Multiplex Recurrence Networks

Deniz Eroglu, Norbert Marwan, Jürgen Kurths
1Potsdam Institute for Climate Impact Research, 2Institute of Physics, Humboldt University Berlin

Combine recurrence networks with multiplex network approach for multivariate time series analysis.

\[ R_k(i,j) = \Theta(|x_k(i) - x_k(j)|) \]

\[ A_k = R_k - I_N \]

\[ D = \begin{bmatrix} A_1 & I_N & \cdots & I_N \\ I_N & A_2 & \cdots & \cdots \\ \vdots & \ddots & \ddots & \vdots \\ I_N & \cdots & I_N & A_m \end{bmatrix} \]

Similarity of recurrence network in distinct layers:

\[ \omega = \frac{\sum_i \sum_j \sum_k A_k(i,j)}{m \sum_i \sum_j (1 - \delta_{i,j} A_k(i,j))} \]

Prototypical Example: Coupled Map Lattice (CML)

- multi-component dynamical system
- discrete-time model of diffusively coupled oscillators on a ring model of m sites
- well-studied dynamical system
- models a variety of nonlinear phenomena

\[ x_k(t+1) = (1-\epsilon) f(x_k(t)) + \frac{\epsilon}{2} \left( f(x_{k-1}(t)) + f(x_{k+1}(t)) \right) \]

The similarity measure \( \omega \) clearly distinguishes the different dynamics depending on \( \epsilon \).

Real World Application: Historical Vegetation Dynamics

Investigation of historical vegetation dynamics (multivariate pollen records) collected from Lake Shali-longwan.

Recurrence network similarity \( \omega \) for the vegetation around the Lake Shali-longwan during the Holocene: Dynamics of the different vegetation classes is more similar during the weak monsoon phases.

Similarity between the dynamics of different vegetation classes changes several times during the Holocene:

- weak monsoon periods \( \Rightarrow \) higher similarity
- strong monsoon periods \( \Rightarrow \) less similarity

References


Contact
Deniz Eroglu
Potsdam Institute for Climate Impact Research
marwan@pik-potsdam.de

This study has received funding from the European Union’s Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 691037, project QUEST (QUantitative palaeoEnvironments from SpeleoThems).