Last update: 19-07-2019

270214 - OM - Mathematical Optimization

Coordinating unit: 270 - FIB - Barcelona School of Informatics

Teaching unit: 749 - MAT - Department of Mathematics

Academic year: 2019

Degree: BACHELOR'S DEGREE IN DATA SCIENCE AND ENGINEERING (Syllabus 2017). (Teaching unit Compulsory)

ECTS credits: 6 Teaching languages: Catalan

Prior skills

A first course on calculus and linear algebra. To implement algorithms in some programming language.

Degree competences to which the subject contributes

Specific:

CE3. Analyze complex phenomena through probability and statistics, and propose models of these types in specific situations. Formulate and solve mathematical optimization problems.

Generical:

CG1. To design computer systems that integrate data of provenances and very diverse forms, create with them mathematical models, reason on these models and act accordingly, learning from experience.

CG2. Choose and apply the most appropriate methods and techniques to a problem defined by data that represents a challenge for its volume, speed, variety or heterogeneity, including computer, mathematical, statistical and signal processing methods.

Transversal:

CT5. Solvent use of information resources. Manage the acquisition, structuring, analysis and visualization of data and information in the field of specialty and critically evaluate the results of such management.

CT6. Autonomous Learning. Detect deficiencies in one's own knowledge and overcome them through critical reflection and the choice of the best action to extend this knowledge.

CT7. Third language. Know a third language, preferably English, with an adequate oral and written level and in line with the needs of graduates.

Teaching methodology

Theoretical lectures where the concepts will be introduced, including exercises to fix these concepts (75%)
Problems and lab sessions (25%).

Learning objectives of the subject

1.To know what a mathematical optimization problem is, what types of problems are there, and to have a basic knowledge of optimization algorithms.
2.To model mathematical optimization problems and to formulate them through modeling languages. To know how to choose the best method or "solver" according to the type of problem.
3.To solve data science problems previously formulated as mathematical optimization problems.

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Study load

Total learning time: 150h	Hours large group:	30h	20.00%
	Hours small group:	30h	20.00%
	Guided activities:	0h	0.00%
	Self study:	90h	60.00%

Content

Unconstrained Optimization.

Degree competences to which the content contributes:

Description:
Problem modeling. Optimality conditions. Convexity. Descent directions. Line search methods. The gradient or steepest descent method, and variants (stochastic gradients, etc.); convergence rate of the gradient method. The Newton method and globally convergent variants (e.g., modified Newton); Newton's convergence rate. Quasi-Newton Methods. Applications: neural networks, LASSO regression, etc.

Constrained Optimization.

Degree competences to which the content contributes:

Description:
Problem modeling. Convexity. Optimality conditions (Karush-Kuhn-Tucker conditions). Particular cases: linear optimization and quadratic optimization. Simplex method for linear optimization. Duality in optimization. Dual linear and quadratic problems. Applications: support vector machines, etc.

Integer Optimization.

Degree competences to which the content contributes:

Description:
Modeling of problems with binary and/or integer variables.. Combinatorial problems Properties of integer and combinatorial optimization problems. Solution methods: branch-and-bound, and cutting plans. Applications: clustering, k-median, classification, etc.

Planning of activities

Development of the topic "Unconstrained Optimization"	Hours: 70h Theory classes: 14h Practical classes: 7h Laboratory classes: 7h Guided activities: 1h 24m Self study: 40h 36m
Specific objectives: 1, 2, 3	

Development of the topic "Constrained Optimization"	Hours: 60h Theory classes: 12h Practical classes: 6h Laboratory classes: 6h Guided activities: 1h 12m Self study: 34h 48m
Specific objectives: 1, 2, 3	

Development of the topic "Integer Optimization"	Hours: 20h Theory classes: 4h Practical classes: 2h Laboratory classes: 2h Guided activities: 0h 24m Self study: 11h 36m
Specific objectives: 1, 2, 3	

Qualification system

There will be 3 marks (each in [0,10]):

Pr: lab mark.
ExP: midterm exam mark.
ExF: final exam mark.

The final grade (NF) will be calculated as follows:

NF = 0.3 * Pr + 0.7 * (max {ExF, 0.7 * ExF + 0.3 * ExP})

Students with NF<5 will be allowed to do a re-evaluation exam. In the re-evaluation the only mark considered will be that of the re-evaluation exam.

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Bibliography

Basic:

Nocedal, J.; Wright, S.J. Numerical optimization [on line]. 2nd ed. Berlin: Springer, 2006 [Consultation: 29/07/2019]. Available on: <http://dx.doi.org/10.1007/978-0-387-40065-5>. ISBN 0387303030.

Luenberger, D.G.; Ye, Y. Linear and nonlinear programming. 4th ed. Cham, Switzerland: Springer, 2016. ISBN 9783319188416.

Wolsey, L.A. Integer programming. New York: John Wiley & Sons, 1998. ISBN 0471283665.

Fourer, R.; Gay, D.M.; Kernighan, B.W. AMPL: a modeling language for mathematical programming. 2nd ed. Pacific Grove, CA: Thomson/Brooks/Cole, 2003. ISBN 0534388094.

Cristianini, N.; Shawe-Taylor, J. An introduction to support vector machines: and other kermel-based learning methods. New York: Cambridge University Press, 2000. ISBN 0521780195.

Others resources:

Hyperlink

http://www-eio.upc.es/teaching/ple/pfc_ing.html

http://ampl.com/

https://neos-server.org/neos/