context-less data³.

1. Marc Bloch, *Apologia della storia o Mestiere di storico* (Einaudi, 2009); Federico Chabod, *Lezioni di metodo storico* (Laterza, 2000); Benedetto Croce, *Theory & history of historiography* (G.C. Harrap, 1921); Jacques Le Goff, "Documento/monumento," in *Enciclopedia Einaudi*, (Einaudi, 1979).

2. Stefano Vitali, *Passato digitale. Le fonti dello storico nell'era del computer* (Bruno Mondadori, 2004).

3. Luisa Ammirati, Bethany Watrous, Amira Ftaita, Thomas Rigauts, and Michelle de Gruchy,

Many of the digital resources we produce, in fact, lack documentary value; they are often insignificant records that may offer superficial insights today but will, in the future, be completely silent to historians - who, to use Foucault's words, will be concerned with the 'questioning of the document'⁴.

However, this silence will not be the only challenge we leave to future historians. They will likely face two additional scenarios: either an unmanageable overload of data, or a complete absence of information, lost in the relentless technological progress that has so far failed to provide effective and durable solutions to the obsolescence of files, software, and hardware.

This issue is particularly evident in AEC archives, which are inherently complex and characterized by a high degree of heterogeneity in formats and software environments⁵. The conscious and structured creation of born-digital and digitized resources through standardized processes, as well as the careful and forward-looking management of archives, are topics already addressed in guidelines, best practices, and recommendations issued by authoritative national and international institutions in the cultural heritage sector. However, these frameworks are typically aimed at cultural institutions such as archives, museums, and heritage organizations, often leaving AEC researchers and professionals without clear guidance.

What, then, can be done? How can we support the historians of the future who will be called upon to interpret today's digital memory of the built heritage?

First, a fundamental shift in awareness is required among those who produce archives - architects, engineers, and construction professionals. As digital records are increasingly born digital, their archival quality depends not on *post hoc* interventions, but on informed practices at the point of creation. Metadata is not merely descriptive, but constitutive: it shapes how records are understood, interpreted, and reused. Embedding archival literacy within architectural education and continuing profes-

"Dive into Heritage: Paradata and Metadata in an Immersive Digital Heritage Experience," in *3D Research Challenges in Cultural Heritage V. Paradata, Metadata and Data in Digitisation*, ed. M. Ioannides, D. Baker, and A. Agapiou, P. Siegkas (Springer, 2024), https://doi.org/10.1007/978-3-031-78590-0_4.

4. Michel Foucault, *The Archeology of Knowledge* (Pantheon Books, 1972), 6.

5. Stefano Allegrezza, "Architecture, engineering and design archives in the digital era: state of the art, challenges and future perspectives," *APXEOH* 5, no. 5 (2022): 17, <https://u-pad.unimc.it/handle/11393/347971>.

sional development would therefore foster a more reflexive approach to documentation, encouraging practitioners to consider the lifecycle, context, and future usability of their outputs.

Second, stronger collaboration between professionals and archivists is essential. Architectural archives have historically suffered from fragmentation, loss, and inconsistency due to the absence of early dialogue between creators and custodians. As Ketelaar emphasizes, archives are not neutral repositories but socially constructed entities shaped by multiple actors⁶. A proactive, collaborative model, where archivists engage with practitioners during their active careers, can ensure more coherent appraisal, selection, and contextualization processes.

Third, the adoption of open formats and open-source software represents not only a technical solution, but also an ethical and epistemic stance. Proprietary formats risk locking architectural knowledge within closed ecosystems, undermining long-term accessibility and interoperability. Open standards facilitate preservation, enable reuse, and support the integration of heterogeneous datasets, an increasingly important requirement in interdisciplinary research and practice.

Finally, the challenge of ‘digital noise’ must be addressed with critical rigor. The ease of digital production has led to an overabundance of records, often lacking sufficient structure or contextualization. The digital paradigm privileges accumulation over selection, risking a dilution of informational value. Rather than contributing to this excess, archival strategies should prioritize the recovery, enrichment, and reinterpretation of existing materials. This involves not only technical processes of metadata enhancement, but also intellectual interventions that re-establish context, provenance, and relationships between records. In this sense, paradata - understood as documentation of interpretative and curatorial processes - plays a crucial role in making explicit the decisions underlying archival construction⁷.

However, an open issue remains in the context of structured digital resources: how can we demonstrate that such resources effectively comply with established guidelines and standards? Is it possible to imagine a tool or an institutional body responsible for validation?

The concept of the ‘validated digital object’ offers a promising fra-

6. Eric Ketelaar, “Archival contexts,” *Archeion*, no. 124 (2023): 35-56, <https://doi.org/10.4467/26581264ARC.23.003.17863>.

7. Drew Baker, “Defining paradata in heritage visualization,” in *Paradata and Transparency in Virtual Heritage*, ed. A. Bentkowska-Kafel and H. Denard (Routledge, 2012).

mework for addressing the quality and reliability of digital records in networked environments. Validation implies not only technical integrity, but also semantic richness and contextual completeness. In this perspective, metadata and paradata are not ancillary layers, but essential components of the digital object itself, enabling trust, transparency, and scholarly reuse.

In conclusion, the future of architectural archives in the digital age depends on a paradigm shift from reactive preservation to proactive curation. This entails rethinking the roles and responsibilities of all actors involved, embracing open and sustainable technologies, and developing more sophisticated approaches to metadata and paradata. Only through such integrated efforts can architectural archives continue to function as meaningful, accessible, and enduring repositories of cultural memory.

References

Chapter 01 • Bibliographic references

- Adams, Dennis. *Malraux's Shoes*. KENT Fine Art LLC, 2012.
- Benjamin, Walter. "The Work of Art in the Age of Mechanical Reproduction," in *Illumination*, edited by H. Arendt. Schocken Books, 1969.

Chapter 02 • Bibliographic references

- Assmann, Aleida. *Ricordare. Forme e mutamenti della memoria culturale*. il Mulino, 2002.
- Assmann, Jan. *La memoria culturale. Scrittura, ricordo e identità politica nelle grandi civiltà antiche*. Einaudi, 1997.
- Barthes, Roland. *Elementi di semiologia*. Einaudi, 2002.
- Benjamin, Walter. "The Work of Art in the Age of Mechanical Reproduction," in *Illumination*, edited by H. Arendt. Schocken Books, 1969.
- Bertetto, Paolo, and Alovisio, Silvio. "Immagine." *Enciclopedia Treccani. Enciclopedia del Cinema*. 2003. [https://www.treccani.it/enciclopedia/immagine_\(Enciclopedia-del-Cinema\)/](https://www.treccani.it/enciclopedia/immagine_(Enciclopedia-del-Cinema)/).
- Bohem, Gottfried. *La svolta iconica*. Meltemi, 2009.
- Bloch, Marc. *Apologia della storia o Mestiere di storico*. Einaudi, 2009.
- Bloch, Marc. *Storici e storia*. Einaudi, 1997.
- Bloch, March. *The Historian's Craft*. Alfred A. Knopf, 1959.
- Brusatin, Manlio. *Storia delle immagini*. Einaudi, 1989.
- Caminito, Maurizio. *La biblioteca nella nuvola. Utenti e servizi al tempo degli smartphone*. Editrice Bibliografica, 2018.
- Caprettini, Gian Paolo. "Immagine," In *Enciclopedia Einaudi*. Einaudi, 1979.
- Cauvin, Thomas. "Digital Public History in the United States," in *Handbook of Digital Public History*, edited by S. Noiret, M. Tebeau, and G. Zaagsma. De Gruyter, 2022.
- Chabod, Federico. *Lezioni di metodo storico*. Laterza, 2000.
- Ciappelli, Giovanni. "Memoria collettiva e memoria culturale. La famiglia fra antico e moderno." In *Annali dell'Istituto storico italo-germanico in Trento*, no. 29 (2003): 13-32.
- Cicalò, Enrico. "Saving images. Memory and oblivion of knowledge in the digital age." In *XY. Rassegna critica di studi sulla rappresentazione dell'architettura e sull'uso dell'immagine nella scienza e nell'arte*, no.

- 4 (2019): 92-107. <https://doi.org/10.15168/xy.v4i7.121>.
- Codeluppi, Vanni. "Il ruolo sociale delle immagini digitali." In *Mediascapes journal*, no. 19 (2022).
- Croce, Benedetto. *La storia come pensiero e come azione*. Laterza, 1966.
- Croce, Benedetto, *Theory & history of historiography*. G.C. Harrap, 1921.
- D'Autilia, Gabriele. *L'indizio e la prova. La storia nella fotografia*. Bruno Mondadori, 2005.
- de Coulanges, Fustel. *Histoire des Institutions politiques de l'ancienne France. La monarchie franque*. 1888.
- de Rubertis, Roberto, and Massari, Giovanna A. "Il ruolo dell'immagine nella cultura, nella scienza e nell'arte. Una riflessione sulla dimensione visuale nei diversi ambiti del sapere e sulle possibili applicazioni interdisciplinari." *UniTrentoMag*, September 1, 2015. <https://mag.unitn.it/eventi/6214/il-ruolo-dell-immagine-nella-cultura-nella-scienza-e-nell-arte>.
- De Simone, Margherita. *Disegno, rilievo, progetto. Il disegno delle idee, il progetto delle cose*. La Nuova Italia Scientifica, 1990.
- Didi-Huberman, Georges. *Storia dell'arte e anacronismo delle immagini*. Bollati Boringhieri, 2007.
- Dotto, Edoardo. "Making visible. Learning from sciences and arts." In *XY. Rassegna critica di studi sulla rappresentazione dell'architettura e sull'uso dell'immagine nella scienza e nell'arte*, no. 1 (2016): 20-35. <https://doi.org/10.15168/xy.v1i2.32>.
- Droysen, Johann G.. *Istorica: lezioni sulla enciclopedia e metodologia della stori*. Ricciardi, 1966.
- Droysen, Johann G.. *Sommario di istorica*. Sansoni, 1967.
- Erll, Astrid. *Memory in Culture*. Palgrave Macmillan, 2011.
- Febvre, Lucien. "Vers une autre Histoire." In *Revue de Métaphysique et de Morale* 54, no. 3/4 (1949).
- Foucault, Michel. *The Archeology of Knowledge*. Pantheon Books, 1972.
- Furet, François. "Il quantitativo in storia," in *Fare storia*, edited by J. Le Goff and Pierre Nora. Einaudi, 1981.
- Gabassi, Pier Giorgio, and Tassarolo, Mariselda. *Disegno e comunicazione*. FrancoAngeli, 1991.
- Gehlen, Arnold. *L'uomo nell'era della tecnica. Problemi socio-psicologici della civiltà industriale*. Armando Editore, 2003.
- Giolito, Barbara. *Intelligenza Artificiale. Una guida filosofica*. Carocci, 2007.
- Goody, Jack. *Il potere della tradizione scritta*. Bollati Boringhieri, 2002.
- Graham, Shawn, Massie, Guy, and Feuerherm, Nadine. "The Heritage Crowd Project. A Case Study in Crowdsourcing Public History," in *Writing History in the Digital Age*, edited by J. Dougherty and K. Nawrotzki. The University of Michigan Press, 2013.
- Gubern, Roman. *Immagine e messaggio nella cultura di massa*. Liguori Editore, 1992.
- Guzzi, Diego. "Per una definizione di memoria pubblica. Halbwachs, Ricoeur, Assmann, Margalit." In *Scienza & Politica. Per Una Storia Delle Dottrine* 23, no. 44 (2011): 27-39. <https://doi.org/10.6092/issn.1825-9618/2731>

- Halbwachs, Maurice. *La memoria collettiva*. Edizioni Unicopoli, 1987.
- Jedlowski, Paolo. *Memoria, esperienza e modernità. Memorie e società nel XX secolo*. FrancoAngeli, 2002.
- Jedlowski, Paolo. "Memoria," in *Parole chiave. Per un nuovo lessico delle scienze sociali*, edited by A. Melucci. Carocci, 2000.
- Jedlowski, Paolo. "Introduzione," in *La memoria collettiva*, edited by M. Halbwachs. Edizioni Unicopoli, 1987.
- Le Goff, Jacques. "Documento/monumento." In *Enciclopedia Einaudi*. Einaudi, 1979.
- Le Goff, Jacques. "Memoria." In *Enciclopedia Einaudi*. Einaudi, 1979.
- Leroi-Gourhan, André. *Gesture and Speech*. MIT Press, 1993.
- Lodolini, Elio. *Archivistica. Principi e problemi*. Franco Angeli, 1990.
- Luzzatto, Sergio. *Prima lezione di metodo storico*. Laterza, 2015.
- Liotard, Jean-François. *The Postmodern Condition: A Report on Knowledge*. Manchester University Press, 1984.
- Marrone, Gianfranco. *Prima lezione di semiotica*. Laterza, 2018.
- Meadows, Darrell R., and Sternfeld, Joshua, "Artificial Intelligence and the Practice of History: A Forum." In *The American Historical Review* 128, i. 3 (2023): 1345-1349. <https://doi.org/10.1093/ahr/rhad362>
- Menchetelli, Valeria. "Reproduce to preserve. From the disappearance of the original to the multiplied memory." In *XY. Rassegna Critica Di Studi Sulla Rappresentazione dell'architettura e sull'uso dell'immagine nella scienza e nell'arte*, no. 4 (2019): 74-91. <https://doi.org/10.15168/xy.v4i7.126>.
- Menchetelli, Valeria. "Archiving, remembering obliating. Notes on interdisciplinary connections between memory and representation," in *Connettere. Un disegno per annodare e tessere*, edited by A. Arena, M. Arena, R.G. Brandolino, D. Colistra, G. Ginex, D. Mediatì, S. Nucifora, P. Raffa. Proceedings of 42° Convegno Internazionale dei Docenti delle Discipline della Rappresentazione. FrancoAngeli, 2020.
- Mirzoeff, Nicholas. *Introduzione alla cultura visuale*. Meltemi Press, 2020.
- Mitchell, Thomas W.J. *Picture theory*. University of Chicago Press, 1994.
- Montani, Pietro. "La funzione testimoniale dell'immagine." *Treccani.XXI Secolo* (2009). [https://www.treccani.it/enciclopedia/la-funzione-testimoniale-dell-immagine_\(XXI-Secolo\)/](https://www.treccani.it/enciclopedia/la-funzione-testimoniale-dell-immagine_(XXI-Secolo)/).
- Montesperelli, Paolo. *Sociologia della memoria*. Laterza, 2003.
- Noiret, Serge. "Digital Public History," in *A Companion to Public History*, edited by D. Dean. Wiley-Blackwell, 2018.
- Noiret, Serge. "Storia contemporanea digitale," in *Il web e gli studi storici*, edited by R. Minuti. Carocci Editore, 2015.
- Nora, Pierre. "Mémoire collective," in *La nouvelle histoire*, edited by J. Le Goff. Retz, 1978.
- Pinotti, Andrea. *Alla soglia dell'immagine. Da Narciso alla realtà virtuale*. Einaudi, 2021.
- Roncaglia, Gino. *L'architetto e l'oracolo. Forme del sapere da Wikipedia a ChatGPT*. Laterza, 2023.
- Rossi, Pietro. *La memoria del sapere*. Laterza, 1988.
- Sisto, Davide. *Ricordati di me. La rivoluzione digitale tra memoria e oblio*.

- Bollati Boringhieri, 2020.
- Sontag, Susan. *On Photography*. RosettaBooks, 2005.
- Spennemann, Dirk H.R. “Generative Artificial Intelligence, Human Agency and the Future of Cultural Heritage.” *Heritage*, no.7 (2024): 3597-3609. <https://doi.org/10.3390/heritage7070170>.
- Spina, Salvatore. *Digital History. Metodologie informatiche per la ricerca storica*. Edizioni Scientifiche Italiane, 2022.
- Testa, Annamaria. “La lunga strada dell’intelligenza artificiale.” *Internazionale*. March 10, 2023. <https://www.internazionale.it/opinione/annamaria-testa/2023/03/10/storia-intelligenza-artificiale>.
- Tremolada, Luca. “La storia dell’intelligenza artificiale in due grafici.” *Il Sole 24 ore*. 24 December 2022. <https://www.infodata.ilsole24ore.com/2022/12/24/la-storia-dellintelligenza-artificiale-in-due-grafici/>.
- Valacchi, Federico. *Diventare archivisti. Competenze tecniche di un mestiere sul confine*. Editrice Bibliografica, 2015.
- Valacchi, Federico. *Gli Archivi tra storia, uso e futuro*. Editrice Bibliografica, 2020.
- Valéry, Paul. *Scritti sull’arte*. TEA, 1996.
- Vitali, Stefano. *Passato digitale. Le fonti dello storico nell’era del computer*. Bruno Mondadori, 2004.

Chapter 02 • Web references

- “Metodologia della ricerca storica,” Dizionario di storia, Treccani, accessed May 1, 2026, https://www.treccani.it/enciclopedia/metodologia-della-ricerca-storica_%28Dizionario-di-Storia%29/.

Chapter 03 • Bibliographic references

- Allegrezza, Stefano, ed. *La digitalizzazione del patrimonio culturale. Linee guida, standard, esperienza*. Civita Editoriale, 2021.
- Altobelli, Dario, Blasetti, Francesca, and Stellavato, Ornella. “Scenari della dematerializzazione in Italia. Finalità, criticità, approccio metodologico,” in *Reti di archivi per gli archivi in rete. Conservazione e accesso ai patrimoni digitali*, edited by G. Crupi, and M. Guercio. ANAI, 2017.
- Ambrosoli, Umberto, and Sideri, Massimo. *Diritto all’oblio, dovere della memoria. L’etica nella società interconnessa*. Bompiani, 2017.
- Andersson, Lisa, Huvila, Isto, and Sköld, Olle. “Foreword” in *Perspectives on Paradata. Research and Practice of Documenting Process Knowledge*, edited by L. Andersson, I. Huvila, and O. Sköld. Springer, 2024. <https://doi.org/10.1007/978-3-031-53946-6>.
- Barbuti, Nicola. *La digitalizzazione dei beni documentali. Metodi, tecniche, buone prassi*. Editrice bibliografica, 2022.
- Berners-Lee, Tim. “Linked Open Data.” <https://www.w3.org/DesignIssues/LinkedData.html>.
- Berners-Lee, Tim, Hendler, James, and Lassila, Ora. “The semantic web.” In *Scientific American* 284, no. 5 (2001).

- Berners-Lee, Tim. *Weaving the Web: the past, present and future of the World Wide Web by its inventor Tim Berners-Lee with Mark Fischetti*. HarperBusiness, 2000.
- Billah Nagoudi, El Moatez, Alcoba Inciarte, Alcides, and Muhammad, Abdul-Mageed. "Improving Archives-Focused LLMs with Retrieval Augmented Generation," in *Artificial Intelligence and Documentary Heritage*, edited by L. Duranti, and C. Rogers. SCEaR, 2024.
- Casanova, Eugenio. *Archivistica*. Arti Grafiche Lazzeri, 1928.
- Castellucci, Paola, and Gomelino, Elisabetta. "Chatbot. Un giorno, al museo." In *DigItalia 2* (2021): 9-24. [10.36181/digitalia-00034](https://doi.org/10.36181/digitalia-00034).
- Caminito, Maurizio. *La biblioteca nella nuvola. Utenti e servizi al tempo degli smartphone*. Editrice bibliografica, 2018.
- Ciandrini, Paola, ed. *Records management. ISO 154889: progettare sistemi documentali*. Editrice Bibliografica, 2020.
- Codice dell'amministrazione digitale, Decreto Legislativo 7 March, 2005, no. 82.
- Colavizza, Giovanni, Blanke, Tobias, Jeurgens, Charles, and Noordegraaf, Julia. "Archives and AI: An Overview of Current Debates and Future Perspectives." In *Journal on Computing and Cultural Heritage* 15, no. 1 (2021). <https://doi.org/10.1145/3479010>.
- Commission Recommendation of 27 October 2011 on the digitisation and online accessibility of cultural material and digital preservation.
- Commissione Tecnologie Digitali di ICOM Italia, ed. *Digitale e Tecnologie. Glossario* (2020), <https://www.icom-italia.org/wp-content/uploads/2020/10/ICOMItalia.CommissioneTecnologie.2020.Glossario-Tecnologie.pdf>.
- Crupi, Gianfranco, and Guercio, Maria, ed., *Reti di archivi per gli archivi in rete. Conservazione e accesso ai patrimoni digitali*. ANAI, 2017.
- Dalton, Kellie. *The Rise and Fall of the NFT Empire: The Social Phenomenon of Non-fungible Tokens*, degree of Master of Information at Dalhousie University, 2023. <http://hdl.handle.net/10222/82412>.
- Damiani, Concetta. *Gli archivi dell'arte. Gestione e rappresentazione tra analogico e digitale*. Editrice Bibliografica, 2023.
- De Luca, Livio, and Lo Buglio, David. "Geometry vs Semantics: Open Issues on 3D Reconstruction of Architectural Elements," in *3D Research Challenges in Cultural Heritage*, edited by M. Ioannides, and E. Quak. Springer, 2014. [10.1007/978-3-662-44630-0_3](https://doi.org/10.1007/978-3-662-44630-0_3).
- Di Marcantonio, Giorgia. "Intelligenza artificiale, Large Language Models (LLMs) e Retrieval-Augmented Generation (RAG). Nuovi strumenti per l'accesso alle risorse archivistiche e bibliografiche." In *Bibliothecae.it* 13, no. 1 (2024). <https://doi.org/10.6092/issn.2283-9364/19982>.
- Di Marcantonio, Giorgia. "Verso una descrizione artificiale?," in *L'archivio aumentato. Tempi e modi di una digitalizzazione critica*, edited by Federico Valacchi. Editrice Bibliografica, 2024.
- Disposizioni e deleghe al Governo in materia di intelligenza artificiale, Legge n. 132/25 del 23 settembre 2025, GU n. 223 del 25 settembre 2025
- Doer, Martin. "The CIDOC CRM: an ontological approach to semantic interoperability of metadata." In *AI Magazine* 24, no. 3 (2003): 75-92.

- Duranti, Luciana, and Rogers, Corinne, ed. *Artificial Intelligence and Documentary Heritage*. SCEaR, 2024.
- Duranti, Luciana, and Blanchette, Jean-François, *The Authenticity of Electronic Records: The InterPARES Approach*. 2004. https://www.interpares.org/display_file/ip1-2_dissemination_cpr_duranti_paris_2001.pdf.
- Fairfield, Joshua A.T. "Tokenized: The law of non-fungible tokens and unique digital property." *Indiana Law Journal*, v. 97. 2021. <https://www.repository.law.indiana.edu/ilj/vol97/iss4/4>.
- Feliciati, Pierluigi. "Archivi e intelligenza artificiale: sfide, rischi e opportunità per la ricerca storica." Oral presentation, Archivio di Stato di Taranto, September 19, 2025. <https://anai.org/eventi/archivi-e-intelligenza-artificiale-sfide-rischi-e-opportunita-per-la-ricerca-storica/>.
- Feliciati, Pierluigi. "Archival users and AI tools for reference and access: a study within the InterPARES Trust AI project." In *JLIS* 14, no. 3 (2023). [10.36253/jlis.it-558](https://doi.org/10.36253/jlis.it-558).
- Feliciati, Pierluigi, and Duranti, Luciana. "The responsible use of Artificial Intelligence in archives through the use of paradata." In *JLIS* 16, no. 2 (2025). <https://doi.org/10.36253/jlis.it-636>.
- Giglio, Daniela. *Per una storia della Biblioteca digitale: prototipi, definizioni, esperienze e modelli*, PhD dissertation, Università degli Studi di Firenze and Università degli Studi di Siena, 2017.
- Gilliland, Anne J., and McKemmish, Sue. "The Role of Participatory Archives in Furthering Human Rights, Reconciliation and Recovery." *Atlanti: Review for Modern Archival Theory and Practice*, no. 24 (2014): 78-88.
- Giovannini, Elisabetta Caterina. "Digital Transitions for the Use and Reuse of Digital Assets for Museum Collections," in *Transizioni. Atti del 44° Convegno Internazionale dei Docenti delle Discipline della Rappresentazione/ Transitions. Proceedings of the 44th International Conference of Representation Disciplines Teachers*, edited by M. Cannella, A. Garozzo, S. Morena. FrancoAngeli, 2023. doi.org/10.3280/oa-1016-c435.
- Giovannini, Elisabetta Caterina, Lo Turco, Massimiliano, and Mafri, Noemi. "Documenting historical research for a collection information modeling. A proposal for a digital asset management system." *ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* 2, no. 42 (2019): 519-525. <https://doi.org/10.5194/isprs-archives-XLII-2-W15-519-2019>.
- Giuvà, Linda, and Guercio, Maria, ed. *La selezione in Archivistica. Teorie, metodi, pratiche*. Carocci, 2014.
- Guercio, Maria. *Archivistica informatica. I documenti in ambiente digitale*. Carocci editore, 2021.
- Guerrini, Mauro, and Possemato, Tiziana. *Linked data per biblioteche, archivi e musei*. Editrice bibliografica, 2015.
- ICA. *ISAD(G): General International Standard Archival Description, adopted by the Committee on Descriptive Standards*, Stockholm, Sweden, 19-22 September 1999, https://www.ica.org/app/uploads/2024/01/CBPS_2000_Guidelines_ISADG_Second-edition_EN.pdf.
- Imboden, Silvio, Guidazzoli, Antonella, Cardano, Giorgia, Mattei, Luca, An-

- drucci, Federico, Shemek, Deanna, Pansini, Rossella, Albertin, Fauzia, and Liguori, Maria C. "An Open-Source Workflow for Handwritten Character Recognition," in *Digital Heritage*, edited by S. Campana, D. Ferdani, H. Graf, G. Guidi, Z. Hegarty, S. Pescarin, and F. Remondino. 2025. [10.2312/dh.20253069](https://doi.org/10.2312/dh.20253069).
- InterPARES, *Authenticity Task Force Final Report*. 2001. https://www.interpares.org/documents/atf_draft_final_report.pdf.
- InterPARES, *Preservation Task Force Final Report*. 2001. https://www.interpares.org/documents/ptf_draft_final_report.pdf.
- Istituto Centrale per la Digitalizzazione del Patrimonio Culturale - Digital Library, *Linee guida per la digitalizzazione del patrimonio culturale. Versione 1.0 – giugno 2022*. Ministero della Cultura, 2022.
- Kahle, Brewster. "Preserving the internet." In *Scientific American* 3, no. 276 (1997): 72-74.
- Kastenhofer, Julia. "The logic of archival authenticity: ISO 15489 and the varieties of forgeries in archives." *Archives and Manuscripts* 3, no. 43 (2015): 166-180. <https://doi.org/10.1080/01576895.2015.1074085>.
- Lévi-Strauss, Claude. *Il pensiero selvaggio*. il Saggiatore, 1964.
- Lvping, Shen. "Blockchain Technology for Management of Intangible Cultural Heritage." In *Hindawi. Scientific Programming* 2021. 2021. <https://doi.org/10.1155/2021/2613656>.
- Masanès, Julien. *Web Archiving*. Springer, 2007.
- Morriello, Rossana. "Blockchain, intelligenza artificiale e internet delle cose in biblioteca." In *Aib Studi*, no. 59, i. 1-2. 2019. <https://doi.org/10.2426/aibstudi-11927>.
- Mustajap, Siti Irna, Husain, Adzira, Zaibon, Syamsul Bahrin, Helmi, Mohd Amirul, and Hamid, Mohd Noor Abdul. "The Potential of Non-Fungible Tokens (NFTs) In Enhancing Malaysia's Arts and Cultural Heritage Preservation." In *paperASIA*, no. 40. 2024. <https://doi.org/10.59953/paperasia.v40i6b.282>.
- Nakamoto, Satoshi. *Bitcoin: A Peer-to-Peer Electronic Cash System*. 2009. <https://bitcoin.org/bitcoin.pdf>.
- Owens, Trevor. *Theory and Craft of Digital Preservation*. Johns Hopkins University Press, 2018.
- Paoli, Cesare. *Diplomatica*. Le Lettere, 1987.
- Patel, Sanskruti. "A Comprehensive Analysis of Convolutional Neural Network Models." In *International Journal of Advanced Science and Technology* 29, no.4 (2020): 771-777.
- Pedone, Thea. "Sistemi informativi (archivi) digitali iconografici," in *Metodi, applicazioni, tecnologie. Colloqui del dottorato di ricerca in Storia, Disegno e Restauro dell'Architettura*, edited by A. Carannante, S. Lucchetti, S. Menconero, A. Ponzetta. Sapienza Università Editrice, 2022.
- Petrova, Tatiana, Bliznioukov, Boris, Puzikov, Aleksandr, and State, Radu. "From Semantic Web and MAS to Agentic AI: A Unified Narrative of the Web of Agents." In *ArXiv*, no. 2507 (2025), <https://doi.org/10.48550/arXiv.2507.10644>.
- Philips, James, and Tabrizi, Nasseh. "Historical Document Processing: A Survey of Techniques, Tools, and Trends," in *Proceedings of the 12th In-*

- ternational Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management*, v. 1 (KDIR, 2020): 341-349. [10.5220/0010177403410349](https://doi.org/10.5220/0010177403410349).
- Plessi, Giuseppe. *Compendio di archivistica*. CLUEB, 1990.
- Pratesi, Alessandro. *Genesi e forme del documento medievale*. Jouvence, 1987.
- Riscica, Rossella, and Voltarel, Chiara, ed. *Treviso urbs picta. Facciate affrescate della città dal XIII al XXI secolo: conoscenza e futuro di un bene comune*. Fondazione Benetton Studi Ricerche - Antiga, 2017.
- Romein, Annemieke C., Kemman, Max, Birkholz, Julie M., Baker, James, De Gruijter, Michel, Meroño-Peñuela, Albert, Ries, Thorsten, Ros, Ruben, and Scagliola, Stefania. "State of the field: Digital history." In *History* 105, no. 365 (2020): 291-312. <https://doi.org/10.1111/1468-229X.12969>.
- Sabiescu, Amalia G. "Living Archives and The Social Transmission of Memory." In *Curator*, no. 63 (2020): 497-510. <https://doi.org/10.1111/cura.12384>.
- Smallwood, Robert. *Information Governance: Concepts Strategies and Best Practices*. Wiley, 2015.
- Smith, David, and Cordell, Ryan. "A research agenda for historical and multi-lingual optical character recognition," in *NUlab*. Northeastern University Report, 2018. <https://ocr.northeastern.edu/report>.
- Stublić, Helena, Bilogrivić, Matea, and Zlodi, Goran. "Blockchain and NFTs in the Cultural Heritage Domain: A Review of Current Research Topics." In *Heritage*, no. 6. 2023. <https://doi.org/10.3390/heritage6040202>.
- Valacchi, Federico. "Archivi storici e risorse tecnologiche," in *Archivi e informatica*, edited by A. Romiti, M. Guercio, S. Pigliapoco, and F. Valacchi. Civita editoriale, 2010.
- Valacchi, Federico. "Contenitori e contenuti. L'offerta archivistica nel web." *Archivi* IV, no.1 (2009): 33-72.
- Valacchi, Federico. *Diventare archivisti. Competenze tecniche di un mestiere sul confine*. Editrice Bibliografica, 2015.
- Valacchi, Federico. *L'archivio aumentato. Tempi e modi di una digitalizzazione critica*. Editrice Bibliografica, 2024.
- Valacchi, Federico. "Se l'archivio è artificiale. Verso uno ius archivi partecipativo?" In *AIDAinformazioni. Rivista semestrale di scienze dell'informazione* 41, no. 1-2, Cacucci editore (2023): 153-170. <https://doi.org/10.57574/596529288>.
- Valacchi, Federico. "The Season of Living Archives: a Generative Provenance." In *JLIS* 15, no. 2 (2024): 52-60. <https://doi.org/10.36253/jlis.it-597>.
- Veninata, Chiara. "Al servizio degli utenti: Archivi e Sala Studio." Oral presentation, Archivio di Stato di Taranto, November 12, 2024. <https://www.youtube.com/watch?v=-mV2LWK7Sxs>.
- van Bussel, Geert-Jan. "Determining the value of a Digital Archive: The Framework for the 'Archive-As-Is'," in *From Dust to Dawn. Archival Studies After the Archival Turn*, edited by A. Öhrberg, T. Berndtsson, O. Fischer, A. Mattsson. Uppsala Rhetorical Studies, 2021.
- Vessia, Francesca. "DAW, NFT, IA e diritti sulle immagini dei beni culturali."

- IMMERSINSCENA. November 25, 2024. <https://www.immersinscena.org/daw-nft-ia-e-diritti-sulle-immagini-dei-beni-culturali/>.
- Vitali, Stefano. *Passato digitale. Le fonti dello storico nell'era del computer*. Bruno Mondadori, 2004.
- Vitali, Stefano. "Premessa," in *Il potere degli archivi. Usi del passato e difesa dei diritti nella società contemporanea*, edited by L. Giuva, S. Vitali, and I. Zanni Rosiello. Bruno Mondadori, 2007.
- Weston, Paul G. "Digital curation. Nuove opportunità per bibliotecari e archivisti," in *Il libro, gli archivi e la memoria digitale*, edited by P.G. Weston. Edizioni Unicopli, 2013.
- Witte, Jessica, Lee, Edmund, Brausem, Lisa, Shillabeer, Verity, and Bonacchi, Chiara. "Generative AI in Heritage Practice: Improving the Accessibility of Heritage Guidance." In *arXiv*, no. 2510 (2025). <https://doi.org/10.48550/arXiv.2510.13811>.
- Yeo, Geoffrey. "Trust and context in cyberspace." In *Archives and Records*, no. 34 (2013): 214-234. <https://doi.org/10.1080/23257962.2013.825207>.
- Zanni Rosiello, Isabella. *Andare in archivio*. il Mulino, 1996.

Chapter 03 • Web references

- Agenzia per l'Italia Digitale. "L'Agenzia." accessed May 1, 2026. <https://www.agid.gov.it/it/agenzia>.
- Agenzia per l'Italia Digitale. "Qualified Electronic Signature." accessed May 1, 2026. <https://www.agid.gov.it/en/platforms/qualified-electronic-signature>.
- CIRICE. "Naples Digital Archive. Moving Through Time and Space." accessed May 1, 2026. <https://www.iconografiacittaeuropea.unina.it/cms/naples-digital-archive-2/>.
- Dictionary of Archives Terminology, accessed May 1, 2026. <https://dictionary.archivists.org/entry/archival-bond.html>.
- Digital Library. "Online il nuovo sito di I.PaC – Infrastruttura e servizi per il Patrimonio Culturale. Il primo punto di accesso all'infrastruttura tecnologica di Ecomic." Last modified August 18, 2025. <https://digital-library.cultura.gov.it/notizie/online-il-nuovo-sito-di-i-pac-infrastruttura-e-servizi-per-il-patrimonio-culturale/>.
- Directorate General for Communication. "EU AI Act: first regulation on artificial intelligence." February 19, 2025. https://www.europarl.europa.eu/pdfs/news/expert/2023/6/story/20230601STO93804/20230601STO93804_en.pdf.
- Direzione Generale per gli Archivi. "Glossario." accessed May 1, 2026. <http://2.42.228.207/archivi/index.php/abc-degli-archivi/glossario>.
- Direzione Generale per gli Archivi. "Sistema Guida generale degli Archivi di Stato italiani." accessed May 1, 2026. <http://www.guidageneralearchivistato.beniculturali.it/>.
- European Commission. "Ethics guidelines for trustworthy AI." accessed May 1, 2026. <https://digital-strategy.ec.europa.eu/en/library/ethics-guidelines-trustworthy-ai>.
- GO FAIR. "FAIR Principles." accessed May 1, 2026. <https://www.go-fair.org/>

- /fair-principles/*.
- Infrastruttura digitale per il patrimonio informativo culturale. accessed May 1, 2026. <https://ecommic.cultura.gov.it/ipac>.
- Interference Archive, accessed May 1, 2026. <https://interferencearchive.org/>.
- International Council on Archives (ICA), accessed May 1, 2026. <https://www.ica.org/>.
- International Organization for Standardization, accessed May 1, 2026. <https://www.iso.org/home.html>.
- InterPARES Trust AI, accessed May 1, 2026. <https://interparestrustai.org/>.
- Istituto Centrale per gli Archivi - ICAR. "ISAD (G)." accessed May 1, 2026. <https://icar.cultura.gov.it/standard/standard-internazionali/isad-g>.
- International Council on Archives. "ISAD(G): General International Standard Archival Description." accessed May 1, 2026. <https://www.ica.org/resource/isadg-general-international-standard-archival-description-second-edition/>.
- Istituto centrale per la digitalizzazione del patrimonio culturale – Digital Library, accessed May 1, 2026. <https://digitallibrary.cultura.gov.it/>.
- Namiral Focus. "Documents for which you may need a time stamp." accessed May 1, 2026. <https://focus.namirial.com/en/documents-for-which-you-may-need-a-time-stamp/>.
- SAN. "Il Catalogo delle Risorse Archivistiche." accessed May 1, 2026. <http://san.beniculturali.it/web/san/ricerca-negli-archivi>.
- The September 11 Digital Archive. Saving the histories of September 11, 2001. accessed May 1, 2026. <https://911digitalarchive.org/>.
- TOTEM. 4D Trento Time Machine, accessed May 1, 2026. <https://totem.fbk.eu/>.
- Trentino Cultura. "Il Sistema informativo degli archivi storici del Trentino - AST." accessed May 1, 2026. <https://www.cultura.trentino.it/archivistorici/home>.
- Treviso Urbs Picta. accessed May 1, 2026. <https://trevisourbspicta.fbsr.it/>.
- Ukraine War Archive. The largest independent multi-media archive of Russia's war in Ukraine. accessed May 1, 2026. <https://ukrainewararchive.org/eng/>.
- W3C Community & Business. "What is 5 Star Linked Data?" accessed May 1, 2026. <https://www.w3.org/community/webize/2014/01/17/what-is-5-star-linked-data/>.
- W3C Working Group Note. "Best Practices for Publishing Linked Data." accessed May 1, 2026. <https://www.w3.org/TR/ld-bp/>.
- W3C Working Group Note. "Linked Data Glossary." accessed May 1, 2026. <https://www.w3.org/TR/ld-glossary/#linked-open-data>.

Chapter 04 • Bibliographic references

- Abergel, Violette, Jacquot, Kevin, De Luca, Livio, and Veron, Philippe. "Combining on-site and off-site analysis: towards a new paradigm for cultural heritage surveys." In *Disegnarecon* 14, no. 26 (2021). <https://doi.org/10.20365/disegnarecon.26.2021.13>.
- Attenni, Martina, Bianchini, Carlo, Griffio, Marika, and Senatore, Luca J.

- “HBIM Meta-Modelling: 50 (and More) Shades of Grey.” In *ISPRS International Journal of Geo-Information*, no. 11, 468 (2022). <https://doi.org/10.3390/ijgi11090468>.
- Balsa-Barreiro, José, and Fritsch, Dieter. “Generation of visually aesthetic and detailed 3D models of historical cities by using laser scanning and digital photogrammetry.” In *Digital Applications in Archaeology and Cultural Heritage*, v. 8 (2018): 57-64. <https://doi.org/10.1016/j.daach.2017.12.001>.
- Banfi, Fabrizio. “The Evolution of Interactivity, Immersion and Interoperability in HBIM: Digital Model Uses, VR and AR for Built Cultural Heritage.” In *ISPRS Int. J. Geo-Inf.*, no. 10 (2021): 685. <https://doi.org/10.3390/ijgi10100685>.
- Banfi, Fabrizio, Brumana, Raffaella, and Stanga, Chiara. “Extended Reality and informative models for the architectural heritage: from scan-to-BIM process to Virtual and Augmented Reality.” In *Virtual Archaeology Review* 21, no. 10 (2019): 14-30. <https://doi.org/10.4995/var.2019.11923>.
- Barazzetti, Luigi. “Parametric as-built model generation of complex shapes from point clouds.” In *Advanced Engineering Informatics*, v. 30, i. 3 (2016): 298-311. <https://doi.org/10.1016/j.aei.2016.03.005>.
- Barazzetti, Luigi, Banfi, Fabrizio, Brumana, Raffaella, and Previtali, Mattia. “Creation of Parametric BIM Objects from Point Clouds Using Nurbs.” In *The Photogrammetric Record*, no. 30 (2015): 339-362. <https://doi.org/10.1111/phor.12122>.
- Barbini, Ambra. “Integrazione automatizzata e parametrica di oggetti BIM in un contesto urbano. Automatic and parametric integration of BIM objects in an urban context,” in *3D MODELING & BIM: Digital Twin 3*, edited by T. Empler, A. Caldarone, and A. Fusinetti. DEI s.r.l. Tipografia del Genio Civile, 2021.
- Barbini, Ambra, and Chioni, Chiara. “Reality vs Virtual Modelling. From Building to Landscape Heritage Representation,” in *Proceedings of the 26th International Conference on Cultural Heritage and New Technologies*. Propylaeum, 2021. [10.11588/propylaeum.1449.c20776](https://doi.org/10.11588/propylaeum.1449.c20776).
- Barbini, Ambra, Giampiccolo, Francesco, Maragno, Anna, Massari, Giovanna A., and Pellegatta, Cristina. “Innovation and tradition: integrated practices in the architectural survey of Pretorio palace in Trento.” In *SCientific RESearch and Information Technology Ricerca Scientifica e Tecnologie dell’Informazione*, v. 14, i. 1 (2024): 45-62. <http://dx.doi.org/10.2423/i22394303v14n1p45>.
- Bernardini, Elena. “Tecniche di rappresentazione e modellazione per il progetto sul patrimonio del Novecento,” in *3D MODELING & BIM: Digital Twin 3*, edited by T. Empler, A. Caldarone, and A. Fusinetti. DEI s.r.l. Tipografia del Genio Civile, 2021.
- Bianchini, Carlo. “Metamodelling.” In *Disegnare. Idee immagini XXXIV*, no. 66 (Gangemi Editore, 2023): 80-95.
- Bianchini, Carlo. “Modelli discreti e modelli continui nel rilievo e rappresentazione informatizzata dell’architettura.” In *Disegnare. Idee immagini XII*, no. 22 (Gangemi editore, 2001): 51-60.
- Bianchini, Carlo. “Survey, modeling, interpretation as multidisciplinary com-

- ponents of a Knowledge System.” In *SCientific RESearch and Information Technology Ricerca Scientifica e Tecnologie dell'Informazione* 4, i. 1 (2014): 15-24. <http://dx.doi.org/10.2423/i22394303v4n1p15>.
- Bianchini, Carlo, Inglese, Carlo, and Ippolito, Alfonso. *I Teatri Antichi del Mediterraneo come esperienza di rilevamento integrato / The Ancient Theatres of the Mediterranean as integrated survey experience*. Sapienza Università Editrice, 2016.
- Bianchini, Carlo, and Russo, Michele. “Massive 3D acquisition of CH,” in *3rd Digital Heritage International Congress (DigitalHERITAGE)*, 24th International Conference on Virtual Systems & Multimedia (2018).
- Bianconi, Fabio, Filippucci, Marco, Cornacchini, Filippo, Meschini, Michela, and Mommi, Chiara. “Cultural Heritage And Virtual Reality: Application For Visualization Of Historical 3d Reproduction.” In *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences XLVIII-M-2-2023* (2023): 203-210. <https://doi.org/10.5194/isprs-archives-XLVIII-M-2-2023-203-2023>.
- Bocchi, Renato, and Oradini, Carlo. *Le città nella storia d'Italia*. Trento. Laterza, 1983.
- Bolognesi, Cecilia. “From heritage to massive future fruition,” in *Digital & Documentation. Digital strategies for Cultural Heritage*, edited by M. Lo Turco, E.C. Giovannini, and N. Mafri, v. 2. Pavia University Press, 2020.
- Boriani, Maurizio. “Rilievo, tutela e conservazione del paesaggio antropico.” In *XY Dimensioni del disegno XII*, no. 32-33 (Officina Edizioni, 1998): 40-43.
- Cassar, Anthony, Baker, Drew, and Ioannides, Marinos. “From Digital Twin to Memory Twin: A Holistic Framework for Cultural Heritage Documentation, Interpretation, and Adaptive Reuse.” In *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.* XLVIII-M-9-2025 (2025): 203-209, <https://doi.org/10.5194/isprs-archives-XLVIII-M-9-2025-203-2025>.
- Catana, Luca, D'Acunto, Giuseppe, and Vattano, Starlight. “Archive Drawing in Digital Reconstructions. Unbuilt Venice in Cannaregio Ovest (1978).” In *TRIA* 15, no. 1 (2022): 19-40. <https://doi.org/10.6093/2281-4574/9252>.
- Chiabrando, Filiberto, Sammartano, Giulia, and Spanò, Antonia. “Historical Buildings Models and Their Handling Via 3D Survey: From Points Clouds To User-Oriented Hbim.” *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci.* XLI-B5 (2016): 633-640. <https://doi.org/10.5194/isprs-archives-XLI-B5-633-2016>.
- Chioni, Chiara, Maragno, Anna, Pianegonda, Angelica, Ciolli, Marco, Favargiotti, Sara, and Massari, Giovanna A. “Low-Cost 3D Virtual and Dynamic Reconstruction Approach for Urban Forests: The Mesiano University Park.” In *Sustainability* 15, no. 19 (2023). <https://doi.org/10.3390/su151914072>.
- Chioni, Chiara, Murtiyoso, Arnadi, Favargiotti, Sara, and Massari, Giovanna A. “Low-Cost Workflow For 3d Urban Forest Virtual Reconstruction.” In *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences XLVIII-1/W2-2023* (2023): 1723-1728.

- <https://doi.org/10.5194/isprs-archives-XLVIII-1-W2-2023-1723-2023>.
- Chiavoni, Emanuela, and Filippa, Monica, ed. *Metodologie integrate per il rilievo, il disegno, la modellazione dell'architettura e della città*. Gangemi editore, 2011.
- Çubuk, Gencay. "3D printing for the reinterpretation of architectural heritage: Proposal of a model." In *Cultural Heritage and Science*, no. 5, i. 1 (2024): 24-37. <https://doi.org/10.58598/cuhes.1415522>.
- Cursi, Stefano, Calvano, Michele, Martinelli, Letizia, Cessari, Luciano, Calcerano, Filippo, and Gigliarelli, Elena. "Digital processes for the conservation and valorisation of built heritage," in *Digital Humanities & Heritage*, edited by K. Kuzman Šlogar, and A. Žugić Borić. Institute of Ethnology and Folklore Research, University of Zadar, 2024. <https://hdl.handle.net/11573/1729148>.
- De Luca, Livio. "Un ecosistema digitale per lo studio interdisciplinare di Notre-Dame de Paris." In *Disegnare. Idee immagini XXXIV*, no. 66 (Gangemi Editore, 2023).
- De Luca, Livio, Busayarat, Chawee, Stefani, Chiara, Véron, Philippe and Florenzano, Michel. "A semantic-based platform for the digital analysis of architectural heritage." In *Computers & Graphics*, v. 35, i. 2 (2011): 227-241. <https://doi.org/10.1016/j.cag.2010.11.009>.
- De Simone, Margherita. *Disegno, rilievo, progetto. Il disegno delle idee, il progetto delle cose*. La Nuova Italia Scientifica, 1990.
- de Rubertis, Roberto. "Editoriale." In *XY. Dimensioni del disegno. Rappresentazione e verità*, no. 32-33 (Officina Edizioni, 1998): 3-4.
- de Rubertis, Roberto. "Riflessioni sulle nuove tendenze." In *XY Dimensioni del disegno IX*, no. 23-24-25 (Officina Edizioni, 1995): 12-13.
- Docci, Mario, and Bianchini, Carlo. "Editoriale. Il ruolo dei modelli virtuali 3D nella conservazione del patrimonio architettonico e archeologico." In *Disegnare idee immagini XXVII*, no. 53 (Gangemi Editore, 2016), 3-6.
- Empler, Tommaso, Caldarone, Adriana, and Fusinetti, Alexandra. "L'interazione visibile: transizioni tra modelli analogici e digitali per le ricostruzioni storiche/Visible Interaction: Transitions between Analogical and Digital Models for Historical Reconstructions," in *Transizioni. Atti del 44° Convegno Internazionale dei Docenti delle Discipline della Rappresentazione/Transitions. Proceedings of the 44th International Conference of Representation Disciplines Teachers*, edited by M. Cannella, A. Garozzo, and S. Morena (FrancoAngeli, 2023). doi.org/10.3280/oa-1016-c346.
- European Commission, *Bussola per il digitale 2030: il modello europeo per il decennio digitale* (2021), <https://digital-strategy.ec.europa.eu/en/news/commission-proposes-common-european-data-space-cultural-heritage>.
- European Commission, *Study on quality in 3D digitisation of tangible cultural heritage: mapping parameters, formats, standards, benchmarks, methodologies, and guidelines*, VIGIE 2020/645 (2022)
- Fasolo, Marco. "Il rilievo come modello conoscitivo." In *XY. Dimensioni del disegno IX*, no. 23-24-25 (Officina Edizioni, 1995), 103-107.

- Ferro, Alessandra, Lo Brutto, Mauro, and Ventimiglia, Gaspare M. "Scan-to-BIM process for the monitoring and conservation of the architectural heritage: integration of thematic information in a HBIM model." In *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* XLVIII-M-2-2023 (2023), 549-556. <https://doi.org/10.5194/isprs-archives-XLVIII-M-2-2023-549-2023>.
- Foucault, Michel. *L'archeologia del sapere. Una metodologia per la storia della cultura*. BUR Rizzoli, 2020.
- Fusco, Giuseppe. "Rilievo e memoria." In *XY. Dimensioni del disegno* V, no. 11-12 (Officina Edizioni, 1991): 128-130.
- Gajski, Dubravko, Župan, Robert, Racetin, Ivana, and Krstic, Ruzica "Straight-forward Stereoscopic Techniques for Archaeometric Interpretation of Archeological Artifacts." In *Heritage*, no. 6 (2023): 5066-5081. <https://doi.org/10.3390/heritage6070268>
- Guagenti, Elisa. "Modello, ovvero conoscere per decidere," in *Tempo forma immagine dell'architettura. Scritti in onore di Vittorio Ugo con due suoi testi inediti*, edited by G.A. Massari. Officina Edizioni, 2010.
- Guercio, Mariella. *Conservare il digitale. Principi, metodi e procedure per la conservazione a lungo termine di documenti digitali*. Laterza, 2013.
- Herban, Sorin, Costantino, Domenica, Alfio, Vincenzo S. and Pepe, Massimiliano. "Use of Low-Cost Spherical Cameras for the Digitisation of Cultural Heritage Structures into 3D Point Clouds." In *Imaging* 8, no. 13 (2022). <https://doi.org/10.3390/jimaging8010013>.
- Innocente, Chiara, Ulrich, Luca, Moos, Sandro, and Vezzetti, Enrico. "A framework study on the use of immersive XR technologies in the cultural heritage domain." In *Journal of Cultural Heritage*, v. 62 (2023): 268-283. <https://doi.org/10.1016/j.culher.2023.06.001>.
- Ippolito, Alfonso, Palmadessa, Claudia, Noursati Kordkandi, Mahsa, and Arias Tapiero, Juan C. "The Domus of the Calendar: a qualitative comparison analysis of digital data obtained from 3D laser scanners, SfM methodologies and portable devices." In *Archeologia e Calcolatori*, no. 34.2 (2023): 247-262. <https://doi.org/10.19282/ac.34.2.2023.13>.
- Janiszewski, Mateusz, Torkan, Masoud, Uotinen, Lauri, and Rinne, Mikael. "Rapid Photogrammetry with a 360-Degree Camera for Tunnel Mapping." In *Remote Sensing* 2022 14, no. 21 (2022). <https://doi.org/10.3390/rs14215494>.
- Jones, David, Snider, Chris, Nassehi, Aydin, Yon, Jason, and Hicks, Ben. "Characterising the Digital Twin: A systematic literature review." In *CIRP Journal of Manufacturing Science and Technology* 29, p. A (2020): 36-52. <https://doi.org/10.1016/j.cirpj.2020.02.002>.
- Jouan, Pierre, and Hallot, Pierre. "Digital twin: a HBIM-based methodology to support preventive conservation of historic assets through heritage significance awareness." In *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* XLII-2/W15 (2019): 609-615. [10.5194/isprs-archives-XLII-2-W15-609-2019](https://doi.org/10.5194/isprs-archives-XLII-2-W15-609-2019).
- Kantaros, Antreas, Ganetsos, Theodore, and Petrescu, Florian I.T. "Three-Dimensional Printing and 3D Scanning: Emerging Technologies Exhibiting High Potential in the Field of Cultural Heritage." In *Applied Scienc-*

- es, no. 13 (2023). <https://doi.org/10.3390/app13084777>.
- Kolbe, Thomas H., and Donaubaauer, Andreas. "Semantic 3D City Modeling and BIM," in *Urban Informatics. Singapore: The Urban Book Series*, edited by W. Shi, M.F. Goodchild, M. Batty, M.P. Kwan, and A. Zhang. Springer, 2021. https://doi.org/10.1007/978-981-15-8983-6_34.
- Lo Brutto, Mauro, Iuculano, Emanuele, and Lo Giudice, Paolo. "Integrating topographic, photogrammetric and laser scanning techniques for a scan-to-BIM process." In *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences XLIII-B2-2021* (2021), 883-890. <https://doi.org/10.5194/isprs-archives-XLIII-B2-2021-883-2021>.
- Maragno, Anna, Barbini, Ambra, Bernardini, Elena, Chioni, Chiara, and Massari, Giovanna A. "La misura per la dismisura dei dati da rilievo digitale 3D. Il caso del centro storico di Trento = The Measure for Uncountable data from 3D Digital Survey. The Case of the Historical Centre of Trento," in *Misura / Dismisura. Atti del 45° Convegno Internazionale dei Docenti delle Discipline della Rappresentazione = Measure / Outline of Measure. Transitions. Proceedings of the 45th International Conference of Representation Disciplines Teachers*, edited by F. Bergamo, A. Calandriello, M. Ciammaichella, I. Friso, F. Gay, G. Liva, and C. Monteleone (FrancoAngeli, 2024), 1679-1698. [10.3280/oa-1180-c554](https://doi.org/10.3280/oa-1180-c554).
- Maragno, Anna, and Volpi, Cristiana. *Dove Trento si ingegna. Il ruolo degli ingegneri nello sviluppo della città di Trento nel corso del XIX secolo*. Edizioni Efesto, 2023.
- Massari, Giovanna A. "Del rigore della misura." In *XY. Dimensioni del disegno. Rappresentazione e verità* 9, no. 47 (Officina Edizioni, 2005): 105-116.
- Massari, Giovanna A., Pellegatta, Cristina, and Bonaria, Elena. *Rilievo urbano e ambientale. Appunti, repertorio iconografico, antologia critica*. Libreria Clup, 2006.
- Melucci, Alberto, and Nider, Flavio. "Fotografia, infografica e rilievo d'architettura," in *Gli archivi per la storia dell'architettura*, Atti del convegno internazionale di studi, Reggio Emilia, 4-8 ottobre 1993 (1999).
- Montusiewicz, Jerzy, Barszcz, Marcin, and Korga, Sylwester. "Practical Aspects of Using 3D Technology to Disseminate Cultural Heritage Among Visually Impaired People," in *Learning in the Age of Digital and Green Transition*, edited by M.E. Auer, W. Pachatz, and T. Rüütmann, v. 633. Springer, 2023. https://doi.org/10.1007/978-3-031-26876-2_45.
- Murphy, Maurice, McGovern, Eugene, and Pavia, Sara. "Historic building information modelling (HBIM)." In *Structural Survey*, v. 27, no. 4 (2009): 311-327. <https://doi.org/10.1108/02630800910985108>.
- Migliari, Riccardo. *Geometria dei modelli: rappresentazione grafica e informatica per l'architettura e per il design*. Kappa, 2003.
- Pescarin, Sofia. "Digital heritage into practice." In *Scientific REsearch and Information Technology Ricerca Scientifica e Tecnologie dell'Informazione*, v. 6, i. 1 (2016): 1-4. <http://dx.doi.org/10.2423/i22394303v6n1p1>.
- Pocobelli, Danae P., Boehm, Jan, Bryan, Paul, Still, James, and Grau-Bové, Josep. "BIM for heritage science: a review." In *Heritage Science* 1, no.

- 6 (2018). <https://doi.org/10.1186/s40494-018-0191-4>.
- Purini, Franco. "Tre divagazioni al margine." In *XY Dimensioni del disegno. Nuove tendenze IX*, no. 23-24-25 (Officina, 1995): 15-18.
- Quattrini, Ramona, Pierdicca, Roberto, Frontoni, Emanuele, and Barcagliani, R. "Virtual Reconstruction Of Lost Architectures: From The Tls Survey To Ar Visualization." In *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences XLI-B5* (2016): 383-390. <https://doi.org/10.5194/isprs-archives-XLI-B5-383-2016>.
- Quici, Fabio. "Un progetto per la rappresentazione," in *Tempo forma immagine dell'architettura*, edited by G.A. Massari. Officina Edizioni, 2010.
- Radanovic, Marko, Khoshelham, Kourosh, and Fraser, Clive. "Geometric Accuracy and Semantic Richness in Heritage BIM: A Review." In *Digital Applications in Archaeology and Cultural Heritage*, v. 19 (2020). <https://doi.org/10.1016/j.daach.2020.e00166>.
- Remondino, Fabio. "Heritage Recording and 3D Modeling with Photogrammetry and 3D Scanning." In *Remote Sensing* 6, no. 3 (2011): 1104-1138. <https://doi.org/10.3390/rs3061104>.
- Remondino, Fabio. "Il rilievo 3D fotogrammetrico," in *Teorie e tecniche della rappresentazione contemporanea*, edited by R. Salerno. Maggioli Editore, 2011.
- Rinaudo, Fulvio. "From physical to digital models," in *Digital & Documentation. Digital strategies for Cultural Heritage*, edited by M. Lo Turco, E.C. Giovannini, and N. Mafri, v. 2. Pavia University Press, 2020.
- Shaer, Orit, and Hornecker, Eva. "Tangible User Interfaces: Past, Present and Future Directions." In *Foundations and Trends in Human-Computer Interaction*, v. 3, no. 1-2 (2010): 4-137. <http://dx.doi.org/10.1561/11000000026>.
- Stylianidis, Efstratios, Evangelidis, Konstantinos, Vital, Rebeka, Dafiotis, Panagiotis, and Sylaiou, Stella. "3D Documentation and Visualization of Cultural Heritage Buildings through the Application of Geospatial Technologies." In *Heritage* 5, no. 4 (2022): 2818-2832. <https://doi.org/10.3390/heritage5040146>.
- Tucci, Grazia, Balletti, Caterina, Bonora, Valentina, Fassi, Francesco, Spanò, Antonia, Parisi, Erica I., Previtali, Mattia, and Sammartano, Giulia. "Documenting, understanding, preserving cultural heritage. Humanities and digital technologies for shaping the future: preface." In *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences X-M-1-2023* (2023). <https://doi.org/10.5194/isprs-annals-X-M-1-2023-1-2023>.
- Ugo, Vittorio. *Architettura e temporalità*. Edizioni Unicopli, 2008.
- Ugo, Vittorio. *Fondamenti della rappresentazione architettonica*. Progetto Leonardo, 1994.
- Ugo, Vittorio. "Misura-interpretazione-conoscenza-interpretazione-misura: circolo vizioso, o virtuoso?" In *XY Dimensioni del disegno. Rappresentazione e verità*, no. 32-33 (Officina Edizioni, 1998): 19-24.
- UNESCO, *Convention Concerning the Protection of the World Cultural and Natural Heritage*. 1972. <https://whc.unesco.org/archive/convention-en.pdf>.

- UNESCO, *The 2009 UNESCO framework for Cultural Statistics (FCS)*. UNESCO Institute for Statistics, 2009. <https://unesdoc.unesco.org/ark:/48223/pf0000191061>.
- Vacca, Giuseppina. “3D Survey with Apple LiDAR Sensor - Test and Assessment for Architectural and Cultural Heritage.” In *Heritage*, no. 6 (2023): 1476-1501. <https://doi.org/10.3390/heritage6020080>.
- Valacchi, Federico. *La memoria integrata nell'era digitale. Continuità archivistica e innovazione tecnologica*. Archilab, 2006.
- Valacchi, Federico. *La verità di carta. A cosa servono gli archivi?*. Graphe.it, 2023.
- Velo, Uliva. “Alcune considerazioni sul significato di modello d'architettura,” in *Metodologie integrate per il rilievo, il disegno, la modellazione dell'architettura e della città*, edited by E. Chiavoni, and M. Filippa. Gangemi editore, 2011.
- Weston, Paul G. “Digital curation. Nuove opportunità per bibliotecari e archivisti,” in *Il libro, gli archivi e la memoria digitale*, edited by P.G. Weston. Unicopli, 2013.
- Wu, Shaoze, Hou, Lei, and Zhang, Guomin. “Integrated Application of BIM and eXtended Reality Technology: A Review, Classification and Outlook,” in *Proceedings of the 18th International Conference on Computing in Civil and Building Engineering* (2021), 1227-1236. [10.1007/978-3-030-51295-8_86](https://doi.org/10.1007/978-3-030-51295-8_86).
- Zevi, Bruno. *As space. How to look at architecture*. Joseph A. Barry, 1957.
- Zhang, Jingru, Yahaya, Wan A.J., and Sanmugam, Mageswaran. “The Impact of Immersive Technologies on Cultural Heritage: A Bibliometric Study of VR, AR, and MR Applications.” In *Sustainability* 16, no. 15 (2024). <https://doi.org/10.3390/su16156446>.

Chapter 04 • Web references

- CyArk. accessed May 1, 2026. <https://www.cyark.org/>.
- European Commission, “Commission proposes a common European data space for cultural heritage.” last modified January 30, 2023. <https://digital-strategy.ec.europa.eu/en/news/commission-proposes-common-european-data-space-cultural-heritage>.
- Global Digital Heritage. accessed May 1, 2026. <https://globaldigitalheritage.org/>.
- Smithsonian. accessed May 1, 2026. <https://www.si.edu/>.
- Wikipedia. “Architectural heritage.” accessed May 1, 2026. https://en.wikipedia.org/wiki/Architectural_heritage#cite_note-3.
- Zamani Project. accessed May 1, 2026. <https://www.zamaniproject.org/>.

Chapter 05 • Bibliographic references

- Albena, Yaneva. *Crafting History: Archiving and the Quest for Architectural Legacy*. Cornell University Press, 2020. <https://doi.org/10.1515/9781501751837>.

- Allegrezza, Stefano. "Architecture, engineering and design archives in the digital era: state of the art, challenges and future perspectives." In *APXEOH* 5, no. 5 (2022). <https://u-pad.unimc.it/handle/11393/347971>.
- Allegrezza, Stefano. "Gli archivi degli architetti nell'era digitale," in *Nuovi annali della scuola speciale per archivisti e bibliotecari* XXXV. Leo S. Olschki Editore, 2021.
- Ammirati, Luisa, Watrous, Bethany, Ftaita, Amira, Rigauts, Thomas, and de Gruchy, Michelle. "Dive into Heritage: Paradata and Metadata in an Immersive Digital Heritage Experience," in *3D Research Challenges in Cultural Heritage V. Paradata, Metadata and Data in Digitisation*, ed. M. Ioannides, D. Baker, and A. Agapiou, P. Siegkas. Springer, 2024. https://doi.org/10.1007/978-3-031-78590-0_4.
- ANAI. *Linee guida per la formazione, gestione, conservazione degli archivi digitali e ibridi degli studi di progettazione* (2023). https://www.anai.org/wp-content/uploads/2023/04/ANAI_Linee_guida_ADISPRO.pdf.
- Barbuti, Nicola. *La digitalizzazione dei beni documentali. Metodi, tecniche, buone prassi*. Editrice bibliografica, 2022.
- Bordato, Enrica. "Conservare e descrivere gli Archivi del progetto. Esempi dai fondi conservati al Politecnico di Torino," in *Riordinare e inventariare gli archivi di architettura. Testimonianze del seminario 20-21 settembre 2021*, edited by E. Bodrato, R. Iacobucci. Hapax Editore, 2023.
- Capaccioni, Andrea. "Digitized and born-digital cultural heritage: implications for digital humanities." In *JLIS.it* 16, no. 3 (2025): 1-11. <https://doi.org/10.36253/jlis.it-657>.
- Carassi, Marco, ed. *Riordinare e inventariare gli archivi di architettura*. Hapax, 2023.
- Cassar, Anthony. "Digitising the National Collection," in *3D Research Challenges in Cultural Heritage V. Paradata, Metadata and Data in Digitisation*, edited by M. Ioannides, D. Baker, A. Agapiou, and P. Siegkas. Springer, 2024. https://doi.org/10.1007/978-3-031-78590-0_16.
- Cerullo, Luigi, Bartoli, Margherita, Coppola, Lina A., Landino, Costantino, Madonna, Antonio D., Negri, Antonella, Pescarmona, Giovanni, Fauda Pichet, Chiara, Porena, Margherita, and Rossetti, Valentina. "Verso la creazione di un Ecosistema digitale nazionale per la Cultura." In *Digitalia* 19, no. 2 (2024): 11-48. <https://doi.org/10.36181/digitalia-00101>.
- De Luca, Livio, and Lo Buglio, David. "Geometry vs Semantics: Open Issues on 3D Reconstruction of Architectural Elements," in *3D Research Challenges in Cultural Heritage*, ed. M. Ioannides, and E. Quak. Springer, 2014. https://doi.org/10.1007/978-3-662-44630-0_3.
- EUreka3D. *3D Digitisation Guidelines: Step to Success. A guide based on the EU VIGIE2020/654 Study on quality in 3D digitisation of tangible cultural heritage* (European Union, 2024). <https://eureka3d.eu/wp-content/uploads/2024/06/3D-digitisation-guidelines-EUreka3D.pdf>.
- European Commission. *Commission Recommendation (2011/711/EU) on the digitisation and online accessibility of cultural material and digital preservation* (2011). <https://eur-lex.europa.eu/eli/reco/2011/711/oj/eng>.
- European Commission. *Commission Recommendation (2021/1970/EU) on a*

- common European data space for cultural heritage* (2021). <https://eur-lex.europa.eu/eli/reco/2021/1970/oj/eng>.
- European Commission. *Study on quality in 3D digitisation of tangible cultural heritage: mapping parameters, formats, standards, benchmarks, methodologies, and guidelines*, VIGIE 2020/645 (2022).
- Guercio, Maria. “Gli archivi come depositi di memorie digitali.” In *DigItalia* III, no. 2 (2008). <https://digitalia.cultura.gov.it/article/view/280>.
- ICOM Italia, ed. *Glossario museologia digitale e nuove tecnologie* (2020). https://www.icom-italia.org/wp-content/uploads/2020/10/ICOMItalia_CommissioneTecnologie.2020.GlossarioTecnologie.pdf.
- Istituto centrale per la digitalizzazione del patrimonio culturale - Digital Library. *D.PaC Executive Summary. Report di inquadramento concettuale* (2025), 13, https://digitallibrary.cultura.gov.it/wp-content/uploads/2025/09/Ecomic_Report-di-inquadramento-concettuale_v1.0.pdf.
- Istituto centrale per la digitalizzazione del patrimonio culturale - Digital Library. *Economic. Ecosistema digitale per la cultura. Report di inquadramento concettuale* (2025). https://digitallibrary.cultura.gov.it/wp-content/uploads/2025/09/Ecomic_Report-di-inquadramento-concettuale_v1.0.pdf.
- Istituto centrale per la digitalizzazione del patrimonio culturale – Digital Library. *Linee guida per la digitalizzazione del patrimonio culturale. Release v1.0-giugno-2022* (Ministero della Cultura, 2022), <https://docs.italia.it/italia/icdp/icdp-pnd-digitalizzazione-docs/it/v1.0-giugno-2022/index.html>.
- Istituto Centrale per la Digitalizzazione del Patrimonio Culturale - Digital Library. *Piano nazionale di digitalizzazione del patrimonio culturale 2022-2023 (Versione 1.1)* (2023). https://digitallibrary.cultura.gov.it/wp-content/uploads/2023/10/PND_V1_1_2023-1.pdf.
- Noor, Salma, Shah, Lubna, Adil, Mohammad, Gohar, Neelam, Saman, Gul E., Jamil, Sehrish, and Qayum, Fawad. “Modeling and representation of built cultural heritage data using semantic web technologies and building information model.” In *Comput. Math. Org. Theory* 25, no. 3 (2019): 247-270. <https://doi.org/10.1007/s10588-018-09285-y>.
- Porena, Margherita, Negri, Antonella, and Cerullo, Luigi. “I.PaC: the National Data Space for Cultural Heritage,” in *Proceedings of the Ital-IA Inteligenza Artificiale - Thematic Workshops colocated with the 4th CINI National Lab AIIS Conference on Artificial Intelligence. Ital-IA 2024*. CEUR-WS.org, 2024.
- Smith, MacKenzie. *Future-proofing architectural computer-aided design: MIT's facade project*. Editions InFolio, 2008. <http://hdl.handle.net/1721.1/46329>.
- Souchon, Cécile. “Introduction,” in *A guide to the archival care of Architectural Records 19th-20th centuries*, edited by ICA. 2000.
- Tošić, Jovana. “Continuity or Discontinuity of Architectural History: Digital Repositories and Social Media as Archives,” in *Proceedings of “Architecture Archives of the Future”, Delft-Rotterdam, November 2023*. 2023.

- Tošić, Jovana. "Digital Mini-Archives: Social Media Users as Curators of an Architectural Utopia." In *AM Journal of Art and Media Studies*, no. 34 (2024): 27-38. <https://doi.org/10.25038/am.v0i28.562>.
- UNESCO, *Charter on the Preservation of the Digital Heritage* (2009), <https://unesdoc.unesco.org/ark:/48223/pf0000179529>.
- Veninata, Chiara. "Il Piano nazionale di digitalizzazione del patrimonio culturale: stato di attuazione e sviluppi futuri," in *La digitalizzazione del patrimonio culturale. Linee guida, standard, esperienza*, edited by S. Allegrezza. Civita Editoriale, 2021.

Chapter 05 • Web references

- Associazione Nazionale Archivi Italiani. "ANAI - Costituzione del Gruppo di lavoro sugli archivi digitali degli architetti – ADA." last modified September 30, 2021. https://anai.org/webarchiving/ANAI_2010-2023/sito/anai_cms/cmsf45e.html?numDoc=1756&munu_str=.
- Canadian Centre for Architecture. "Archaeology of the Digital." accessed May 1, 2026. <https://www.cca.qc.ca/en/events/3333/archaeology-of-the-digital>.
- Catalogo Generale dei Beni Culturali. accessed May 1, 2026. <https://catalogo.beniculturali.it>.
- Cultura Italia. "Patrimonio culturale e tecnologie digitali: documenti strategici." accessed May 1, 2026. <https://www.culturaitalia.it/patrimonio-culturale-e-tecnologie-digitali-documenti-strategici/>.
- Digital Library. accessed May 1, 2026. <https://digitallibrary.cultura.gov.it/>.
- Ecomic. "Ecosistema digitale per la cultura." accessed May 1, 2026. <https://ecomic.cultura.gov.it/>.
- EUR-Lex. "Digital Agenda for Europe." last modified June 25, 2010. <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=legisum:si0016>.
- Eureka3D. accessed May 1, 2026. <https://eureka3d.eu/>.
- European Commission. "Basic principles and tips for 3D digitisation of cultural heritage." last modified September 11, 2020. <https://digital-strategy.ec.europa.eu/en/library/basic-principles-and-tips-3d-digitisation-cultural-heritage#1.%20Consider%20the%20value>.
- European Commission. "Digital Europe Programme (DIGITAL)," EU Funding & Tenders Portal. accessed May 1, 2026. <https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/programmes/digital>.
- European Commission. "Digital Twin for the Reconstruction of Ukraine." last modified November 13, 2025. <https://digital-strategy.ec.europa.eu/en/news/digital-twin-reconstruction-ukraine/>.
- European Commission. "EU Member States sign up to cooperate on digitising cultural heritage." last modified April 9, 2019. <https://digital-strategy.ec.europa.eu/en/news/eu-member-states-sign-cooperate-digitising-cultural-heritage>.
- European Commission. "Shaping the Future of Cultural Heritage." last modified August, 2024. <https://www.echoes-eccch.eu/wp-content/uploads/2025/02/shaping-the-future-of-cultural-heritage-KI-0923174ENN.pdf>.

- European Commission. "Study on quality in 3D digitisation of tangible cultural heritage." last modified April 19, 2022. <https://digital-strategy.ec.europa.eu/en/library/study-quality-3d-digitisation-tangible-cultural-heritage>.
- European Commission. "The Cultural Heritage Cloud." accessed May 1, 2026. https://research-and-innovation.ec.europa.eu/research-area/social-sciences-and-humanities/cultural-heritage-and-cultural-and-creative-industries-ccis/cultural-heritage-cloud_en.
- European Union. "NextGenerationEU." accessed May 1, 2026. https://next-generation-eu.europa.eu/index_en.
- EuropeanaPro. accessed May 1, 2026. <https://pro.europeana.eu/>.
- EuropeanaPro. "Common European data space for cultural heritage." last modified May 15, 2025. <https://pro.europeana.eu/page/common-european-data-space-for-cultural-heritage>.
- ISO. "ISO 8601. Date and time format." accessed May 1, 2026. <https://www.iso.org/iso-8601-date-and-time-format.html>.
- Istituto Centrale per il Catalogo e la Documentazione. accessed May 1, 2026. <http://www.iccd.beniculturali.it/it/istituto/>.
- Istituto Centrale per il Catalogo e la Documentazione. "I numeri del SIGECweb." accessed May 1, 2026. <http://www.iccd.beniculturali.it/it/i-numeri-del-sigeweb>.
- Istituto Centrale per la Digitalizzazione del Patrimonio Culturale - Digital Library. accessed May 1, 2026. <https://digitallibrary.cultura.gov.it/>.
- Istituto centrale per la digitalizzazione del patrimonio culturale - Digital Library. "Online il progetto I.PaC Infrastruttura e servizi digitali per il Patrimonio Culturale." last modified March 8, 2024. <https://digital-library.cultura.gov.it/progetti/online-il-progetto-i-pac-infrastruttura-e-servizi-digitali-per-il-patrimonio-culturale/>.
- Italia Domani. "Strategia digitale e piattaforme per il patrimonio culturale," Piano Nazionale di Ripresa e Resilienza. accessed May 1, 2026. <https://www.italiadomani.gov.it/it/Interventi/investimenti/strategia-digitale-e-piattaforme-per-il-patrimonio-culturale.html>.
- Molteni&C. "Il potere dell'archivio. Renzo Piano Building Workshop." last modified September 14, 2018. <https://www.molteni.it/it/news/the-power-of-the-archive-renzo-piano-building-workshop>.
- Share3D. accessed May 1, 2026. <https://www.share3d.eu/it/>.
- SourceForge. "DAArch: Digital Archive for Architecture." accessed May 1, 2026. <https://sourceforge.net/projects/daarch/>.
- Time Machine Europe. accessed May 1, 2026. <https://www.timemachine.eu/>.
- UNESCO. "Concept of Digital Heritage." accessed May 1, 2026. <https://webarchive.unesco.org/web/20230616073538/https://en.unesco.org/themes/information-preservation/digital-heritage/concept-digital-heritage>.
- UNESCO. "Cultural heritage," Glossary. accessed May 1, 2026. <https://data-browser.uis.unesco.org/resources/glossary/2488>.
- UNESCO. "Digital Heritage." accessed May 1, 2026. <https://webarchive.unesco.org/web/20230615235525/https://en.unesco.org/themes/information-preservation/digital-heritage>.

UNESCO. "Memory of the World. About the programme." accessed May 1, 2026. <https://www.unesco.org/en/memory-world/about?hub=1081>.
Zenodo. accessed May 1, 2026. <https://zenodo.org/>.

Chapter 06 • Bibliographic references

- Barbini, Ambra, Giampiccolo, Francesco, Maragno, Anna, Massari, Giovanna A., and Pellegatta, Cristina. "Innovation and tradition: integrated practices in the architectural survey of Pretorio palace in Trento." In *SCientific RESearch and Information Technology Ricerca Scientifica e Tecnologie dell'Informazione*, v. 14, i. 1 (2024): 45-62. <http://dx.doi.org/10.2423/i22394303v14n1p45>.
- Bassetti, Michele. "L'acqua disfa li monti e riempie le valle.... Il ruolo dei processi fluviali nell'evoluzione del paesaggio urbano di Trento," in *Archeologia delle Alpi. Studi in onore di Gianni Ciurletti*, edited by F. Nicolis and R. Oberosler. Provincia Autonoma di Trento, 2018.
- Bassi, Cristina. "Tridentum città romana. Osservazioni cronologiche sulla fondazione," in *Da Camunni a Romani. Archeologia e storia della romanizzazione alpina, atti del convegno (Breno-Cividate Camuno, 10-11 ottobre 2013)*, edited by S. Solano. Edizioni Quasar, 2017.
- Bertoluzza, Aldo. *Aria di Trento. Contrade, vicoli, androne, fossati, vo, antiche fiere e mercati*. Dossi, 1990.
- Bocchi, Renato, and Oradini, Carlo. *Le città nella storia d'Italia. Trento*. Laterza, 1983.
- Blanco, Luigi, and Tonezzer, Elena, ed. *L'invenzione di via Verdi. Una strada di Trento tra Otto e Novecento*. Fondazione Museo Storico del Trentino, 2010.
- Campolongo, Fabio, ed. *Trento ieri, oggi, domani. Uno sguardo sulla città. La storia, i luoghi, i progetti, catalogo della mostra, Trento 8-31 dicembre 2007*. Provincia Autonoma di Trento, Soprintendenza per i beni architettonici, 2008.
- Cassar, Anthony, Baker, Drew, and Ioannides, Marinos. "From Digital Twin to Memory Twin: A Holistic Framework for Cultural Heritage Documentation, Interpretation, and Adaptive Reuse." In *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.* XLVIII-M-9-2025 (2025): 203-209, <https://doi.org/10.5194/isprs-archives-XLVIII-M-9-2025-203-2025>.
- Cesarini Sforza, Lamberto. "Piazze e strade di Trento, 1896," edited by E. Fox. U.C.T., 1991.
- Chini, Ezio, Ferrari, Salvatore, and Toffolon, Beppo. *Trento città dipinta. I decori murali esterni dal Medioevo ai giorni nostri*. Italia Nostra, Antiga, 2022.
- Chioni, Chiara, Maragno, Anna, Pianegonda, Angelica, Ciolli, Marco, Favargiotti, Sara, and Massari, Giovanna A. "Low-Cost 3D Virtual and Dynamic Reconstruction Approach for Urban Forests: The Mesiano University Park." In *Sustainability* 15, no. 19 (2023). <https://doi.org/10.3390/su151914072>.
- Chemelli, Aldo. *Trento. La piazza del Duomo*. Provincia Autonoma di Trento,

- 1997.
- Curzel, Emanuele. *Trento*. Fondazione Centro italiano di studi sull'alto medioevo, 2013.
- Francescotti, Renzo. *I rioni di Trento*. U.C.T., 1999.
- Istituto centrale per la digitalizzazione del patrimonio culturale - Digital Library. *Economic. Ecosistema digitale per la cultura. Report di inquadramento concettuale* (2025). https://digitallibrary.cultura.gov.it/wp-content/uploads/2025/09/Ecomomic_Report-di-inquadramento-concettuale_v1.0.pdf.
- Lando, Mauro. *Trento nuova. Le sue strade, le sue storie*. Curcu&Genovese, 2018.
- Maragno, Anna, and Volpi, Cristiana. *Dove Trento si ingegna. Il ruolo degli ingegneri nello sviluppo della città di Trento durante il XIX secolo*. Edizioni Efesto, 2023.
- Maragno, Anna, and Volpi, Cristiana. "Il ruolo degli Ingegneri Circolari e degli Ingegneri Civici a Trento nella prima metà dell'Ottocento," in *History of Engineering/Storia dell'Ingegneria. Proceedings of the 5th International Conference/Atti del 9° Convegno Nazionale*. Cuzzolin, 2022.
- Maragno, Anna, and Volpi, Cristiana. "Lo sviluppo urbano di Trento dalle origini alla seconda metà dell'Ottocento," in *L'arte in Trentino dal Medioevo al Novecento*, ed. E. Chini, and M. Beato. Antiga edizioni, 2025.
- Mariani, Michelangelo. *Trento con il Sacro Concilio et altri notabili. Description' Historica. Libri tre. Con un Ristretto del Trentin Vescovato; l'Indice delle Cose notabili, et le figure in rame*. 1673, ripr. anastatica 1989.
- Massari, Giovanna A. "Rilievo geometrico e rappresentazione digitale," in *Palazzo Pretorio. Da residenza vescovile a sede del Museo diocesano tridentino: una storia plurisecolare*, edited by M. Anderle, F. Cagol, E. Possenti, and A. Quendolo. Publistampa Edizioni, 2024.
- Pancheri, Roberto, ed. *La fontana del Nettuno. "Salute e decoro della città"*. Temi, 2004.
- Petrova, Tatiana, Bliznioukov, Boris, Puzikov, Aleksandr, and State, Radu. "From Semantic Web and MAS to Agentic AI: A Unified Narrative of the Web of Agents." In *ArXiv*, no. 2507 (2025), <https://doi.org/10.48550/arXiv.2507.10644>.
- Pincio, Giano Pirro. *Annali, ovvero, Croniche di Trento*. Zanetti, 1648.

Chapter 06 • Web references

- Austrian State Archives. "Allgemeines Verwaltungsarchiv." accessed May 1, 2026. <https://www.statearchives.gv.at/tasks-and-organisation/allgemeines-verwaltungsarchiv-finanz-und-hofkammerarchiv.html>.
- Biblioteca Comunale di Trento. accessed May 1, 2026. <https://bibcom.trento.it/>.
- Biblioteca Comunale di Trento. "Archivio storico." accessed May 1, 2026. <https://bibcom.trento.it/Archivio-storico>.
- CIDOC CRM. accessed May 1, 2026. <https://cidoc-crm.org/>.
- GitHub. "Folium." accessed May 1, 2026. <https://python-visualization.github.io/folium/latest/>.

- Fondazione Museo storico del Trentino. accessed May 1, 2026. <https://muse-ostorico.it/>.
- GitHub. accessed May 1, 2026. <https://github.com/>.
- Knight lab. “JuxtaposeJS.” accessed May 1, 2026. <https://juxtapose.knightlab.com/>.
- Land Tirol. “Tiroler Landesarchiv.” accessed May 1, 2026. <https://www.tirol.gv.at/kunst-kultur/landesarchiv/>.
- Ministero della Cultura. “Archivio di Stato di Trento.” accessed May 1, 2026. <https://archiviodistatotrento.cultura.gov.it/>.
- Museo Diocesano Tridentino. accessed May 1, 2026. <https://www.museodiocesano-tridentino.it/>.
- Pandas. accessed May 1, 2026. <https://pandas.pydata.org/>.
- Trentino Cultura. “Archivio Diocesano Tridentino.” accessed May 1, 2026. <https://www.cultura.trentino.it/Luoghi/Tutti-i-luoghi-della-cultura/Archivi/Archivio-Diocesano-Tridentino>.
- Trentino Cultura. “Archivio fotografico storico provinciale.” accessed May 1, 2026. <https://www.cultura.trentino.it/Luoghi/Tutti-i-luoghi-della-cultura/Archivi/Archivio-fotografico-storico-provinciale>.
- Trentino Cultura. “Archivio provinciale di Trento.” accessed May 1, 2026. <https://www.cultura.trentino.it/Luoghi/Tutti-i-luoghi-della-cultura/Archivi/Archivio-provinciale-di-Trento>.
- W3C Working Draft. “RDF 1.2 Turtle.” accessed May 1, 2026. <https://www.w3.org/TR/rdf1.2-turtle/>.

Chapter 06 • Historical cartography (chronological order)

- Giovanni Andrea Vavassore, Tridentum Trient, 1562 (British Library, Londra)
- Ludovico Sordani, pianta prospettica di Trento, 1660 ca. (Tiroler Landesarchiv, Innsbruck)
- Mappa della città di Trento, 1813 (BDTn, TG 1 a 1)
- Ph. Miller, Plan der Provinzial Kreis Stadt Trient mit einem Theil der umliegenden Gegend, 1822 (BDTn, TP e 187)
- Carlo Caminada, Pianta della città di Trento e delle sue vicinanze, con tre proposte per il posizionamento della stazione, 1851 (ASCTn, 3.8 - VII.366.1851)
- Mappe catastali asburgiche d’impianto di Trento, 1855 (Provincia autonoma di Trento, Esposizione storica del libro fondiario e del catasto di Trento)
- Carlo Perini, Pianta della città di Trento, 1868 (BDTn, T II k 136)
- Francesco Ranzi, Pianta di Trento antica e moderna, 1869 (BDTn, T II h 738)
- Francesco Ambrosi, Pianta di Trento, 1881 (BDTn, TG 2 f 23)
- Annibale Apollonio, Pianta della città e dei sobborghi di Trento, 1883 (BDTn, TG 2 a 06)
- Ottone Brentari, Pianta di Trento, 1890 (BDTn, T II k 1238)
- Annibale Apollonio, Pianta della città e dei sobborghi di Trento, 1891 (BDTn, TG 2 a 11)
- Annibale Apollonio, Pianta della città e dei sobborghi di Trento, 1902 (BDTn, TG 2 a 12).

Chapter 07 • Bibliographic references

- Allegrezza, Stefano. "Architecture, engineering and design archives in the digital era: state of the art, challenges and future perspectives." In *APXEOH* 5, no. 5 (2022). <https://u-pad.unimc.it/handle/11393/347971>.
- Ammirati, Luisa, Watrous, Bethany, Ftaita, Amira, Rigauts, Thomas, and de Gruchy, Michelle. "Dive into Heritage: Paradata and Metadata in an Immersive Digital Heritage Experience," in *3D Research Challenges in Cultural Heritage V. Paradata, Metadata and Data in Digitisation*, edited by M. Ioannides, D. Baker, and A. Agapiou, P. Siegkas. Springer, 2024. https://doi.org/10.1007/978-3-031-78590-0_4.
- Baker, Drew. "Defining paradata in heritage visualization," in *Paradata and Transparency in Virtual Heritage*, edited by A. Bentkowska-Kafel and H. Denard. Routledge, 2012.
- Bloch, Marc. *Apologia della storia o Mestiere di storico*. Einaudi, 2009.
- Chabod, Federico. *Lezioni di metodo storico*. Laterza, 2000.
- Croce, Benedetto. *Theory & history of historiography*. G.C. Harrap, 1921.
- Foucault, Michel. *The Archeology of Knowledge*. Pantheon Books, 1972.
- Ketelaar, Eric. "Archival contexts." In *Archeion*, no. 124 (2023). <https://doi.org/10.4467/26581264ARC.23.003.17863>.
- Le Goff, Jacques. "Documento/monumento," in *Enciclopedia Einaudi*. Einaudi, 1979.
- Vitali, Stefano. *Passato digitale. Le fonti dello storico nell'era del computer*. Bruno Mondadori, 2004.

Sinossi

La tesi “Shaping the memory of the built heritage. The digital record as new historical source” si configura come una riflessione critica sul rapporto tra memoria, tecnologia e ricerca storico-documentale relativa al patrimonio costruito.

Nel corso dell’ultimo secolo, la storiografia ha conosciuto una profonda estensione del significato di fonte storica. Dalla rivoluzione della *Nouvelle histoire* negli anni Venti fino all’avvento del World Wide Web negli anni Novanta, oltre alla nozione di fonte sono mutate anche le tipologie di risorse, la quantità dei documenti disponibili, il rapporto di questi con il metodo storico e le modalità di accesso alle informazioni. Un mutamento veloce, accelerato vertiginosamente negli ultimi anni dalla diffusione dell’Intelligenza Artificiale, capace di generare e analizzare dati su una scala senza precedenti. Nell’ambito *Architecture, Engineering, and Construction* (AEC), ad esempio, si avverte ormai regolarmente la necessità di conservare e consultare nuovi tipi di risorse, quali modelli virtuali tridimensionali, elaborazioni iconografiche computerizzate o mappe digitali, riflesso di una realtà professionale che si evolve in parallelo al progresso tecnologico.

La diffusione di queste risorse digitali apre importanti interrogativi su alcuni aspetti fondamentali per la storiografia e l’archivistica, quali la verità, l’evidenza e l’autenticità delle fonti, e fa emergere cruciali questioni legate alla loro selezione, conservazione e durabilità. Consapevoli (o meno) che i dati prodotti e conservati oggi contribuiranno a supportare la storiografia di domani, e domani quella dell’oggi, si pongono le domande: in che modo i materiali digitalizzati e quelli nativi digitali potranno trasmettere nel tempo una conoscenza storica attendibile? Come è possibile garantire l’accessibilità e la conservazione a lungo termine, a fronte dell’evidente fragilità e vulnerabilità tecnologica? E

in ambito architettonico, tutti gli esiti della pratica contemporanea, così come le risorse digitali disponibili online, possiedono valore di fonte storica per il futuro? È possibile definire procedure condivise per la produzione di risorse digitali alle quali sia riconosciuto un effettivo valore documentario?

È da queste domande che trae origine la presente ricerca. Con la tesi si intende indagare la memoria digitale del patrimonio costruito non come semplice esito tecnologico, ma come processo culturale, anche in senso epistemologico complesso, capace di incidere sulle modalità attraverso le quali la conoscenza dell'ambiente costruito viene prodotta, organizzata e trasmessa.

L'indagine prende avvio da una premessa teorica finalizzata a ripercorrere l'evoluzione del significato e degli strumenti con i quali l'umanità ha trasmesso la memoria e interpretato la storia, dalle società primitive fino all'età contemporanea. L'obiettivo è duplice: da un lato, approfondire le radici della memoria collettiva per comprendere la natura della memoria digitale, intesa non come mera trasposizione di contenuti analogici in formato digitale, ma come processo attivo di selezione, organizzazione e interpretazione; dall'altro, ricostruire l'evoluzione della storiografia e, parallelamente, del concetto di fonte storica nel corso del tempo. Tra i diversi tipi di fonte, particolare attenzione è riservata all'evoluzione dell'immagine e al valore che essa assume nel corso del tempo come veicolo di memoria storica.

Nella tesi si affronta successivamente il tema della ricerca storico-documentale nell'era digitale. A partire dalla definizione di archivio, si ripercorrono i punti salienti del passaggio, dalla dimensione analogica a quella digitale, evidenziando i differenti cicli di vita dei documenti e delineando le principali complessità connesse alla digitalizzazione, con particolare attenzione ai temi della qualità, dell'autenticità e dell'accessibilità a lungo termine delle informazioni. Si analizzano quindi i profondi cambiamenti introdotti dal web nell'ambito della ricerca storica, sia in termini di vincoli, sia di opportunità. La trattazione prende in esame i nuovi principali strumenti digitali disponibili online ed esplora il potenziale delle tecnologie emergenti, quali il Semantic Web, i Linked Open Data e l'intelligenza artificiale, applicate alla ricerca storica. Nella tesi si approfondisce inoltre il tema della memoria del patrimonio costruito attraverso l'attività del rilievo. Quest'ultima, per sua natura, al contempo tecnica e culturale, e profondamente connessa al proprio tempo, è oggi chiamata a confrontarsi con la rivoluzione digitale nel

campo della rappresentazione, della gestione delle informazioni e della loro comunicazione, soprattutto alla luce della crescente “mania archivistica” che pervade, a vari livelli, le più comuni attività culturali e scientifiche. A partire da queste considerazioni, vengono analizzati i principali processi di acquisizione ed elaborazione dei dati derivanti dal rilievo digitale 3D, con particolare attenzione ai metodi *image-based* e *range-based*. Si considerano inoltre i potenziali esiti dei modelli *reality-based*, intesi come risorse digitali che, se opportunamente strutturate e gestite, possono configurarsi come una prima forma di fonte storica del patrimonio costruito. In questa prospettiva, il passaggio dai modelli fisici a quelli virtuali non rappresenta solo un’evoluzione degli strumenti di rappresentazione, ma apre a nuove modalità di accesso, interpretazione e trasmissione della conoscenza: nella tesi si indagano quindi le principali forme di fruizione di tali modelli in ambienti di Realtà Estesa (VR, AR, MR), intesi come dispositivi capaci di amplificare il valore conoscitivo e comunicativo degli esiti del rilievo digitale.

Si affrontano poi i passaggi metodologici fondamentali che consentono di attribuire a una risorsa digitale, intesa come dato grezzo, esito del rilievo digitale, un valore documentale, configurandola come *digital record*: un’informazione strutturata e semanticamente arricchita, potenzialmente in grado di assumere il ruolo di fonte storica, ovvero di documento. In questo quadro viene analizzato il concetto di Patrimonio Culturale Digitale e svolta una rassegna dei principali indirizzi operativi e delle linee guida, a livello italiano ed europeo, in materia di digitalizzazione del costruito, con l’obiettivo di metterne in luce convergenze, criticità e disallineamenti. All’interno del più ampio ambito del Patrimonio Culturale Digitale, si approfondiscono in particolare le sfide che gli archivi di architettura contemporanea sono chiamati ad affrontare per rispondere alle trasformazioni imposte dai tempi, con specifico riferimento alle linee guida ANAI (Associazione Nazionale Archivi Italiani) per gli archivi degli architetti.

Gli esiti delle trattazioni teoriche e metodologiche prendono forma attraverso il progetto di sviluppo IT della piattaforma web *The Imaginary Map*: una piattaforma online di supporto alla ricerca storico-documentale sulla città di Trento nel corso dell’Ottocento. La piattaforma, attraverso l’applicazione dei principi della scienza aperta (FAIR) e delle metodologie dei Linked Open Data, si propone come un collettore di *digital records* - nuovi e già presenti nel web - utile a orientare le fasi iniziali della ricerca storica su Trento.

L'intreccio tra riflessioni teoriche, approfondimenti metodologici e sperimentazioni pratiche sviluppate nel corso delle indagini tende a far emergere i risultati della tesi in modo organico.

Tra i principali esiti si evidenzia, sia in ambito italiano, sia europeo, l'importanza della descrizione semantica dei dati, vale a dire il ruolo centrale dei metadati e dei paradata nei processi di digitalizzazione del patrimonio costruito. Essi non rappresentano semplici informazioni accessorie, ma elementi fondamentali per garantire la comprensione, la riusabilità e la conservazione delle risorse digitali nel tempo. Infatti, in assenza di un adeguato apparato descrittivo, molti documenti digitali rischiano di perdere consistenza e significato per gli storici del futuro.

A tale questione è strettamente connessa la pratica della validazione digitale dei dati, che è processo volto a garantire che le informazioni descrittive siano strutturate correttamente, in modo completo e conformi a standard specifici. La diffusione di tale procedura costituisce un fondamentale passaggio da una logica di conservazione passiva a una di cura attiva e strutturata delle risorse digitali, nella quale qualità, affidabilità e contestualizzazione assumono un ruolo centrale. In questa prospettiva, il futuro della memoria digitale del patrimonio costruito dipende dalla capacità di integrare competenze tecniche, consapevolezza critica e responsabilità culturale.

Nella tesi si sottolinea inoltre come, di fronte all'obsolescenza tecnologica e alle sfide che le tecnologie digitali oggi pongono, non esista ancora una soluzione definitiva. Mentre gli istituti culturali possono fare riferimento a numerose linee guida, nazionali e internazionali, per i professionisti e i ricercatori nell'ambito AEC la strategia più efficace, ad oggi, consiste nell'adozione di standard aperti e formati non proprietari, per evitare la perdita di dati legata all'obsolescenza di software e file, e di garantire l'interoperabilità tra sistemi differenti anche nel lungo periodo. Ai fini della conservazione a lungo termine, inoltre, risulta fondamentale l'organizzazione e l'archiviazione dei dati secondo logiche lungimiranti e strutturate.

Soprattutto, viene evidenziata la necessità di rafforzare la collaborazione tra professionisti del settore AEC, archivisti e informatici, promuovendo un modello proattivo di gestione degli archivi basato su pratiche condivise e su un dialogo continuo tra chi produce le risorse digitali e chi le conserva.

In conclusione, con la tesi si intende dimostrare come la costruzione della memoria digitale non sia soltanto una questione tecnologica, ma

un processo complesso che coinvolge aspetti epistemologici, metodologici e culturali. Solo attraverso un approccio consapevole e integrato sarà possibile garantire che le tracce digitali prodotte oggi possano costituire, domani, una base solida e significativa per la conoscenza storica.

Acknowledgements

I would like to express my gratitude to my supervisors, prof. Cristiana Volpi, prof. Giovanna A. Massari, prof. Marco Guerrieri, and prof. Raffaele Mauro, for their constant support and invaluable guidance throughout this journey.

I am also deeply thankful to prof. Gianluca Maracchini and prof. Michela Dalprà for their encouragement and for accompanying me through key transitional moments along the way.

I would like to extend my sincere gratitude to the staff of the Archivio storico del Comune di Trento and Biblioteca Comunale di Trento, in particular Franco Cagol, Brunella Brunelli, Francesca Gianformaggio, and Roberta Iseppi, for their invaluable assistance and guidance during the long and demanding archival research process.

My heartfelt thanks go to my fellow researchers, Ambra Barbini, Elena Bernardini, Chiara Chioni, and Angelica Pianegonda, for the stimulating discussions and constructive exchanges that greatly enriched this experience.

I would also like to acknowledge all those who, directly or indirectly, contributed to this achievement. In particular, I wish to thank Roberta Arcaini, Sara Di Valerio, Sara Favargiotti, Francesco Giampiccolo, Gregorio Gottardo, Flavia Guarracino, Alberto Leoni, Cristina Pellegratta, Starlight Vattano, and Giulia Zantedeschi.

Finally, my deepest gratitude and affection go to my family and friends, who have always stood by me and believed in me.

