

Operational research

Code: 100125
ECTS Credits: 6

Degree	Type	Year	Semester
2500149 Mathematics	OT	4	0

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: catalan (cat)
Some groups entirely in English: No
Some groups entirely in Catalan: Yes
Some groups entirely in Spanish: No

Prerequisites

This course assumes that the student has obtained the knowledge taught in different courses on the following topics:

- Calculus in several variables.
- Probability
- Linear models.
- R programming.

Objectives and Contextualisation

This course aims to familiarize the student with different methods of machine learning by applying the point of view used when large amounts of data are available.

Competences

- Actively demonstrate high concern for quality when defending or presenting the conclusions of ones work.
- Effectively use bibliographies and electronic resources to obtain information.
- Recognise the presence of Mathematics in other disciplines.
- Students must be capable of applying their knowledge to their work or vocation in a professional way and they should have building arguments and problem resolution skills within their area of study.
- 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.
- Students must develop the necessary learning skills to undertake further training with a high degree of autonomy.
- Students must have and understand knowledge of an area of study built on the basis of general secondary education, and while it relies on some advanced textbooks it also includes some aspects coming from the forefront of its field of study.

- Use computer applications for statistical analysis, numeric and symbolic calculus, graphic display, optimisation or other purposes to experiment with Mathematics and solve problems.
- When faced with real situations of a medium level of complexity, request and analyse relevant data and information, propose and validate models using the adequate mathematical tools in order to draw final conclusions

Learning Outcomes

1. Achieve mastery and security in the handling of specific scientific programs for problem-solving with real data and in order to perform simulations.
2. Actively demonstrate high concern for quality when defending or presenting the conclusions of ones work.
3. Distinguish, of a problem, which thing is important of expensive to the building of the mathematical model and his resolution of what is not it.
4. Dominate the basic concepts of the theory and be able to combine them and use them to resolve problems.
5. Draw adequate conclusions from the result of the model.
6. Effectively use bibliographies and electronic resources to obtain information.
7. Evaluate the difficulty to do a calculation of analytical probabilities in complex situations and know distinguish when can realise these calculations and when has to resort to the simulation stochastic.
8. Find models of scientific or topological reality in relation to a decision-making problem and express it using the mathematical language of optimisation problems with dynamic programming or stochastic queues.
9. Know generate and manipulate models of simulation of the reality to establish and check hypothesis in the study of problems or realities more complex.
10. Students must be capable of applying their knowledge to their work or vocation in a professional way and they should have building arguments and problem resolution skills within their area of study.
11. 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.
12. Students must develop the necessary learning skills to undertake further training with a high degree of autonomy.
13. Students must have and understand knowledge of an area of study built on the basis of general secondary education, and while it relies on some advanced textbooks it also includes some aspects coming from the forefront of its field of study.
14. Understand the rudiments of logistics and other fields in which operative research is applied to the technological and industrial fields

Content

These are the contents of the subject*

- Introduction to Tidyverse
- Introduction to machine learning
- Linear and logistic regression
- Tractament de Big Data amb R
- La llibreria caret
- Mètodes d'aprenentatge automàtic
 - KNN
 - LDA
 - SVM
- Methods to deal with non-balanced outcomes
- Decision trees
 - Classification trees
 - Regression trees
 - Bagged trees
 - Random Forest
- Boosting

- AdaBoost
- GBM
- Estochastic GBM
- XGBoost
- Others

**Unless the requirements enforced by the health authorities demand a prioritization or reduction of these contents.*

Methodology

The course has two hours of theory and two hours of practices each week.

- Theory: the different methods with their particular characteristics are defined and explained and concrete examples are shown.

- Practices: working with the methods explained in theory class using different data sets and the R programming language.

It is considered that, for each hour of theory and practice, the student must dedicate an additional hour for the preparation and/or finalization of the session. Self-evaluating questionnaires will be filled-in to check whether the main concepts are acquired after each session.

NOTE:

*The proposed teaching methodology may experience some modifications depending on the restrictions to face-to-face activities enforced by health authorities.

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.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Lab sessions	50	2	1, 7, 14, 2, 3, 4, 5, 13, 12, 9, 8, 6
Type: Supervised			
Theory sessions	50	2	1, 7, 14, 2, 3, 4, 5, 13, 12, 10, 11, 9, 8
Type: Autonomous			
Weekly tasks + self-evaluation	50	2	1, 7, 14, 3, 4, 5, 13, 12, 10, 11, 9, 8, 6

Assessment

The evaluation of the course will be carried out with one exam (final) some weekly tasks and self-evaluation questions. The final grade will be calculated with the formula:

$$NF = 0.5 * NE + 0.4 * NT + 0.1 * NS$$

where NT is the average grade of weekly tasks, NS the average grade of self-evaluated questions and NE the grade of the examen that should be greater than 5.

At the end of the semester there will be a recovery exam for those students whose NE is less than 5 and/or NF lower than 5. In this case, the final grade will be calculated with the formula:

$$NF = 0.7 * NR + 0.3 * NT$$

where NR is the grade of the recovery exam.

NOTE: Student's assessment may experience some modifications depending on the restrictions to face-to-face activities enforced by health authorities.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Final exam	50%	0	0	7, 14, 2, 4, 13, 12, 10, 11, 9, 8, 6
Self-evaluation	10%	0	0	1, 2, 3, 4, 13, 12, 10, 11, 6
Tasks + self-learning	40%	0	0	1, 14, 2, 3, 4, 5, 13, 10, 11, 9, 8, 6

Bibliography

Basic bibliography:

- An Introduction to Statistical Learning with Applications in R - Gareth James, Daniela Witten, Trevor Hastie and Robert Tibshirani
- The bookdown of the topic: https://isglobal-brge.github.io/Aprendizaje_Automatico_1/

Complementary bibliography:

- The Elements of Statistical Learning: Data Mining, Inference, and Prediction - Trevor Hastie, Robert Tibshirani and Jerome Friedman
- Data Science from Scratch - Joel Grus
- Computer Age Statistical Inference: Algorithms, Evidence and Data Science - Trevor Hastie and Bradley Efron

Software

Theory and practical exercises will be done using R