

18D028

Networks: Concepts and Algorithms

Spring Term - 3 ECTS

Elective Course

Prof. Joan de Martí

Prerequisites to Enroll

Elements of linear algebra and probability theory are strongly recommended.

Overview and Objectives

Nowadays, networks are pervasive and influence many of our decisions and outcomes. If the shape and structure of the network matters, and if individual positions in such network lead to different outcomes, we need to quantify and measure network and individual actor properties; therefore, we are going to introduce network-based concepts and measures that show up in theoretical and empirical studies. These concepts relate to the local and global properties of a networks. We are going to apply these measures to the analysis of community structure and to the study of computationally tractable models of dynamic behavior in networks, and we are going to study classical models of random network formation that try to express some of the aggregate characteristics of networks.

The course, together with the second part *Networks: Models and Applications*, provides a multifaceted approach to the study of networks, bringing together concepts, models, algorithms, and tools from graph theory, game theory, sociology, economics, computer science, and statistics, among other areas.

Prerequisite reading

This course has no prerequisite readings.

Course Outline

Individual Measures. Connectivity, Centrality, and Similarity.

Global Measures.

Identifying Communities

Random graphs. Power laws, Six Degrees of Separation, and Giant Components

Dynamic Processes in Networks

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Required Activities

Attendance to theory class. Problem sets (that may include theory problems as well as practice with software and data sets).

Evaluation

60% Problem Sets, 40% Project/Literature Review

Competences

- Construct a global vision of the situation of the problem based on knowledge of the synergies between advanced statistical methods, computing and business analysis to generate added value.
- Modeling and predicting high-dimensional data with advanced statistical methods in the field of data science in order to improve strategic decision making.
- Apply the knowledge of programming languages, computer programs and advanced services in the Cloud to solve the problems that are presented to the data scientist.
- Solve the real problems that arise in the fields of study through the accurate analysis of the data.
- Communicate with conviction in English the results and implications of the required analytical study using a language related to the receiver.
- Work in a heterogeneous team of researchers in the field of the economic analyst using specific group techniques.
- Own and understand knowledge that provides a basis or opportunity to be original in the development and / or application of ideas, often in a research context.
- That students know how to apply the acquired knowledge and their ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their area of study.
- That the students be able to integrate knowledge and face the complexity of making judgments based on information that, being incomplete or limited, include reflections on the social and ethical responsibilities linked to the application of their knowledge and judgments.
- That the students know to communicate their conclusions and the knowledge and last reasons that sustain them to specialized and non-specialized publics in a clear and unambiguous way.

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That students have the learning skills that allow them to continue studying in a way that will be largely self-directed or autonomous.

Learning Outcomes

- Apply mathematical and computational analysis of social, business and economic networks knowing the theory and optimization algorithms.
- Apply search algorithms and estimation methodologies in networks through observation of data.
- Apply optimization algorithms in business and marketing problems.
- Apply learning and optimization methods in marketing environments.
- Apply mathematical and statistical analysis using economic theory in complex problems with high-dimensional data.
- Apply mathematical theory and statistics on data sets from disparate disciplines.

Material

Books:

D. Easley and J. Kleinberg, *Networks, Crowds, and Markets*, Cambridge University Press 2010

Matthew Jackson, *Social and Economic Networks*, Princeton University Press 2010

Mark Newman, *Networks: An Introduction*, Oxford University Press 2010

S. Wasserman and K. Faust, *Social Network Analysis: Methods and Applications*, Cambridge University Press 1994

Barabási, A. L. (2016). *Network science*. Cambridge university press

Zafarani, R., Abbasi, M. A., & Liu, H. (2014). *Social media mining: an introduction*. Cambridge

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University Press.

Other:

A list of other resources (data sets, papers,...) will be provided as the course progresses.