UAB
Universitat Autònoma de Barcelona

Adjustment of Optimisation Models

Code: 104360
ECTS Credits: 6

2025/2026

Degree	Type	Year
Data Engineering	OB	3

Contact

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Teachers

Sundus Zafar

Teaching groups languages

You can view this information at the end of this document.

Prerequisites

Students should have the following knowledge and skills:

1. Multivariable Calculus and Linear Algebra: To understand optimization methods (Linear and Nonlinear Programming) and formulate cost functions. This corresponds to Mathematical Foundations, Optimization Techniques (Linear and Nonlinear Programming).
2. Familiarity with NumPy, SciPy, for Python-based optimization tasks: This corresponds to Practical Programming Subjects, Optimization in Real-World Systems.
3. Knowledge of probability distributions and statistical methods, which are fundamental for machine learning and optimization in AI. This corresponds to Optimization in Machine Learning, Probabilistic Optimization Methods.
4. Basic knowledge of machine learning algorithms and hyperparameter tuning: This corresponds to Optimization in AI/Machine Learning, Hyperparameter Optimization.
5. Knowledge of basic algorithms and graph theory for routing, scheduling, and shortest path problems: This corresponds to Optimization in Real-World Systems (Transportation, Routing, and Distribution).

Objectives and Contextualisation

This course aims to equip students with the skills to model real-world problems and apply optimization techniques across a wide range of industries, including transportation, logistics, manufacturing, and information technology, as well as AI, data science, and machine learning. Students will learn both constrained and unconstrained optimization methods, including multi-objective optimization, gradient descent, and evolutionary algorithms. Specifically, students will:

1. Understand the role of optimization in improving processes and systems across various industries, including logistics, transportation, manufacturing, finance, and AI.
2. Analyze and evaluate cost functions and select the most appropriate optimization methods based on the properties and constraints of the problem at hand.
3. Formulate and adjust optimization models to solve real-world problems, considering both industry-specific constraints and operational objectives.
4. Apply optimization techniques such as linear programming, non-linear programming, genetic algorithms, and grid search to optimize processes in different sectors, including production, supply chain management, route optimization, and machine learning.
5. Gain practical experience with Python tools (e.g., Pyomo, LinProg) to implement optimization models for solving complex, real-world problems in a variety of industries.

Competences

- Analyse data efficiently for the development of smart systems with the capacity for autonomous learning and/or data mining.
- Develop critical thinking and reasoning and know how to communicate it effectively in both your own language and in English.
- Students must be capable of collecting and interpreting relevant data (usually within their area of study) in order to make statements that reflect social, scientific or ethical relevant issues.
- Use the concepts and methods of algebra, differential and integral calculus, numerical methods, statistics and optimisation necessary for solving engineering problems.
- Work cooperatively in complex and uncertain environments and with limited resources in a multidisciplinary context, assuming and respecting the role of the different members of the group.

Learning Outcomes

1. Analyse mathematically the properties of a particular cost function to be optimised in order to pick the best optimisation method and/or search algorithm.
2. Choose the search algorithm and programming paradigm for a problem of optimisation of parameters or states
3. Develop critical thinking and reasoning and know how to communicate it effectively in both your own language and in English.
4. Formulate the most suitable cost function for a specific problem of parameter adjustment or mathematical model, in line with the characteristics of the experimental data and the requirements/restrictions of the problem.
5. Students must be capable of collecting and interpreting relevant data (usually within their area of study) in order to make statements that reflect social, scientific or ethical relevant issues.
6. Work cooperatively in complex and uncertain environments and with limited resources in a multidisciplinary context, assuming and respecting the role of the different members of the group.

Content

1. Mathematical modeling of optimization problems (variables, cost functions, constraints).
2. Types of optimization: with constraints vs. without constraints and multi-objective optimization.
3. Linear Programming (LP): Simplex method, formulation of linear objective functions and constraints.
4. Nonlinear Programming (NLP): KKT conditions, optimization conditions in constrained nonlinear problems.
5. Convexity: Definition of convex sets and functions, importance in optimization.
6. Gradient Descent: Mathematical foundation of gradient calculation, convergence analysis.
7. Evolutionary Algorithms (Genetic Algorithms): Mathematical principles of genetic algorithms for optimization (selection, mutation, crossover).

8. Heuristic Methods: Grid search and simulated annealing, probabilistic approach, and search space evaluation.
9. Pyomo & LinProg: Mathematical modeling in Python, translating optimization problems into code.
10. Optimization in Transportation and Logistics: Shortest path problems (Dijkstra's algorithm), network flow optimization.
11. Manufacturing and Supply Chain: Production scheduling, resource allocation models.
12. Data Pipeline Optimization: Mathematical modeling for data flow and system efficiency.

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Practice classes	16	0.64	1, 3, 5, 6
Problem assessment	24	0.96	1, 5
Theory Classes	30	1.2	1, 2, 4, 5, 6
Type: Autonomous			
Studi	60	2.4	1, 3, 2, 4, 5, 6

The course is structured around theory classes, problem-solving sessions, and practical exercises, with a focus on real-world applications of optimization.

1. Theory Classes: Introduces core optimization concepts and techniques, supported by the recommended literature.
2. Problem-Solving Sessions: Students apply learned techniques to solve problems. Problem sets and solutions will be posted on the Virtual Campus.
3. Practical Sessions: Hands-on exercises using real-world data to reinforce the theoretical concepts. Instructions for each session will be available on the Virtual Campus.
4. Presentations: Two presentations: Progress presentation and Final capstone project presentation.
5. Capstone Project (Ongoing): Students will work in group (5 students) on a real-world optimization problem throughout the course,culminatingin a finalreport and presentation.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Practices Exam - Midterm and Final	20%	4	0.16	1, 3, 2, 4, 5
Final Project Evaluation	20%	8	0.32	1, 3, 2, 4, 5, 6
Final Theory and Problems exam	30%	4	0.16	1, 2, 4

Midterm Exam - Theory and Problems	30%	4	0.16	1, 2, 4

The assessment of the subject will consist of:

1. Midterm Exam: Theory (30%): Assessment of the fundamental theoretical concepts of optimization.
2. Midterm Exam: Practical (10%): Application of optimization techniques to practical problems using tools such as Python.
3. Final Exam: Theory (30%): Assessment of the theoretical knowledge acquired throughout the course.
4. Final Exam: Practical (10%): Evaluation of the ability to apply theoretical concepts to practical problems using Python or other optimization tools.
5. Final Project (20%): Objective: To assess the students' ability to apply optimization techniques to a real-world problem,
6. Content: The final project will involve a written report and oral presentation, in which students will describe the problem, methodology used, results obtained, and conclusions.

None of the Assessment activities removes material for the final exam. The final grade will be the weighted average of the activities. No minimum grade policy is set for any activity. If applying the weights mentioned above the student's grade is 5 or higher, the subject is considered passed and this may not be the subject of a new assessment. A student is considered to be "Not assessed" in the subject as long as there is no participation in any of the assessment activities.

Recovery Process "To participate in the Recovery Process, students must have previously been assessed in a set of activities that represent a minimum of two thirds of the total grade of the subject or module." Section 3 of Article 112b. Recovery (UAB Academic Regulations). Students must have obtained an average grade of the subject between 4.0 and 4.9. The date of this test will be scheduled in the calendar of examinations of the Faculty. The student who presents and passes it will pass the subject with a grade of 5. Otherwise he will keep the same grade.

Irregularities in the Evaluation

Without prejudice to Other disciplinary measures deemed appropriate, and in ACCORDANCE with current academic regulations, "in the event that the student commits any Irregularities that may lead to a significant variation in the rating of an assessment actor, he / she will be graded with an 0 this actor of evaluation, independently of the disciplinary Process that can instruct. in case that produce Several Irregularities in the Acts of evaluation a same subject, the final qualification of this subject will be 0 ". Section 10of Article 116. Results of theEvaluation. (UAB Academic Regulations) The Proposed Evaluation may undergo some modification depending on the restrictions on attendance imposed by the health authorities.

Bibliography

To be provided at the begining of the course

Software

To be provided at the begining of the course

Groups and Languages

Please note that this information is provisional until 30 November 2025. You can check it through this link. To consult the language you will need to enter the CODE of the subject.

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	81	Catalan/Spanish	first semester	afternoon