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Unveiling generalized synchronization among coupled oscillators and geophysical signals: A recurrence network perspective

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The emergence of complex synchronization phenomena is a characteristic feature of many nonlinear systems. Among other types, generalized synchronization (GS) describes the mutual locking of the different dynamical degrees of freedom in the most general sense. As a consequence, GS is not necessarily reflected in a simple functional interdependence between the variables of two systems, which makes its detection from time series a challenging task.

Here, we introduce a set of new indicators of GS based on the concept of recurrences in phase space. Numerical results for two coupled Rössler systems in different dynamical regimes reveal that indicators utilizing recurrence network transitivity as a proxy for the effective dimensionality of the system under study exhibit a particularly good performance in detecting the known transition to GS from short time series data. The corresponding potentials for the analysis of real-world data are exemplified using some time series reflecting climate and ecosystem variability.