Course guide
270416 - OPT - Optimisation

Last modified: 03/02/2025

Unit in charge: Barcelona School of Informatics
Teaching unit: 715 - EIO - Department of Statistics and Operations Research.
707 - ESAII - Department of Automatic Control.

Degree: BACHELOR'S DEGREE IN ARTIFICIAL INTELLIGENCE (Syllabus 2021). (Compulsory subject).

Academic year: 2024 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish

LECTURER

Coordinating lecturer: PAU FONSECA CASAS

Others: Segon quadrimestre:
CECILIO ANGULO BAHON - 11, 12
PAU FONSECA CASAS - 11, 12
MARÍA PAZ LINARES HERREROS - 11, 12

PRIOR SKILLS

Know the concept of model and system.
Knowledge of basic statistics.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE01. To be able to solve the mathematical problems that may arise in the field of artificial intelligence. Apply knowledge from: algebra, differential and integral calculus and numerical methods; statistics and optimization.
CE20. To select and put to use techniques of statistical modeling and data analysis, assessing the quality of the models, validating and interpreting.
CE21. To formulate and solve mathematical optimization problems.
CE22. To represent, design and analyze dynamic systems. To acquire concepts such as observability, stability and controllability.
CE23. To design controllers for dynamic systems that represent temporary physical phenomena in a real environment.

Generical:
CG2. To use the fundamental knowledge and solid work methodologies acquired during the studies to adapt to the new technological scenarios of the future.
CG4. Reasoning, analyzing reality and designing algorithms and formulations that model it. To identify problems and construct valid algorithmic or mathematical solutions, eventually new, integrating the necessary multidisciplinary knowledge, evaluating different alternatives with a critical spirit, justifying the decisions taken, interpreting and synthesizing the results in the context of the application domain and establishing methodological generalizations based on specific applications.
CG5. Work in multidisciplinary teams and projects related to artificial intelligence and robotics, interacting fluently with engineers and professionals from other disciplines.
CG8. Perform an ethical exercise of the profession in all its facets, applying ethical criteria in the design of systems, algorithms, experiments, use of data, in accordance with the ethical systems recommended by national and international organizations, with special emphasis on security, robustness , privacy, transparency, traceability, prevention of bias (race, gender, religion, territory, etc.) and respect for human rights.
CG9. To face new challenges with a broad vision of the possibilities of a professional career in the field of Artificial Intelligence. Develop the activity applying quality criteria and continuous improvement, and act rigorously in professional development. Adapt to organizational or technological changes. Work in situations of lack of information and / or with time and / or resource restrictions.

Transversal:
CT2. Sustainability and Social Commitment. To know and understand the complexity of economic and social phenomena typical of the welfare society; Be able to relate well-being to globalization and sustainability; Achieve skills to use in a balanced and compatible way the technique, the technology, the economy and the sustainability.
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.

Basic:
CB2. That the students know how to apply their knowledge to their work or vocation in a professional way and possess the skills that are usually demonstrated through the elaboration and defense of arguments and problem solving within their area of ??study.
CB3. That students have the ability to gather and interpret relevant data (usually within their area of ??study) to make judgments that include a reflection on relevant social, scientific or ethical issues.
CB4. That the students can transmit information, ideas, problems and solutions to a specialized and non-specialized public.

TEACHING METHODOLOGY

The classes will combine lectures with practical sessions where the students will work on the content of the topics they have covered. The laboratory classes will allow you to develop cases that allow you to apply the knowledge acquired.

LEARNING OBJECTIVES OF THE SUBJECT

1.Be able to apply basic optimization techniques to be able to solve computationally complex problems.
3.Contextualize the different existing optimization techniques.

STUDY LOAD

Type	Hours	Percentage
Self study	90,0	60.00
Hours small group	30,0	20.00
Hours large group	30,0	20.00

Total learning time: 150 h

CONTENTS

Introduction to optimization

Description:
The concept and need for optimization will be presented. Examples and real cases will be shown in which some of the techniques that will be explained during the course have been used.

Discrete optimization

Description:
Introducció a l'optimització discreta, dualitat, SIMPLEX...

Heuristics

Description:
Optimització basada en heurístics.

Linear Dynamical Systems

Description:
Introduction to linear dynamical systems and their representations: ordinal differential equations; Laplace transform; Fourier transform

Discrete Dynamical Systems Models

Description:
Discrete representation of dynamical systems and modelling: AR, MA, ARMA, NARMAX

Control and Optimisation of Dynamical Systems

Description:
Control of dynamical systems and optimisation processes for tuning

ACTIVITIES

Introduction to optimization

Description:
Description and classification of the different techniques and approaches to optimization.

Specific objectives:
1, 3

Related competencies :
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Full-or-part-time: 23h
Theory classes: 4h
Practical classes: 4h
Self study: 15h

Linear programming

Full-or-part-time: 23h
Theory classes: 4h
Practical classes: 4h
Self study: 15h

Introduction to heuristics

Specific objectives:
1, 3

Related competencies :
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Full-or-part-time: 27h
Theory classes: 4h
Practical classes: 4h
Laboratory classes: 4h
Self study: 15h

Linear Dynamical Systems

Full-or-part-time: 27h
Theory classes: 6h
Practical classes: 6h
Self study: 15h

Modelling Discrete Dynamic Systems

Full-or-part-time: 25h
Theory classes: 4h
Practical classes: 6h
Self study: 15h

Control and Optimization of Dynamic Systems

Full-or-part-time: 25h
Theory classes: 6h
Practical classes: 4h
Self study: 15h

GRADING SYSTEM

For the optimization part, two practical works will be developed.
For the second part there will be a practical exercise and an evaluative written exam.

For the optimization part, two practical works will be developed.
For the second part there will be a practical work and an evaluation in the form of a written exam.

For the optimization part, two practical tasks T01 and T02 will be developed

For the second part there will be a practical work T03 and an assessment in the form of an EX written exam

Final Grade= 0.25* T01+0.25*T02+0.25*T03+0.25*EX

Reassessment: Only those who have failed the final exam may take the reassessment. The maximum grade that can be obtained in the reassessment is 7.

BIBLIOGRAPHY

Basic:
- Robert J. Vanderbei. Linear Programming. 5th ed. Cham, Switzerland: Springer, 2020. ISBN 9783030394141.
- Nocedal, Jorge; Wright, Stephen J.. Numerical Optimization. 2nd ed. Berlin: Springer, 2006. ISBN 9780387303031.
- Luke, Sean. Essentials of Metaheuristics. 2nd ed. San Francisco: [editor no identificat],, 2016. ISBN 978-1-300-54962-8.