Introduction to networks and games

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Description
This course focuses on the essential knowledge of social network analysis and game models, in which the network is the primary ingredient. We start with the fundamentals of the network theory by covering the basic concepts, measures and metrics and by paying attention to large-scale networks and processes developing on networks. Next, we proceed to the study of games on networks where we discuss the main solution concepts used in the theory, static and dynamic mechanisms of network formation, and finally, we conclude with the combination of the cooperative game theory and networks for allocating a total value generated by the players.

Prerequisites
Students should have the knowledge of Calculus, Linear Algebra, and Probability Theory.

Schedule
The course consists of 32 academic hours, or 16 lectures, each of which is allocated two academic hours.

#	Topic	Total hours	Lectures (hours)
1	Networks	20	20
2	Games on networks	12	12
Total:		32	32

The following list describes the topics that will be covered:

Part 1. Networks

Lectures 1. Concepts and definitions
Graph. Adjacency matrix. Weighted and directed networks. Trees. Paths. Degree. Components.

Lecture 2. Measures
Centrality measures: degree centrality, closeness centrality, betweenness centrality, eigenvector centrality, Katz centrality, PageRank.

Lecture 3. Groups of nodes and clustering
Cliques, plexes, and cores. Clustering coefficient. Redundancy.

Lecture 4. Similarity of nodes
Cosine similarity. Pearson coefficient.

Lecture 5. Homophily and Assortativity. Modularity

Lecture 6. Community detection

Lecture 7. Large-scale networks
Diameter and Small world. Degree distribution. Power laws and scale-free networks.

Lecture 8. Random networks

Lecture 9. Spreading information
SI-, SIS-, and SIR-models. Spreading information in a network.

Lecture 10. Social influence and learning
The DeGroot model. The Friedkin–Johnsen model.

Part 2. Games on networks

Lecture 11. General model and solution concepts
Nash equilibrium. Pareto efficiency. Social optimum. Pairwise stability.

Lecture 12. Graphical games
Threshold games of complements. A public goods model.

Lecture 13. Example in market competition

Lecture 14. Network formation
One-sided link formation. Two-sided link formation.

Lecture 15. Dynamic models of network formation
Best response dynamics. Sequential announcements.

Lecture 16. Networks and cooperative allocation rules
Communication game. Allocation rules. The Myerson value.

Grading
The student will be credited with the course if he/she attends at least 75% of the classes and makes a presentation on a given topic from the course topic list.

Reading
The following books may be found useful:

1. Goyal S. Connections: An Introduction to the Economics of Networks. Princeton University Press, 2009
2. Jackson M.O. Social and Economic Networks. Princeton University Press, 2010
3. Newman M. Networks. Oxford University Press, 2nd edition, 2018