CASE STUDIES IN A.I. IN FINANCE

COURSE DESCRIPTION

This course focuses on the application of advanced artificial intelligence techniques to 21 solved case studies in stock trading and hedging strategies, portfolio construction, modelling options strategies, investor's modelling, financial news and building Robotic-Advisors. The advanced techniques include the incorporation of recently open-sourced libraries for the calculation and evaluation of financial indicators, the incorporation of custom functions for cross-validation, evaluation and model selection, the reformulation of problems in terms of reinforcement learning and the implementation in Python of reinforcement learning solutions and the analysis of situations where reinforcement learning fails.

The course will have the format of a SEMINAR, in which (i) the first 4 sessions (theoretical foundations) will be delivered by the instructors, and (ii) the following 8 sessions will be delivered by the student teams. In each one of those 8 sessions, a team of students will present to the class the cases assigned to their team. The teams will prepare each presentation based on cases assigned to them from a collection of solved case studies provided by the instructors. The presentations will explain the theory underlying the case solution and all notable implementation details regarding finance theory, statistical learning (A.I.) theory, code implementation and required improvements and extensions.

PRE-REQUISITES

Students lacking a basic functional knowledge of Finance are recommended to take APS1051 (Portfolio Management) and/or APS1052 (A.I. in Finance), previously to (or simultaneously with) this course.

TEXTBOOKS

Tatsat: Machine Learning and Data science Blueprits for Finance, 2021, by Hariom Tatsat.
Masters: Statistically Sound Indicators for Financial Market Prediction, 2020, by Timothy Masters
Jansen: Machine Learning for Algorithmic Trading 2nd Ed. 2020, by Stephan Jansen

OTHER REFERENCES:

Sofien1: The book of back-tests by Kaabar Sofien
Sofien2: New Technical Indicators in Python by Kaabar Sofien
Masters: Data Mining Algorithms in C+, 2918, by Timothy Masters
Dixon: Machine Learning in Finance, 2020, by Dixon, Halperin, and Bilokon+
Patel: Hands-On Unsupervised Learning Using Python, 2019, by Ankur Patel
Beninga: Financial Modelling, 2008, by Simon Beninga
Nielsen: Practical Time Series Analysis, 2020, by Aileen Nielsen

TENTATIVE MARKING SCHEME:

1. Final Individual Work (Details will be provided): 40%
2. Team Presentations: 60%

REGARDING THE PRESENTATIONS:

Students will prepare each presentation based on a case study from a collection of case studies provided by the professor. The presentation will explain all the theory underlying the case solution, and will explain all notable implementation details.

NOTICE:

The student's presentations format that we propose here is totally compatible with the Zoom technology available, which we have tested extensively (precisely in this regard) along more than a year of online teaching.

DELIVERABLES:

A 50 slide (minimum) presentation including the discussion of all relevant:
a. Finance theory
b. Statistical learning (A.I.) theory
c. Code implementation
d. Required Improvements and extensions

………………………………………………………..………………………………………………………....

--TENTATIVE SYLLABUS--

………..

SESSION 1

MANDATORY meeting on Jan 20, 2023 where the teams will be formed and case-studies will be assigned to teams

……………………………………………………………………………………………………

SESSION 2

Lecture on Finance Foundations

……………………………………………………………………………………………………

SESSION 3

Lecture on Statistically Sound Indicators PART 1

……………………………………………………………………………………………

SESSION 4

Lecture on Statistically Sound Indicators PART 2

……………………………………………………………………………………………

SESSION 5

Lecture on Statistically Sound Indicators PART 3 (Applications)

……..

READING WEEK

……..

SESSION 6

Supervised Learning: Regression

Case Study 1: Stock Price Forecasting
Blueprint for Using Supervised Learning Models to Predict a Stock Price

Case Study 2: Derivative Pricing
Blueprint for Developing a Machine Learning Model for Derivative Pricing

Ref:
Tatsat: Machine Learning & Data Science Blueprints for Finance
Jansen: review chapters 4, 5, 6, 7
Beninga: chapters 16, 19

Case Study 3: Investor Risk Tolerance and Robo-Advisors
Blueprint for Modeling Investor Risk Tolerance and Enabling a Machine Learning–Based Robo-Advisor

Ref:
Tatsat: Machine Learning & Data Science Blueprints for Finance
Jansen: review chapters 4, 5, 6, 7

....

SESSION 7

Supervised Learning: Regression

Case Study 4: Yield Curve Prediction
Blueprint for Using Supervised Learning Models to Predict the Yield Curve

Ref:
Tatsat: Machine Learning & Data Science Blueprints for Finance
Jansen: review chapters 4, 5, 6, 7

Supervised Learning: Classification

Case Study 5: Fraud Detection
Blueprint for Using Classification Models to Determine Whether a Transaction Is Fraudulent

Case Study 6: Loan Default Probability
Blueprint for Creating a Machine Learning Model for Predicting Loan Default Probability

Ref:
Jansen: review chapters 4, 5, 6, 7
Tatsat: Machine Learning & Data Science Blueprints for Finance

....

SESSION 8 (PART A)

Supervised Learning: Classification

Case Study 7: Bitcoin Trading Strategy
Blueprint for Using Classification-Based Models to Predict Whether to Buy or Sell in the Bitcoin Market

Ref :
Tatsat: chapter 6
Dixon: Bitcoin Prediction p. 256
Sofien1 and Sofien2

SESSION 8 (PART B)

Unsupervised Learning: Dimesionality Reduction, t-distributed Stochastic Neighbor Embedding

Case Study 8: Portfolio Management: Finding an Eigen Portfolio

Blueprint for Using Dimensionality Reduction for Asset Allocation

Ref:
Tatsat: Machine Learning & Data Science Blueprints for Finance
Jansen: chapter 13
Patel: chapter 3
Random Matrix Filtering: https://en.wikipedia.org/wiki/Marchenko%E2%80%93Pastur_distribution

Unsupervised Learning: Dimesionality Reduction, t-distributed Stochastic Neighbor Embedding

Case Study 9: Yield Curve Construction and Interest Rate Modeling
Blueprint for Using Dimensionality Reduction to Generate a Yield Curve

Ref :
Tatsat: chapter 7
Jansen: chapter 13
Patel: chapter 3

………………………………………………………………………………………………

SESSION 9

Case Study 10: Bitcoin Trading: Enhancing Speed and Accuracy
Blueprint for Using Dimensionality Reduction to Enhance a Trading Strategy

Ref:
Tatsat: Machine Learning & Data Science Blueprints for Finance
Jansen: chapter 13
Dixon: Applying PCA to decompose stock prices p. 220
Dixon: Factor Modelling pp. 177-179

Unsupervised Learning: Clustering

Case Study 11: Clustering for Pairs Trading
Blueprint for Using Clustering to Select Pairs

Case Study 12: Portfolio Management: Clustering Investors
Blueprint for Using Clustering for Grouping Investors

Ref :
Tatsat: Machine Learning & Data Science Blueprints for Finance
Patel: chapter 5, 6
Jansen: chapters 9, 10

………………………………………………………………………………………………

SESSION 10

Unsupervised Learning: Clustering

Case Study 13: Hierarchical Risk Parity
Blueprint for Using Clustering to Implement Hierarchical Risk Parity

Ref :
Patel: chapter 5, 6
Jansen: chapters 13

Reinforcement Learning

Case Study 14: Reinforcement Learning–Based Trading Strategy
Blueprint for Creating a Reinforcement Learning–Based Trading Strategy

Ref :
Tatsat: chapter 9
Jansen: chapter 22
Dixon: chapter 9

Reinforcement Learning

Case Study 15: Derivatives Hedging
Blueprint for Implementing a Reinforcement Learning–Based Hedging Strategy

Ref:
Jansen: chapter 22
Tatsat: Machine Learning & Data Science Blueprints for Finance

……………………………………………………………………………………………

SESSION 11 (PART A)

Reinforcement Learning

Case Study 16: Portfolio Allocation
Blueprint for Implementing a Reinforcement Learning–Based Portfolio Allocation

Ref :
Tatsat: chapter 9
Jansen: chapter 22

SESSION 11 (PART B)

The "Failure Mode" of Reinforcement Learning

Overfitting to the training regime
Lack of proper exploration
Out-of-experience extrapolation errors
Improper generalization from function approximation

Ref:
http://xaip.mybluemix.net/#/2020
http://proceedings.mlr.press/v80/greydanus18a/greydanus18a.pdf
https://arxiv.org/pdf/1811.12530.pdf

SESSION 11 (PART C)

Natural Language Processing as Machine Learning Input in Finance

Case Study 17: NLP and Sentiment Analysis–Based Trading Strategies
Blueprint for Building a Trading Strategy Based on Sentiment Analysis
Jansen: chapter 14

SESSION 11 (PART D)

Natural Language Processing as Machine Learning Input in Finance

Case Study 18: Chatbot Digital Assistant
Blueprint for Creating a Custom Chatbot Using NLP
Tatsat: chapter 10

……………………………………………………………………………………………

SESSION 12 (PART A)

Case Study 19: Document Summarization
Blueprint for Using NLP for Document Summarization
Tatsat: Machine Learning & Data Science Blueprints for Finance
Jansen: chapter 15
Collaborative Filtering

SESSION 12 (PART B)

Advanced Applications

Case Study 20: Stock Recommendation System
Blueprint for Building a Stock Recommendation System using Matrix Factorization and Boltzman Machines

Ref:

Patel: chapter 10
Clustering/HMM

Case Study 21: Regime Investing
Blueprint for a Regime Investing system based on Gaussian clustering (or HMM) and Fama French Factors
Jansen: chapter 7

………………………………………………………………………………………………