15D018

Machine Learning for Finance

Spring Term - 3 ECTS

Elective Course

Prof. Argimiro Arratia

Prerequisites to Enroll

Foundations of Data Science. Basic Statistics. Knowledge of R or Python.

Overview and Objectives

The course subjects of study range across themes from machine learning, mathematical finance, numerical methods and computer algorithms. There are two main objectives: 1) To acquire expertise in the mechanics of the most popular machine learning models, and their inter-relationship, in order to do proper model selection and fitting. 2) To understand the behavior of financial time series, their statistical properties, and learn to design and assess financial forecasting models and investment strategies based on supervised learning models or other models that use different types (quantitative and qualitative) of information sets.

Course Outline

The course covers the following list of topics:

1. **Understanding Financial Time Series Data:** Asset's price and return. Basic statistics of returns. Measures of dependence. Stationarity. Forecasting. Volatility.
2. **Supervised Learning Modeling:** Linear regression models (ARMA) and GARCH nonlinear model (quick review). Gaussian processes. Kernels in Statistical Machine Learning. Support Vector Regression (SVR). Neural Networks. Multilayered Networks (Deep Learners). The link between Gaussian process with SVR and Neural Networks. Data preprocessing, feature selection and Evaluation of Model Estimation.
3. **Information sets for forecasting.** Technical and Fundamental Financial indicators. Social perception indicators (news-based sentiment analysis).
4. **Financial Applications**. Estimating and Forecasting Financial time series. Porfolio selection. Portfolio optimization under different constraints sets. Credit scoring. Algorithmic trading.

The course is mostly based on my book: Computational Finance. Check the content in the web page of the book http://computationalfinance.lsi.upc.edu/?page_id=123
No deep numerical abilities are needed for this course, as we will make use of many functions and packages in software R that already do the job of modeling and statistics analysis, so you only have to learn how to assemble these functions, not to program from scratch. In fact, one of the goal of this course is to teach you how to use some of these packages for modeling time series data. A partial list of R packages for financial engineering that we use in this course: mrl, quantmod, caret, GA, nnet, neuralnet, kernlab, PerformanceAnalytics, PortfolioAnalytics and others.
Classes will alternate between theory and programming experiments and simulations in R.

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Required Activities

Attendance at classes, and submission of homework.

Evaluation Criteria

There will be no written exam. The evaluation consists on take home work, consisting on some R explorations and exercises to complement the theory, and a project (read a paper about some cool application or model and implement it). These home works will be done by groups of two students. The course will be graded as follows: 2 o 3 Homeworks 60% and Project 40%.

Competences

☒ Modeling and predicting high-dimensional data with advanced statistical methods in the field of data science in order to improve strategic decision making.

☒ Solve the real problems that arise in the fields of study through the accurate analysis of the data.

☒ Communicate with conviction in English the results and implications of the required analytical study using a language related to the receiver.

☒ Work in a heterogeneous team of researchers in the field of the economic analyst using specific group techniques.

☒ Own and understand knowledge that provides a basis or opportunity to be original in the development and / or application of ideas, often in a research context.

☒ That students know how to apply the acquired knowledge and their ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their area of study.

☒ That the students know to communicate their conclusions and the knowledge and last reasons that sustain them to specialized and non-specialized publics in a clear and unambiguous way.

☒ That students have the learning skills that allow them to continue studying in a way that will be largely self-directed or autonomous.

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Learning Outcomes

☒ Make decisions based on the fundamentals of the markets and the behavior of public agents.

☒ Apply mathematical and statistical analysis using economic theory in complex problems with high-dimensional data.

☒ Apply mathematical theory and statistics on data sets from disparate disciplines.

Materials

Books:
A. Arratia, Computational Finance, An Introductory Course with R, Atlantis Press & Springer, 2014.

Rasmussen, C. E. & Williams, C. K. (2006). Gaussian Processes for Machine Learning.
The MIT press. www.GaussianProcess.org/gpml/

P. Cortez (2014) Modern Optimization with R.

McNelis, P. D. (2005). Neural Networks in Finance:
Gaining predictive edge in the market. Elsevier

R. Tsay. Analysis of Financial Time Series. Wiley, 2013

Other:
A list of other resources (data sets, papers,...) will
be provided as the course progresses