Universitat Autònoma de Barcelona

2023/2024

Operational research

Code: 100125
ECTS Credits: 6

Degree	Type	Year	Semester
2500149 Mathematics	OT	4	1

Contact

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Teaching groups languages

You can check it through this link. To consult the language you will need to enter the CODE of the subject.
Please note that this information is provisional until 30 November 2023.

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 one's 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 one's 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 llibrería 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 questionaires will be filled-in to check whether the main concepts are adquired 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			
Problem sessions	14	0.56	1, 7, 14, 2, 3, 4, 5, 13, 12, 10, 11, 9, 8, 6
Theoretical Classes	26	1.04	1, 7, 14, 2, 3, 4, 5, 13, 12, 10, 11, 9, 8, 6
Type: Supervised			
Computer Sessions	12	0.48	1, 7, 14, 2, 3, 4, 5, 13, 12, 10, 11, 9, 8, 6

Type: Autonomous			
Personal work	90.5	3.62	1, 7, 14, 2, 3, 4, 5, 13, 12, 10, 11, 9, 8, 6

Assessment

Continued assesment

There are two partial exams,
EP1 and
EP2, both with a second chance or recovery exam,
EF1 and
EF2. To pass the subject, it is necessary that the
NC course grade (weighted average of the two partial exams) is greater than or

equal to
4, with
min(EP1,EP2)>=3.

In addition, it is al

3.5. Then the final grade
NF is calculated by making
NF = 0.2*P + 0.8*NC, where
P is the practice grade.

In the recovery e

NC course mark is recovered. The practical mark is not recovered but is taken into account to calculate the final r

We say

R the recovery note, calculated with the following formula
R = 0.5*[max(EP1,EF1)+max(EP2,EF2)]. Then the final
NCD course grade is calculated as
NCD = 0.3*NC + 0.7*R.

Note that

NCD depends on recovery and also on the
NC course grade. In this case, the final mark will be
NF = 0.2*P + 0.8*NCD if the condition
min(max(EP1,EF1),max(EP2,EF2))>=3 is met. Otherwise, the final grade will be

min(NF, 4.5).

Unique evaluation

A final exam, EFU, is carried out, which has a second opportunity or recovery exam, ERU, if necessary. The EFU final exam has 2 parts, EFU1 and EFU2, which take place in a single day, one in the morning and one in

the afternoon. In the same way,the ERU recovery exam has 2 parts, ERU1 and ERU2, which take place in a single day, one in the morning and one in the afternoon.

The content of the first part (of the two exams, EFU and ERU) coincides with that of the EP1 exam of the continuous evaluation. The content of the second part (both exams, EFU and ERU) coincides with that of the EP2 exam of the continuous evaluation.

To pass the subject in this modality, it is necessary that the final grade NFU (weighted average of the two parts, EFU1 and EFU2) is greater than or equal to 5, being min(EFU1,EFU2)>=3.5. Otherwise, it is necessary to take the recovery exam, and then the final grade, NFUR, is calculated as follows:

NFUR = 0.3*NFU + 0.35*[max(EFU1,ERU1)+max(EFU2,ERU2)] if the condition min[max(EFU1,ERU1) , max(EFU2,ERU2)]>=3 is met, or min(NFUR, 4.5) if this condition is not met.

Note (valid for both evaluation options): In no case are the second chance (or recovery) options to raise grades that are >= 5.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Final Exam	50%	3	0.12	1, 7, 14, 2, 3, 4, 5, 13, 12, 10, 11, 9, 8, 6
Midterm Exam	30%	2	0.08	1, 7, 14, 2, 3, 4, 5, 13, 12, 10, 11, 9, 8, 6
Tasks	20%	2.5	0.1	1, 7, 14, 2, 3, 4, 5, 13, 12, 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