Study Programme: Applied Mathematics – Data Science

Course Unit Title: Information Theory for Networks

Course Unit Code: МДС18

Name of Lecturer(s): Dušan Jakovetić

Type and Level of Studies: Master Academic Degree

Course Status (compulsory/elective): Elective

Semester (winter/summer): Summer

Language of instruction: English

Mode of course unit delivery (face-to-face/distance learning): Face-to-face

Number of ECTS Allocated: 6

Prerequisites: Basics of theory of probability

Course Aims:

- Understanding basic information measures: entropy, mutual information
- Understanding the concept of compression of information sources and fundamental limits
- Understanding the concept of information recovery from imperfect observations (either through transmission or some other noise additive transformation) and fundamental limits
- Fundamental limits of information compression and transmission in large networks of nodes

Learning Outcomes:

- Ability and experience in applying information-theoretic methods on real-world problems
- Ability to recognize the potential for information-theoretic reasoning across wide application areas

Syllabus:

Theory

Introduction to Information Theory: Entropy, AEP Lemma, Source Coding (Compression) Theorem; Mutual Information (KL Distance), Channel Capacity, Channel Coding (Noisy Information Recovery) Theorem

Single-Hop Network Graphs

Compression and Noisy Information Recovery limits in specific single-hop graph examples: Multiple Access, Broadcast, Relays: Introduction and capacity results.

General (Multi-Hop) Network Graphs:

Information Flows, Max-Flow Min-Cut Theorem, Network Coding, Networking and Information Theory, Coding for Computing, Coding for Storage Systems

Practice

Application examples in communication systems, neuroscience, epidemiology, genomics, finance etc.; Implementation of the taught methods in MATLAB; Application of selected methods on real-world examples through the course project.

Required Reading:

19. T. Cover and J. Thomas: Elements of Information Theory, Wiley, 1991.

20. A. El-Gamal, Y-H. Kim: Network Information Theory, Cambridge University Press, 2011

Weekly Contact Hours: 5	**Lectures:** 2	**Practical work:** 3

Teaching Methods:

Lectures; revisions of the material; active students' participation in problem solving; knowledge tests – colloquia; application of the taught material on real-world examples within the course project.

Knowledge Assessment (maximum of 100 points): 100

Pre-exam obligations	points	**Final exam**	points
Active class participation		written exam	40
Colloquia + Course project	30 (Colloquia) + 30 (Course project)	oral exam	
Preliminary exam(s)		…….	
Seminar(s)			

The methods of knowledge assessment may differ; the table presents only some of the options: written exam, oral exam, project presentation, seminars, etc.