Eigenvector methods for learning from data on networks

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Timetable: 12 hrs. THE COURSE IS TEMPORARILY SUSPENDED. THE TIMETABLE OF THE LECTURES WILL BE COMMUNICATED AS SOON AS POSSIBLE

Course requirements: Standard background in numerical linear algebra, numerical and mathematical analysis.

Examination and grading: Oral presentation or written essay

SSD: MAT/08 Numerical Analysis; INF/01 ComputerScience; MAT/05 Mathematical Analysis

Aim: Provide an introduction to spectral methods for unsupervised and semisupervised learning tasks and centrality on networks based on eigenvectors of matrices, tensors, and multihomogeneous mappings.

Course contents: Graphs are fundamental tools for learning from data and for the analysis of complex systems. In fact, we often state questions and develop analysis in terms of nodes and edges. For example, we can describe a social system by modeling individuals as nodes and social interactions as edges between pair of nodes. Similarly, we can model a biochemical reaction by assigning a node to each protein and edges between them to model physical contacts of high specificity, so-called protein-protein interactions.

Due to the broad scope of this modeling paradigm, the analysis of systems or datasets as networks has enjoyed a tremendous success over the last decade and many mathematical models and numerical methods for handling learning problems on networks have been developed, based on eigenvectors and singular vectors of matrix, tensors (or hypermatrices) and, more generally, multihomogeneous mappings.

The course will give an introduction to spectral methods for learning from network data from a numerical linear algebra perspective by discussing the following topics in various detail:

- Graph Laplacian, spectral partitioning, semisupervised learning
- p-Laplacian and nonlinear spectral clustering
- Lovász extension and homogeneous mappings
- Eigenvector centrality and centrality based on matrix functions
- Centrality in higher order networks (time-varying, multilayer, hypergraphs)
- Nonlinear Perron–Frobenius theory and nonlinear power methods

References:

1. E. Estrada and P. Knight *A first course in network theory*, Oxford University Press, 2015.
2. J. Gallier *Spectral Theory of Unsigned and Signed Graphs. Applications to Graph Clustering: a Survey*, arXiv:1601.04692, 2016.

3. L. Elden *Matrix Methods in Data Mining and Pattern Recognition*, 2nd Ed, SIAM, 2019.