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Recurrence networks – A novel paradigm for nonlinear time series analysis

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We present a novel approach for analysing structural properties of time series from complex systems. Starting from the concept of recurrences in phase space, the recurrence matrix of a time series is interpreted as the adjacency matrix of an associated complex network, which links different points in time if the considered states are closely neighboured in phase space. In comparison with similar network-based techniques, this new approach has important conceptual advantages and can be considered as a unifying framework for transforming time series into complex networks that also includes other existing methods as special cases.

It is demonstrated that there are fundamental relationships between many topological properties of recurrence networks and different non-trivial statistical properties of the phase space density of the underlying dynamical system. Hence, this novel interpretation of the recurrence matrix yields new quantitative characteristics (such as average path length, clustering coefficient, or centrality measures of the recurrence network) related with the dynamical complexity of a time series, most of which are not yet provided by other existing methods of nonlinear time series analysis. The potentials of recurrence networks are illustrated for different dynamical systems with low-dimensional deterministic chaos, including paradigmatic models for geophysical systems such as the Lorenz oscillator.