Optimization 2015/2016

Code: 42250
ECTS Credits: 6

Degree	Type	Year	Semester
4313136 Modelling for Science and Engineering	OT	0	1

Contact

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Use of languages

Principal working language: english (eng)

Prerequisites

- Mathematical knowledge at the level of Science degree
- Programming skills

Objectives and Contextualisation

The course is devoted to study and practise several heuristic and combinatorial optimisation algorithms with special emphasis on routing, graph, network optimisation and scheduling.

The lectures are based based in slides presentations and internet material.

The theoretical material will be complemented with some assignments (at leats one) for every subject to be developed individually by the students. This is a critical part of the learning process.

Skills

- Analyse, synthesise, organise and plan projects in the field of study.
- Apply logical/mathematical thinking: the analytic process that involves moving from general principles to particular cases, and the synthetic process that derives a general rule from different examples.
- Apply specific methodologies, techniques and resources to conduct research and produce innovative results in the area of specialisation.
- Apply techniques for solving mathematical models and their real implementation problems.
- Conceive and design efficient solutions, applying computational techniques in order to solve mathematical models of complex systems.
- Formulate, analyse and validate mathematical models of practical problems in different fields.
- Isolate the main difficulty in a complex problem from other, less important issues.
- Present study results in English.
- Use appropriate numerical methods to solve specific problems.

Learning outcomes

1. Analyse, synthesise, organise and plan projects in the field of study.
2. Apply logical/mathematical thinking: the analytic process that involves moving from general principles to particular cases, and the synthetic process that derives a general rule from different examples.
3. Apply optimisation techniques to study models associated with practical problems.
4. Apply specific methodologies, techniques and resources to conduct research and produce innovative results in the area of specialisation.

5. Identify problems that require optimisation techniques to build models associated with practical problems.
6. Implement the algorithms that are present in the programme.
7. Implement the proposed solutions reliably and efficiently.
8. Isolate the main difficulty in a complex problem from other, less important issues.
9. Present study results in English.
10. Use specific software to solve optimisation problems..

Content

- **Combinatorial Algorithms and routing:** Dijstra and A* algorithms. Optimisation on graphs.
- **Genetic Algorithms**
- **Simulated Annealing**
- **Ant colony optimisation algorithms**
- **Neural Networks in optimisation**
- **Scheduling**

Methodology

The methodology is based on master classes which consist in the presentation of the theory, examples and some case studies for every algorithm of the syllabus.

Students will have to implement independently the algorithms studied in realistic situations as a crucial part of the learning process.

Activities

Title	Hours	ECTS	Learning outcomes
Type: Directed			
Attending lectures and activities	38	1.52	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Type: Autonomous			
Assignments (implementation of the algorithms self-activities)	112	4.48	1, 2, 3, 4, 5, 8

Evaluation

There are 6 practical realistic home assignments (programs). Two of them will be compulsory and two recommended. The compulsory assignments (together with its weight in the final mark in percentage) are:

- Map routing (A* algorithm): 60%
- Genetic algorithm: 40%

Evaluation activities

Title	Weighting	Hours	ECTS	Learning outcomes
Implementation of algorithms in realistic cases	100%	0	0	1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Bibliography

Combinatorial Algorithms

Judea Pearl, A* Algorithms and such: Heuristics: Intelligent Search Strategies for Computer Problem Solving, Addison-Wesley, 1984.

Genetic Algorithms

- Sean Luke,Essentials of Metaheuristics, 2009.

http://cs.gmu.edu/sean/book/metaheuristics/

- Melanie Mitchell, An Introduction to Genetic Algorithms, A Bradford Book, The MIT Press, Cambridge Massachusetts, 1999.
- David Beasley, David R. Bully and Ralph R. Martinz, An Overview of Genetic Algorithms (Part 1: Fundamentals and Part 2: Research Topics)

Simulated Annealing algorithm

- S. Kirkpatrick, C. D. Gelatt Jr. and M. P. Vecchi, Optimization by Simulated Annealing, Science, May 1983, Vol. 220, no. 4598, pp. 671-680.
- François Bergeret and Philippe Besse, Simulated Annealing, weighted simulated annealing and genetic algorithm at work.
- William H. Press, Saul A. Teukolsky, William T. Vetterling, Brian P. Flannery, Numerical Recipes in C. The Art of Scientific Computing (second edition)}, Cambridge University Press.

Ant colony algorithms

- Marco Dorigoa and Christian Blum, Ant colony optimization theory: A survey, Theoretical Computer Science 344 (2005) 243 - 278.

Scheduling

- Ronald L. Graham, Combinatorial Scheduling Theory
- R. Gary Parker, Deterministic Scheduling Theory, Chapman Hall.
- Peter Brucker, Scheduling Algorithms, Fourth Edition, Springer
- R.L. Graham, E.L. Lawler, J.K. Lenstra, A.H.G. Rinnooy Khan, Optimization and approximation in deterministic sequencing and scheduling: a survey
- Peter Brucker, Scheduling Algorithms, Springer-Verlag, 2007, Berlin Heidelberg New York (ISBN 978-3-540-69515-8).

Neural Networks for Combinatorial Optimization

- Jean-Yves Potvin, Kate A. Smith, Artificial Neural Networks for Combinatorial Optimization
- Kate Smith, Neural Networks for Combinatorial Optimization: A Review of More Than a Decade of Research1999.
- Kate Smith, Marimuthu Palaniswami and Mohan Krishnamoorthy. Neural Techniques for Combinatorial Optimization with Applications

The originals of some of these references as presentation slides and other bibliography can be found in the web page of the subject:

http://mat.uab.cat/~alseda/MasterOpt/