Prescriptive Analytics

From Prediction to Action: Modern Prescriptive Analytics

Professor: Alberto Santini

Course Type: Elective

Credits: 4 ETCS

Term: 3rd Term

Course Description

Thanks to advances in machine learning, descriptive and predictive analytics are more accessible than ever. A descriptive analysis helps understand existing data, while a prescriptive analysis forecasts future data. Together, descriptive and predictive analytics allow policymakers, managers, and researchers to understand their data, find correlations and cause-effect relations, and predict future trends. Still, analysts and decision-makers who successfully build analytics solutions are often left with a "Now what?" question. Prescriptive analytics translates the insights from machine learning and statistical models into actions that produce an optimal real-world impact. It answers questions such as: "How to allocate a healthcare budget to reduce wait times?"; "How to route vehicles to deliver thousands of parcels at a low cost and on time?"; "How to purchase electricity to ensure that cheap, clean power is available when needed?". In this last example, descriptive and predictive models could forecast electricity prices, supply and demand; a prescriptive model will then build an actionable purchasing plan using the predictions to procure renewable energy at the lowest expected cost.
The success of descriptive and predictive models is partly due to a vast repertoire of standardised models (from Simple Linear Regression to Deep Neural Networks). By contrast, prescriptive models tend to be uniquely tailored to specific applications. Therefore, the analyst developing a prescriptive solution must be well-versed in the "art" of mathematical modelling. This course will teach you the basics of mathematical modelling and introduce you to advanced techniques that combine predictive and prescriptive models.

Objectives

At the end of the course, the students will:

1. Complement descriptive and predictive techniques with prescriptive ones to take optimal actions at the strategic, tactical and operational levels.
2. Build mathematical models to allocate resources optimally to deliver economic and societal improvements.
3. Obtain optimal solutions to complex problems that do not admit a closed-form solution.

Calendar and Contents

Weeks 1-4	**An introduction to mathematical modelling via examples.** We introduce mathematical models by solving real-life examples. We learn how to translate the English description of a problem into a precise mathematical model. We then transform this model into computer code and solve it to obtain the optimal solution. Our examples come from logistics, supply chain, industrial production planning, and economics and social sciences.
Weeks 5-8	**Simple Machine Learning models for predictive analytics.** We study two classes of simple Machine Learning models used for forecasting. First, we will introduce linear regression models from the point of view of predictive analytics (that is, with a focus on improving out-of-sample accuracy). Then, we will study decision trees for regression.
Weeks 9-10	**Combining predictive and prescriptive methods.** We show how to solve some of the mathematical models introduced in Part 1 when their input data is not deterministic but instead predicted by a Machine Learning model (introduced in Part 2). This third part is the culmination of our journey, in which the concepts introduced in the first two parts come together to unleash the full potential of modern predictive and prescriptive analytics.
Weeks 1-10	**Python Lab.** Throughout the course, we will implement our models using the Python programming language.

The course in the study plan

This elective course belongs to the subject of Strategy and Leadership the study plan. It takes place in the **third quarter** of the program once the knowledge on applied statistics has been achieved.

COURSE LEARNING PLAN

Methodology

Classes are of two types: theory and lab. Theory classes are developed using the blackboard (no slides), and students can access lecture notes covering the theory topics. In lab classes, students are encouraged to bring their laptops. The professor will explain how to solve real-life optimisation problems using computer tools.

Evaluation criteria

Participation: 10%. Final group project: 60%. Final exam: 30%.

Bio of Professor

Alberto Santini is an Associate Professor of Operational Research at Universitat Pompeu Fabra. Prior to his appointment at UPF, he worked at Amazon, Procter & Gamble, and RWTH Aachen University. He has a Ph.D. in Operational Research from the University of Bologna.

Bibliography

H. Paul Williams. *Model Building in Mathematical Programming, 5th Edition.* ISBN: 9781118443330

Gareth James, Daniela Witten, Trevor Hastie, Rob Tibshirani, Jonathan Taylor. *An Introduction to Statistical Learning with Applications in Python*. https://www.statlearning.com/