Universitat Autònoma de Barcelona

**2020/2021**

# Adjustment of Optimisation Models

Code: 104360
ECTS Credits: 6

| Degree | Type | Year | Semester |
|---|---|---|---|
| 2503758 Data Engineering | OB | 3 | 1 |

The proposed teaching and assessment methodology that appear in the guide may be subject to changes as a result of the restrictions to face-to-face class attendance imposed by the health authorities.

## Contact

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## Use of Languages

Principal working language: english (eng)
Some groups entirely in English: Yes
Some groups entirely in Catalan: No
Some groups entirely in Spanish: No

## External teachers

Thomas Batard

## Prerequisites

We recommend that students have the following knowledge and skills:

- Probabilities and statistics
- Differential and integral calculus in several variables
- Programming in Python
- Graphs
- Image and video Processing
- Vector spaces

These concepts correspond to the contents of the subjects:

- Probabilistic descriptions
- Fundamentals of Mathematics
- Fundamentals of programming and advanced programming
- Graphs, topology and discrete geometry
- Signal, image and video processing
- Vector spaces

## Objectives and Contextualisation

The main objective of the subject is to provide the elements for the modeling of experimental data, optimization with and without restrictions, multi-target optimization. Optimization methods and search algorithms, such as variational calculation, gradient descent methods, evolutionary computing. In particular:

Mathematically analyze the properties of a certain cost function to be optimized in order to choose the best optimization method and /or search algorithm

Formulate the most appropriate cost function for a particular problem of adjusting parameters or mathematical model according to the characteristics of the experimental data and requirements/restrictions of the problem

## 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 foundations: Multivariate functions (optimization, integration); Probabilities/Statistics
2. Variational Approaches: formulation, regularization terms, models with restrictions, Lagrange multipliers, numerical methods (gradient descent, stochastic gradient descent, global search), Application to image/video processing (inverse problems, segmentation)
3. Heuristic Approaches. Simulated aliening.
3. Probabilistic Approaches: Bayesian formulation, variational versus probabilistic, expectation maximization, graphical models (conditional random fields, hidden markov models), Application to image/video processing (segmentation)
4. Regression and classification models: Linear models: Least-squares, regularized least-squares (e.g. Lasso), Minimization of cross entropy

## Methodology

The final objective of the course is that students are able to model experimental data, deciding at all times what is the best cost function and method to optimize it. For this reason, the classroom sessions will be highly practical and will focus on the students to consolidate the knowledge that is objective of learning this subject. The general methodology of the course can be divided into three activities:

PREVIOUS PREPARATION. The aim is that the Alumnado can learn the concepts that will work in the next session through diverse activities proposed by the Profesorado like it can be the viewing of videos, the reading of texts, etc. All the necessary material (enunciated, BD scripts, problem results) will be available in the documentary Manager Caronte (http://caronte.uab.cat).

CLASSROOM. The objective is to consolidate the concepts seen and put them into value within the context of the subject. The teacher will ensure that students delve into these concepts through exercises (more or less) guided during the session. For this reason the classroom sessions will take place in 2 weekly 2-hour meetings each in classrooms with of oridnadors and connection to the servant. The distribution will be based on problem groups. The attendance to the classroom is not COMPULSORY, but RECOMMENDABLE.

AUTONOMOUS LEARNING. We will propose several use cases that will be resolved in groups of between 2 and 4 students. The statements of the use cases are available on the Web page in PF and Caronte (http://caronte.uab.cat). Deliveries of self-employed work will be done via Caronte.

Transversal competences: Competences 01.00-working cooperatively, in complex or uncertain environments with limited resources, in a multidisciplinary context, assuming and respecting the role of the different members of the team and T03-develop critical thinking and reasoning and know how to communicate effectively both in their own languages and in English, are working on the resolution of use cases in which the student willhave to work in a group of 2-4 people.

## Activities

| Title | Hours | ECTS | Learning Outcomes |
|---|---|---|---|
| Type: Directed | | | |
| Lecture Sessions | 50 | 2 | 1, 2, 4, 6 |
| Type: Supervised | | | |
| Use cases | 47 | 1.88 | 1, 3, 2, 4, 5, 6 |
| Type: Autonomous | | | |
| Previous Work | 35 | 1.4 | 1, 2, 4, 5, 6 |

## Assessment

The course will be evaluated in 2 aspects: Theory and problems, practices and self-employment (use case resolution). The theory/problems note will be obtained through an individual examination, while the note of self-employment will be taught by a series of exercises throughout the course. The final grade will be the weighted average of the grade obtained in each activity:
FINAL NOTE 0' 6 * Theory Exam Note + 0' 4 * Use Cases
To make the weighted average, you need to pass the theory exam with 5. Resolving use cases does not require a minimum rating to average. In the event that the minimum required in any of the evaluation activities is not reached, the minimum between the final rating (obtained from the weighted average) and a 4 ' 5 shall be recorded. The subject is considered approved if the final grade is equal to or greater than 5.

EVALUATION CRITERIA

Theoretical examination. There will be two individual written exams, with a weight of 60% each in the final

grade. The first test will be conducted approximately in the middle of the semester and the second test will be conducted at the end of the semester during the exam period.
The final degree of the theory will be the average of the 2 partial notes, if the note of each partial exceeds 4. Otherwise, the theoretical part will be considered suspended and the student will have to take a recovery from the suspended part. In the case of not reaching the minimum for one of the exams, the theoretical score will be the minimum between the average and a 4 ' 5.
Resolution of use cases. The final grade will be the average of the grades obtained for all the cases raised

Continuous evaluation: The continuous evaluation process includes all of these activities: resolution of use cases and examination of theory and problems (Recoverable synthesis test)
Theory recovery exam: In case the grade of an individual theoretical exam is less than 4, or the overall average does not reach5, studentsshould take an exam to retrieve the theory part and problems raise the note.

IMPORTANT FOR ALL STUDENTS: It is important to register in Caronte (http://caronte.uab.cat) at the beginning of the course, as the materials of the subject are published, the practical deliveries are made and the final grades of the course are published. To register in Careonte in the subject of databases 1, you must give your personal data and a passport photo in JPG format.

NON-ASSESSABLE: A student is considered non-assessable (NA) only if he has not done any assessment activity. Recall that a non-assessable (NA) also consumes registration.

There is no special treatment for students who repeat the subject.

Pass with Honor: Students who have more than a 9.5 in the final grade will have a distinction of honour (MH) until reaching the limit of 5% of the enrolled holders. In case of having more than 5% of the students over the 9.5 will have MH those that have the highest notes.

EVALUATION CALENDAR:
• Theory and problem Examinations: Theory hours announced in advance.
• Recovery exam: Depending on the academic calendar of the school of Engineering.
• Practice exercises: During the period of the partial seconds, in laboratory practicals and announced in advance.
• Rehabilitation of practices: During the period of theory recovery exams, in laboratory practices and announced in advance.
• Autonomous work: the theory and/or problems will be communicated in advance either via Caronte or in lectures.

The dates of continuous assessment and delivery of work will be published in Caronte and may be subject to programming changes for reasons of adaptation to possible incidents. Caronte will always be informed about thesechangesas it is understood that this is the usual platform for exchanging information between teachers and students.
For each evaluation activity, a place, date and time of revision will be indicated in which the student will be ableto revise the activity with the teacher. In this context, it will be possible to make claims about the activity mark, which will be evaluated by the teachers responsible for the course. If the student is not present for this revision, this activity will not be reviewed later.

ACADEMIC IRREGULARITIES. Notwithstanding other disciplinary measures deemed appropriate, and in accordance with the academic
regulations in force, assessment activities will receive a zero whenever a student commits academic irregularities that may alter such assessment. Assessment activities graded in this way and by this procedure will not be re-assessable. If passing the assessment activity or activities in question is required to pass the subject, the awarding of a zero for disciplinary measures will also entail a direct fail for the subject, with no opportunity to re-assess this in the same academic year. Irregularities contemplated in this procedure include, among others:

• allowing others to copy;
• presenting group work that has not been done entirely by the members of the group;
• presenting any materials prepared by a third party as one's own work, even if these materials are

translations or adaptations, including work that is not original or exclusively that of the student;
• having communication devices (such as mobile phones, smart watches, etc.) accessible during theoretical-practical assessment tests (individual exams).

In case of not passing the subject because one of the evaluation activities does not reach the minimum note, the numerical grade of the file willbe the lowest value between 4.5 and the weighted average of the notes. A "non-assessable" grade cannot beassigned
to students who have participatedin any of the individual partial tests or the final exam.

In short: copying, leaving copying orplagiating in any of the evaluation activities equals a FAIL with a note less than 3.0.

## Assessment Activities

| Title | Weighting | Hours | ECTS | Learning Outcomes |
|---|---|---|---|---|
| Individual final exams of theory and exercicies | 60% | 4 | 0.16 | 1, 2, 4 |
| Individual partial exams of theory and exercicies | 60% | 4 | 0.16 | 1, 2, 4 |
| Us Cases | 40% | 10 | 0.4 | 1, 3, 2, 4, 5, 6 |

## Bibliography

To be provided at the begining of the course