Algorithms of Estimating Reachable Sets of Nonlinear Control Systems with Uncertainty

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The problem of estimating reachable sets of nonlinear dynamical control systems with quadratic nonlinearity and with uncertainty in initial states is studied. We assume that the uncertainty is of a set-membership kind when we know only the bounding set for unknown items and any additional statistical information on their behavior is not available. Applying results of the theory of trajectory tubes of control systems and related techniques of differential inclusions theory we present new approaches that allow finding external and internal ellipsoidal estimates of reachable sets. The algorithms of constructing such ellipsoidal set-valued estimates are given in two cases, for control systems with classical controls and for measure driven (impulsive) control systems. Numerical simulation results related to the proposed techniques and illustrating the algorithms are also included.
Keywords: Nonlinear control systems, The estimation problem, Set-membership uncertainty, Ellipsoidal calculus, Funnel equations, Trajectory tubes, Simulations for uncertain systems.

A new embedding method based on a Kolmogorov-Smirnov approach

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Embedding makes up a powerful tool to analyze the dynamical properties of a chaotic system. To this purpose, the choice of the embedding parameters, namely the dimension m and the lag L, is crucial. The scientific literature describes several methods for selecting the most suitable pair of embedding parameters. However, most methods contain steps in which variables have to be trimmed in a non-completely-objective way – a possible reason why the issue of which method provides the correct embedding choice for a specific application is still debated. To overcome these problems, we developed a new

method for the determination of the embedding parameters that does not require any "internal trimming". The method is based on two steps: first, a potential-like quantity is defined on a lattice of points (m, L); second, optimal embedding parameters are assumed to coincide with a local maximum or minimum of the potential-like quantity. Our method uses the Kolmogorov-Smirnov test to determine potential-like jumps between contiguous lattice points, and geometrical properties to reconstruct the potential-like quantity. The method provides superior performance than all previous methods in test-bench examples aiming at the determination of the maximum Lyapunov exponent.
Keywords: embedding, chaotic time series, time series analysis, maximum Lyapunov exponent.

Partial synchronization groups in a time-delayed Kuramoto model through networks

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Synchronization in a large population of interacting dynamical agents is a remarkable phenomenon that appears ubiquitously in Nature and also supports several technological applications. In many situations, this phenomenon can be modeled by considering each agent as a nonlinear oscillator moving in a globally attracting limit cycle of constant amplitude. A network can be used to model this set of interacting oscillators, in which the nodes are the agents while the edges capture the structure of interactions among the oscillators. Synchronization phenomena emerge due to the interaction and, depending on the system characteristics, it is possible to take the form of global synchronization or cluster synchronization. In the first case, all the agents evolves so that their phase are the same, while in the second one the oscillators split in subgroups so that inside each subgroup the agents are synchronized, while there is almost no synchronization between different subgroups. In this work, we investigate how the model may changes from global synchronization to cluster synchronization, as the population of the oscillators shifts from a uniform distribution to a more heterogeneous one. We also study how the network topology and the propagation delay in the interactions affected these transitions and its consequences for the stability of the synchronous states.