Course Unit Descriptor

Study Programme: Applied Mathematics – Data Science

Course Unit Title: Graphical Models and Probabilistic Inference

Course Unit Code: MDS24

Name of Lecturer(s): Dušan Jakovetić

Type and Level of Studies: Master Academic Degree

Course Status (compulsory/elective): elective

Semester (winter/summer): Winter

Language of instruction: English

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

Number of ECTS Allocated: 5

Prerequisites: Basics of theory of probability

Course Aims:

- Understanding of theory and practical implementations of graphical models and Belief - Propagation (BP) algorithms for probabilistic inference
- Understanding advantages/disadvantages of various graphical models for a given real-world application
- Ability to apply graphical models and BP algorithms in MATLAB in real-world problems

Learning Outcomes:

- Ability and experience in modelling, graphical representation, design and analysis of BP algorithms in real-world probabilistic inference problems
- Ability to apply the concepts of probabilistic inference on research problems from a wide variety of application areas

Syllabus:

Theory

Graphical models for probabilistic systems modeling: directed graphical models – Bayesian Networks; undirected graphical models - Markov Random Fields; Factor Graphs.

Exact Inference: Efficient marginalization via message-passing Belief-Propagation algorithms;

Sum-product algorithm; Max-product (Min-Sum) algorithm.

Approximate Inference: Loopy Belief-Propagation, Monte Carlo Methods.

Learning in Graphical Models: ML estimation, Expectation-Maximization algorithm

Practice

Application examples in communication systems, image processing, statistical physics, electrical grid (smart grid), computational biology etc.; Implementation methods in MATLAB; Application of selected methods on real-world examples through the course project.

Required Reading:

1. D. Koller and N. Friedman: Probabilistic Graphical Models, MIT Press, 2009

2. M. J. Wainwright and M. I. Jordan, Graphical models, exponential families, and variational inference, Foundations and Trends in Machine Learning, 2008.

3. C. Bishop: Pattern recognition and machine learning, Springer, 2006

Weekly Contact Hours:	**Lectures:** 2	**Practical work:** 2
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):		

Pre-exam obligations	points	**Final exam**	points
Colloquia	30	written exam	30
Course project	40	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.