From graph theory to network science

Instructor: Péter Csikvári

Term: Fall

Weeks: 8-14

Contact hours: 3 Credits: 6

Aim and scope:

The aim of the course is to present the basic concepts of graph theory and the modelling methods of networks, to teach the most important algorithms. In the practices the students will learn to formalize real world problems about networks in the language of graphs and algorithms. The students will understand the basic measures of models and the role of linear algebra in network science.

Syllabus:

Understanding the basic concepts of graph theory.

Formalizing real world problems about networks in the language of graphs and algorithms

Being familiar with modelling of large networks.

Understanding the basic measures of models and the role of linear algebra in network science.
Graphs and directed graphs, bipartite graphs, degree of a vertex, handshake lemma. Cliques and colorings.
Connectedness, connected components, spanning trees, paths and distances in graphs. Basic algorithms: breadth-first search tree, depth-first search tree, Kruskal's algorithm for finding a minimum weight spanning tree. Finding shortest path in a graph, Dijkstra's algorithm.
Matchings. Hall-theorem for matchings in bipartite graphs. Matchings in non-bipartite graphs. Stable matchings.
Spectral graph theory. Adjacency and Laplacian matrices.
Graph visualization. Centrality, Page rank algorithm. Spectral clustering.

Markov chain Monte Carlo algorithms for sampling and optimization.

References:
S. Even: Graph algorithms, Cambridge University Press, 2nd edition, 2012.

J.A. Bondy, U.S.R. Murty: Graph Theory, Springer Graduate Texts in Mathematics, 2010.

A. Blum, J. Hopcroft, R. Kannan: Foundations of Data Science, Cornell University preprint, 2018, available at https://www.cs.cornell.edu/jeh/book.pdf

A.-L. Barabási: Network Science, Cambridge University Press, 2016.