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Synchronization in coupled nonlinear dynamical systems

The study of coupling in dynamical systems has received an increasing interest since the 1990s. Recent studies of synchronization have included various measures for the detection of the different types of synchronization. Nevertheless, a comparison of different measures between coupled dynamical systems in controlled settings is still missing. For this aim the notion of synchronization will be used in a loose sense as the synonym of correlation, the similarity of the signals or the similarity of their dynamics. We present some of the nonlinear dynamics methods of synchronization: the mutual correlation dimension, the cross-approximate entropy, the mutual information function, the nonlinear interdependencies S, H, N and apply these measures to three coupled model systems. As the reference method, the linear cross-correlation function was used. We use the coupled Lorenz, Rössler and Lorenz-Rössler systems. Signals appearing here were used to illustrate the problems of reconstruction of attractors in the phase space, validation of methods for different parameters with the coupling strength. Mutual correlation dimension is the amount of information exchanged between systems. It allows to specify the relationship between systems dynamics. Cross approximate entropy is a method of measuring the complexity or irregularity of the signal. More regular signal has less value of approximate entropy. Mutual information is a measure of statistical independence of signals, if the value of zero means that two signals are independent. Low value (close to zero) measures S, H, N indicates the independence between the systems, while a high value indicates the synchronization. Correlation function is the dependence of the correlation of two signals. The results obtained by means of different algorithms failed to answer the question of which method is the best. It turns out that the results depend on the system and the type of coupling.