A New Dimension-reduction Method for Complex Dynamical Networks

SIAM

E. Laurence, N. Doyon, L.J. Dubé, and P. Desrosiers

July 12, 2018

Département de physique, de génie physique, et d'optique
Université Laval, Québec, Canada

Sentinelle Nord

UNIVERSITÉ LAVAL

Dynamical complex networks

Nodes

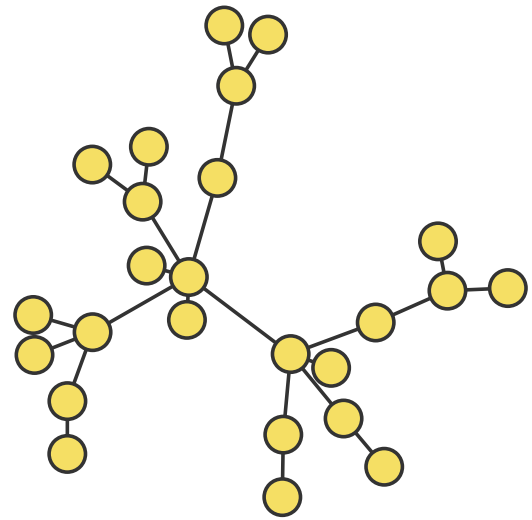
Activity $x_i(t)$

Edges

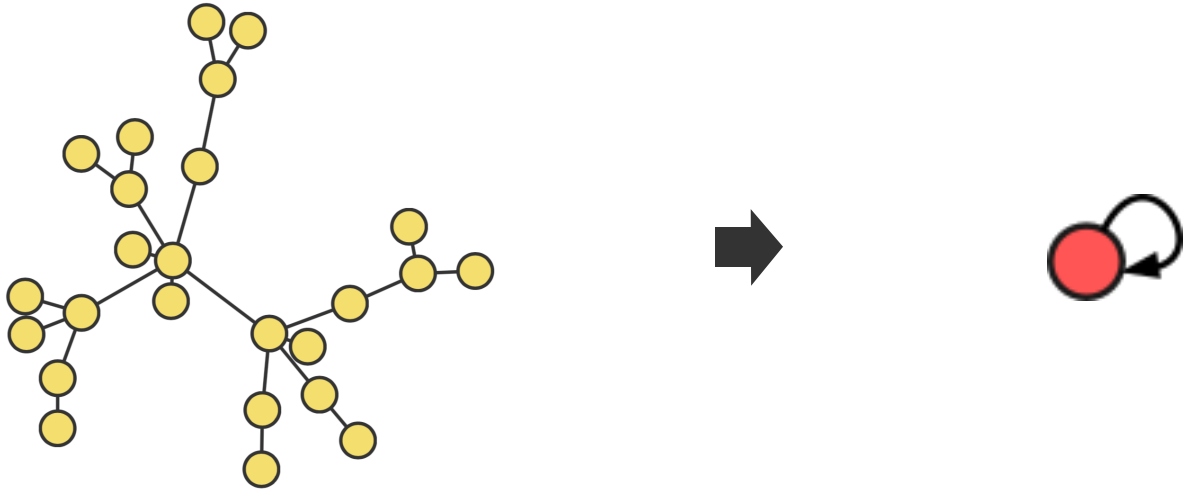
Weights $A = \{a_{ij}\}$

Dynamics

$$\dot{x}_i = F(x_i) + \sum_{j=1}^{N} a_{ij} G(x_i, x_j)$$



1-dimensional reduction



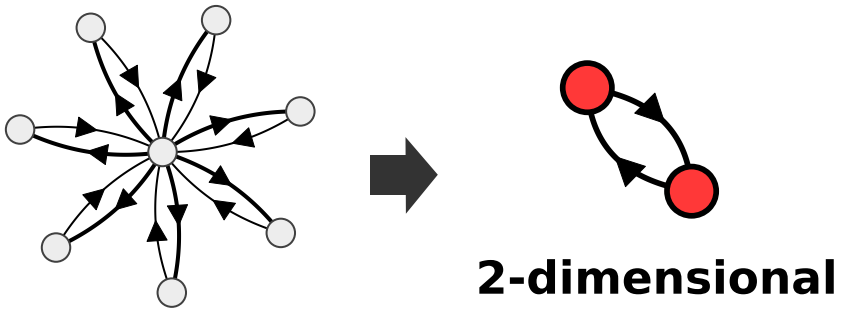
Red node activity = Weighted average activity

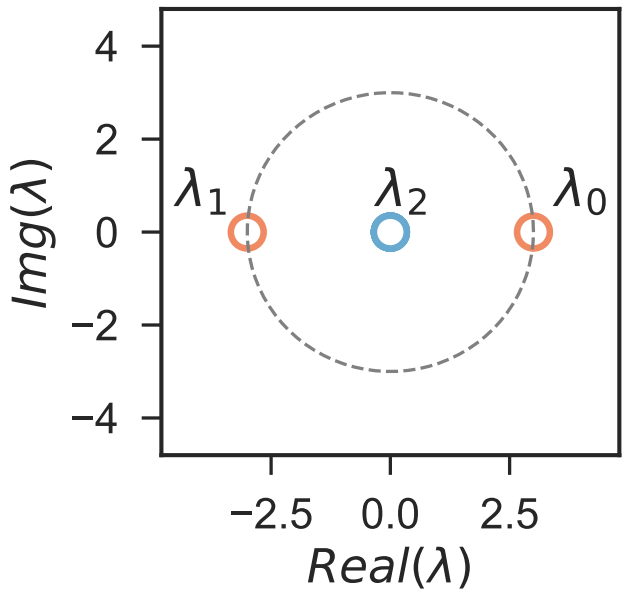
$$\langle x \rangle_w = \sum_{i=1}^{N} w_i x_i$$

w must be the **dominant eigenvector** of A.

Gao *et al.* (2016) reduction is found as an approximation.

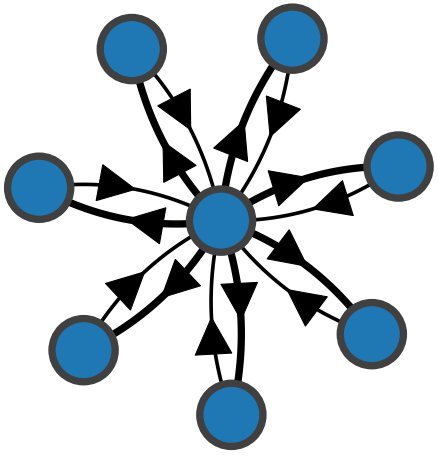
Star networks

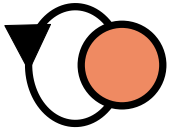


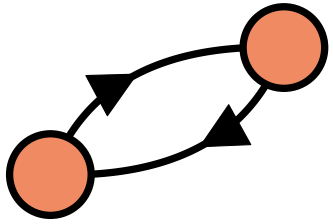


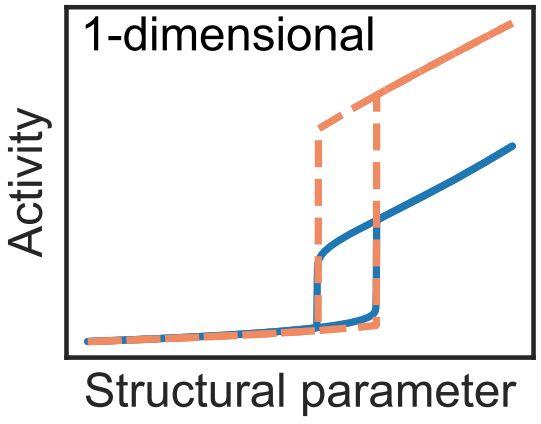
# of eigenvalues on the spectral radius → # of dimensions

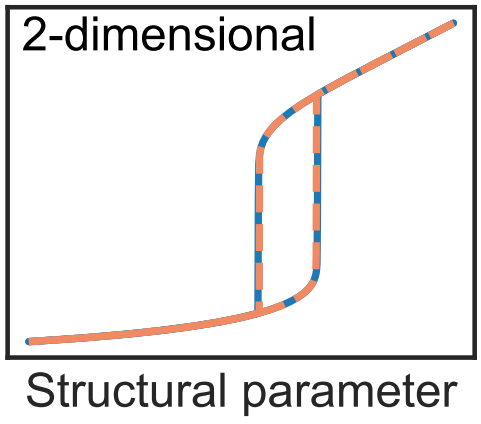
Star networks



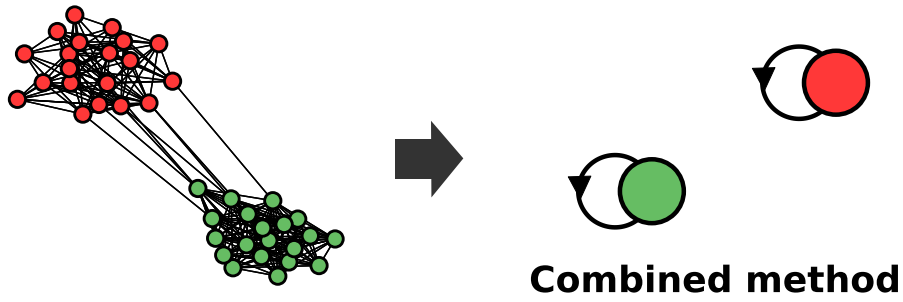


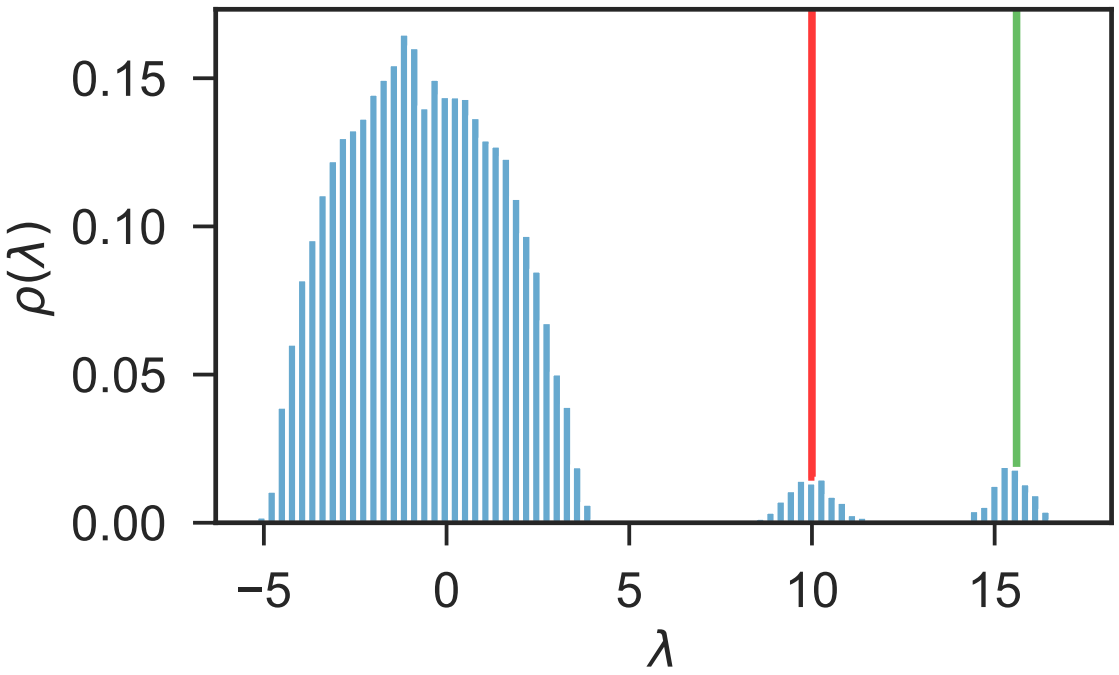




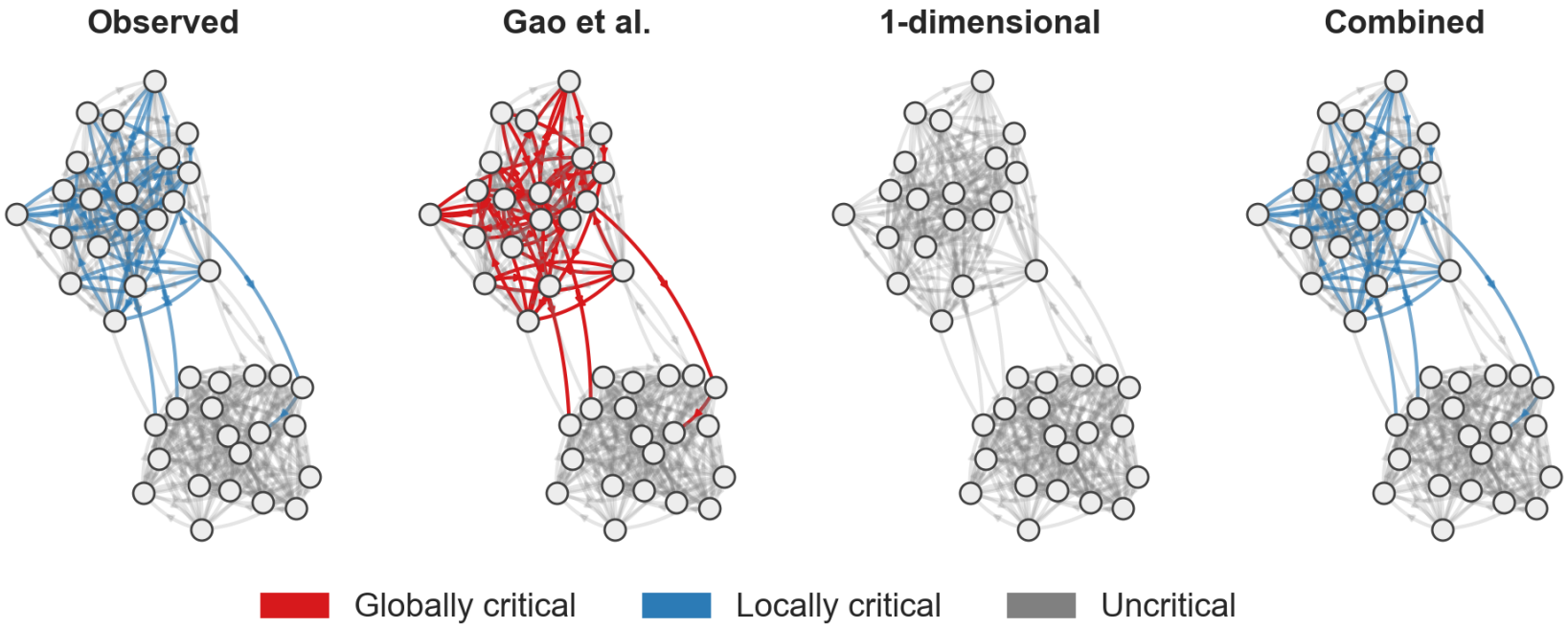


Modular networks | A combined method





Predicting breakdowns



The combined method predicts accurately the critical edges.

FURTHERMORE

Predicting global state using a low dimensional representation of dynamical complex networks

Available soon

- Many dynamics : SIS, Neural, Lotka-Voltera, Genes
- Critical transition of scale-free networks
- Error estimations

Take home message

- Systematic method
- Based on spectral properties of networks

COLLABORATORS

Louis J. Dubé

Patrick Desrosiers

Nicolas Doyon

dynamica.phy.ulaval.ca

edwardlaurence.me

Sentinelle Nord

Fonds de recherche sur la nature et les technologies Québec

CENTRE DE RECHERCHE CERVO BRAIN RESEARCH CENTRE QUÉBEC

UNIVERSITÉ LAVAL

CRSNG NSERC