Course guide
200250 - DSAF - Data Science Applied to Finance

Unit in charge: School of Mathematics and Statistics
Teaching unit: 723 - CS - Department of Computer Science.
Degree: BACHELOR’S DEGREE IN MATHEMATICS (Syllabus 2009). (Optional subject).
Academic year: 2022  ECTS Credits: 3.0  Languages: English

LECTURER
Coordinating lecturer: ARGIMIRO ALEJANDRO ARRATIA QUESADA
Others: Primer quadrimestre:
ARGIMIRO ALEJANDRO ARRATIA QUESADA - M-A

PRIOR SKILLS
Foundations of Machine Learning, Data Science. Basic knowledge of ML models such as neural networks, support vector regressors. Basic Statistics. Knowledge of R (preferable) or Python

TEACHING METHODOLOGY
Lectures combine theory and practice (R scripts for model exploration of time series and other examples will be provided). Attendance at classes is required, and submission of homeworks.

LEARNING OBJECTIVES OF THE SUBJECT
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 knowledge about financial markets, their functioning and products, and in general to understand the behavior of financial time series, their statistical properties. 2) To learn the design and proper assessment of financial forecasting models and investment strategies based on supervised learning models or other models that use different types of information sets (quantitative and qualitative).

STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Hours large group</td>
<td>15,0</td>
<td>20.00</td>
</tr>
<tr>
<td>Self study</td>
<td>45,0</td>
<td>60.00</td>
</tr>
<tr>
<td>Hours small group</td>
<td>15,0</td>
<td>20.00</td>
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Total learning time: 75 h
## CONTENTS

### 1. An abridged introduction to finance and ML

**Description:**
Securities (bonds, stocks, derivatives); price and payoff; market indices; market jargon; financial markets zoo. Essential aspects of data exploration and learning. A review of software in R for ML.

**Full-or-part-time:** 2h 40m  
Theory classes: 1h 30m  
Guided activities: 1h 10m

### 2. Statistics of Financial Time Series

**Description:**

**Full-or-part-time:** 2h 40m  
Theory classes: 1h 30m  
Guided activities: 1h 10m

### 3. Time series model adequacy methods.

**Description:**
Time series model adequacy. Causality. Independence. Correlation. The stationary bootstrap (for synthetic replication of time series). Feature selection through LASSO. (These are all useful techniques to select features for our time series forecasting models)

**Full-or-part-time:** 2h 40m  
Theory classes: 1h 30m  
Guided activities: 1h 10m

### 4. Financial time series models I

**Description:**
Financial Time Series Models. Econometric models: (linear) AutoRegressive Moving Averages models; (nonlinear) ARCH and GARCH. ML models: Feed forward (1-layer) Neural Networks (Nnet).  
An introduction to Financial Fundamental Analysis (Graham and Dobb theory of investment)  
Forecasting time series with Nnet and business fundamental indicators.

**Full-or-part-time:** 2h 40m  
Theory classes: 1h 30m  
Guided activities: 1h 10m

### 5. Financial time series models II

**Description:**
Forecasting financial time series with GP, Nnet, SVM, with alternative data (e.g. News-based sentiment indicators). For this we shall review Sentiment Analysis and financial applications.

**Full-or-part-time:** 2h 50m  
Theory classes: 1h 30m  
Guided activities: 1h 20m
6. Algorithmic trading. Portfolio theory I

**Description:**
Algorithmic trading. 
Portfolio optimization. Markowitz mean-variance model. Expected utility maximization theory.

**Full-or-part-time:** 2h 40m  
Theory classes: 1h 30m  
Guided activities: 1h 10m

7. Portfolio theory II.

**Description:**
Factor models of returns with alternative data. Robust portfolio optimization. The Machine Learning portfolio

**Full-or-part-time:** 2h 40m  
Theory classes: 1h 30m  
Guided activities: 1h 10m

8. Optimization Heuristics in Finance

**Description:**
Heuristic optimization. Simulated Annealing (SA). Genetic Programming (GenP).  
Applications: Calibrating GARCH models. Optimization of portfolios with computationally hard constraints (with SA). Finding profitable trading rules with GenP.

**Full-or-part-time:** 3h  
Theory classes: 1h 40m  
Guided activities: 1h 20m

9. Option pricing models I.

**Description:**
Options. Type of options (European, American, Asian and other). The Black-Scholes Formula for Valuing European Options (a brief review). Monte-Carlo valuation of options I.

**Full-or-part-time:** 2h 50m  
Theory classes: 1h 40m  
Guided activities: 1h 10m

10. Option pricing models II. Research directions.

**Description:**
Monte Carlo valuation of options II. Valuing options with Gaussian processes. Other heuristics for valuing options. Review of further research topics in Machine Learning for Finance.

**Full-or-part-time:** 2h 50m  
Theory classes: 1h 40m  
Guided activities: 1h 10m
GRADING SYSTEM

There will be no written exam. The evaluation consists of take-home works (2), consisting of some R explorations and exercises to complement the theory.

BIBLIOGRAPHY

Basic: