Universitat Pompeu Fabra Barcelona

Academic Year/course: 2021/22

26181 - Applied Machine Learning and Optimisation

Syllabus Information

Academic Course: 2021/22
Academic Center: 304 - Faculty of Law and Economics
332 - Faculty of Economic and Business Sciences

Study: 3327 - Bachelor's degree in International Business Economics

Subject: 26181 - Applied Machine Learning and Optimisation
Credits: 5.0
Course: 3 and 4
Teaching languages:

Theory:	Group 1: English
Seminar:	Group 101: English
	Group 102: English

Teachers: Pablo Martin Calvo
Teaching Period: Third Quarter

Presentation

The goal of this course is to provide an introduction to simulation, optimization and machine learning techniques to students with a background in social sciences, with an approach biased towards practical work. The expected outcome is that students that have passed this course know a variety of modern and useful techniques that can be applied in real-life business contexts. With this knowledge and experience, the students understand what are the right techniques for different problems, which are the main steps and requirements to apply each of these techniques and how to judge the successful application of them.

Many of the techniques taught in this course are usually taught to engineering and technical profiles. This course does not aim to bring students to the same level of technical expertise as their engineering counterparts, but rather to provide enough background so that the students can successfully interact with such profiles. Having said that, this course can also be a first introduction for students that are willing to pursue a more thorough learning of the techniques discussed in the course, after or during itself.

With the knowledge and skills obtained in this course, students become fit for tasks such as:

- Applying simulation, optimization and machine learning techniques to simple cases.
- Planning and designing simulation, optimization and machine learning initiatives.
- Leading simulation, optimization and machine learning projects from a managerial point of view.
- Acting as a liaison between management and technical profiles in business contexts.

Associated skills

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Learning outcomes

Students are expected to obtain the following competences upon completing the course:

- Understand how can simulation, optimization and machine learning be applied in business and organizations to solve practical problems.

- Learn how to assess real world problems to identify the best techniques to use in each case.

- Learn how to translate problems from business domain to simulation, optimization and machine learning solutions.

- Understand the methodological steps to apply simulation, optimization and machine learning solutions.

- Become familiar with the management environment that surrounds the course techniques: how to write business cases, perform project management, assign the right tasks to different technical and non-technical professionals, deliver solutions in

production.

- Learn how to use Python code to implement simulation, optimization and machine learning.

Sustainable Development Goals

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Prerequisites

The course assumes the student has covered Mathematics I, II, III courses and the Probability & Statistics course. Passing this course is not impossible if that is not the case, but the student should expect a non-trivial challenge ahead.

Knowledge of the following topics will help students better leverage this course, but is not strictly required:

- Basic programming, specially in data oriented languages such as Python or R.
- Operations research

Contents

Find below the planned content schedule. Minor changes might be performed during the course to improve the learning experience.

- L1: Introduction and motivation of the course
- L2: Simulation, Optimization and Machine Learning in companies
- L3: Introduction to simulation: What is it, When do we use it, Types of simulation
- L4: Simulation examples in Python.
- L5: Simulation methodology.
- L6: Simulation-based optimization I. Challenges and issues with simulation.
- L7: Introduction to optimization
- L8: Modeling optimization problems
- L9: Taxonomy of optimization techniques
- L10: Simulation-based optimization II.
- L11: Challenges in real-world usage. Simulation vs Optimization
- L12: Introduction to Machine Learning
- L13: Supervised Machine Learning (SML)
- L14: Typical SML workflow
- L15: Algorithm deep dive: Decision trees
- L16: Feature Engineering and Model Evaluation
- L17: Deployment of Models
- L18: Stories from the trenches: applying all of this in the real world
- L19: Where to go from here: further learning and career advice
- L20: Final Q&A, exam preparation

Teaching Methods

The course will have lecture classes and practical seminars. Classes start on April 7th.

There will be 20 lecture classes and 6 practical seminars. Lecture classes will be used to present material to students as well as having discussions on the course contents. For the practical seminars, students will be divided into two groups with independent sessions to reduce the class size. The practical seminars will be used to deep-dive in the three mandatory case assignments that students will do throughout the course. The sesions will also be hands-on and students will work in the case together with the professor.

Students are expected to attend all the activities in the course. Beyond lectures and practical seminars, additional reading resources will be provided to students. For students that need to level up their Python skills, self-paced materials will be suggested.

Evaluation

The following items compose the final grade:

- Case assignments: 50% of the grade. There will be three assignments, each with the same weight. The average grade of the assignments must be of 5 or more to pass the course.
- Final exam: 50% of the grade. There will be a final exam at the end of the course. The grade must be of 5 or more to pass the course.

Students who fail the course, have followed the continuous assessment and took the final exam will get the chance to sit a retake exam. The grade they obtain in the retake exam will replace the grade they obtained in their first final exam. Their grades for the case assignments will remain the same and the final grade will be computed with the same formula.

Bibliography and information resources

All compulsory and required materials will be provided during the course. These include lecture notes, required readings and description readings.

A good book that follows the approach of this course is "Guttag, John. Introduction to Computation and Programming Using Python: With Application to Understanding Data. 2nd ed. MIT Press, 2016. ISBN: 9780262529624", used in the homonymous course at MIT. It is not compulsory to use this book, but some students might find it helpful.

Additional specific readings will be provided throughout the course. Students will be requested to read some of these materials in advance of some sessions.

For students that want to dive deeper in the topics covered in the course, the following books are recommended:

- On simulation: Louis G. Birta Gilbert Arbez, Modelling and Simulation. Springer 2019 ISBN: 978-3-030-18869-6 or Law A., Kelton D., Simulation and Modelling Analysis, Second Edition, McGraw-Hill, ISBN: 978-0071165372
- On machine learning: Hastie T., Tibshirani R., Friedman J., The Elements Of Statistical Learning: Data Mining, Inference, And Prediction, Second Edition ISBN: 978-0387848570