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SVM-BASED CLASSIFICATION APPROACH FOR SYNTHETIC-IMPULSE
MICROWAVE IMAGING – SVM INPUT DATA

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*SVM-based Classification Approach for Synthetic-Impulse
Microwave Imaging*

SVM Input Data

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1 Introduction

In the last years, the learning methodology has been inspired by theory of statistical learning leading up to solutions with good performance and firm mathematical properties. In this framework, the theory of support vector machine (SVM) is based on the interaction between optimization theory and kernel theory [1].

Recently, widely used machine learning algorithms have been successfully applied in the framework of wireless communication problems [2] and inverse scattering problems [3][4] in order to exploit their generalization capabilities and real-time characteristics. Moreover, when a close solution to the problem at hand does not exist, SVM appears to be a good candidate to solve the optimization problem with a trial and error approach. As for the Synthetic-Impulse Microwave Imaging System (SIMIS) developed at LEAT, the learning methodology adopted for the detection of target position can be considered a supervised learning since it exploits input/output examples that are referred to as the training data. When an underlying function from inputs to outputs exists, it is referred to as the target function. In the framework of classification theory, this function is called decision function and gives binary outputs if a binary classification problem is dealt with, otherwise it gives a finite number of categories for multi-class classification. The computational time saving provided by an online binary classification approach justifies some limitations like the qualitative reconstruction of the object position instead of the quantitative estimation of the electromagnetic properties. Within the integration of a SVM classifier and the SIMIS for objects detection and more in general for the reconstruction of the investigation area, the main goal consists in the definition of a risk map of the presence of the targets.

2 SVM Input Data

The classification procedure is based upon training and testing data. In the training set each instance consists in a target value, that is the label of the class, to which data belongs, and several attributes, named features. The learning machine requires that all data instances are represented as a vector of real numbers. In order to define the format of the processed data, let us briefly introduce the SVM basics. The training set is composed by L observations, each of them consists of pairs (\underline{x}_i, y_i) , $i = 1, \dots, L$, where $\underline{x}_i \in \mathbb{R}^n$ is the vector of attributes that determines the input space and $y_i \in \{1, -1\}$ is the associated target value given by a trusted source. The vectors \underline{x}_i , $i = 1, \dots, L$ are mapped in a higher dimensional feature space where a separating hyperplane has to be found in order to maximize the margin between the training data that belong to different classes. This procedure is called training phase and the final output is the decision function that, in the following

testing phase, predicts the target values of the testing set of which only the attributes are given

As far as the SIMIS data have been concerned, the fields collected by the measurement system become a part of the input vectors \underline{x}_i , $i = 1, \dots, L$. In order to exploit the UWB properties of the M exponential tapered slots (ETS) antenna, the input data \underline{I}_i are the time-gated differential time-domain S_{21} data [5] obtained by the application of the inverse fourier transform. The position of the n -object, identified by its barycenter (X_n^{obj}, Y_n^{obj}) , is also a feature that belongs to the input vector. The adopted binary classification requires that input data \underline{x}_i are labeled both to the positive class $y_i = +1$ and negative class $y_i = -1$. Towards this end, for each input data \underline{I}_i , K training data are labeled with negative class and, instead of the features related to the object position, random spatial points $(X_k^{empty}, Y_k^{empty})$, $k = 1, \dots, K$ where the object does not reside are used as shown in Tab. I.

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y_i	x_i	
+1	(X_1^{obj}, Y_1^{obj})	\underline{I}_i
+1	(X_2^{obj}, Y_2^{obj})	\underline{I}_i
\vdots	\vdots	\vdots
+1	(X_N^{obj}, Y_N^{obj})	\underline{I}_i
-1	$(X_1^{empty}, Y_1^{empty})$	\underline{I}_i
-1	$(X_2^{empty}, Y_2^{empty})$	\underline{I}_i
\vdots	\vdots	\vdots
-1	$(X_K^{empty}, Y_K^{empty})$	\underline{I}_i

Tab. I - Input data format of a i -th input data \underline{I}_i .