

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 Blueprints for Finance, 2021, by Hariom Tatsat.

Nyholm: Strategic Asset Allocation in Fixed-Income Markets, 2008, by Ken Nyholm.

Jansen: Machine Learning for Algorithmic Trading, 2nd Ed. 2020, by Stephan Jansen.

OTHER REFERENCES:

Tatsat: Machine Learning and Data science Blueprints for Finance, 2021, by Hariom Tatsat.

Masters: Statistically Sound Indicators for Financial Market Prediction, 2020, by Timothy Masters

Sofien1: The book of back-tests by Kaabar Sofien

Sofien2: New Technical Indicators in Python by Kaabar Sofien

Masters: Data Mining Algorithms in C+, 2018, 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:

- (i) Critical Review of 1 paper AND 1 book from the lists we'll provide (Individual Work): 60% of the Final Grade
- (ii) Presenting to the class the 2 case studies that we'll assign to your team (you can choose it to be Individual or Team work): 40% of the Final Grade
- (iii) A 1,000 words essay and a (>30 Slides) slideshow should be delivered for the critical review of the paper, and a 2,000 words essay (and the corresponding slideshow) for the critical review of the book
- (iv) Each Case Study Class Presentation must be 45 minutes long

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

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--TENTATIVE SYLLABUS--
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SESSION 1

MANDATORY meeting on January 12, 2024 where the teams will be formed and case-studies will be assigned to teams

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SESSION 2

Various topics

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SESSION 3

Various topics

SESSION 4

Various topics

SESSION 5

Various topics

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:
Jansen: review chapters 4, 5, 6, 7
Nyholm: chapter 2

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

Ref:
Jansen: review chapters 4, 5, 6, 7
Nyholm: chapters 2, 4

SESSION 7

Supervised Learning: Regression

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

Ref:
Jansen: review chapters 4, 5, 6, 7
Nyholm: chapter 2, 3, 4, 5

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

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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 :

Jansen: review chapters 4, 5, 6, 7

SESSION 8 (PART B)

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

Case Study 8: Portfolio Management: Finding an Eigen Portfolio

Blueprint for Using Dimensionality Reduction for Asset Allocation

Ref:

Jansen: chapter 13

Nyholm: chapter 6

Unsupervised Learning: Dimensionality 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 :

Jansen: chapter 13

Nyholm: chapter 2, 3, 4, 5

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SESSION 9

Case Study 10: Bitcoin Trading: Enhancing Speed and Accuracy

Blueprint for Using Dimensionality Reduction to Enhance a Trading Strategy

Ref:

Jansen: chapter 13

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 :

Jansen: chapters 9, 10

Nyholm : chapter 6

SESSION 10

Unsupervised Learning: Clustering

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

Ref :

Jansen: chapters 13
Nyholm: chapter 6

Reinforcement Learning

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

Ref :

Jansen: chapter 22

Reinforcement Learning

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

Ref:

Jansen: chapter 22

SESSION 11 (PART A)

Reinforcement Learning

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

Ref :

Jansen: chapter 22
Nyholm: chapter 6

SESSION 11 (PART B)

The “Failure Mode” of Reinforcement Learning

Application of Monte Carlo Permutation Test to Reinforcement Learning Models

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

Ref:

Jansen: chapters 14, 15, 16

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

Ref :

Jansen: chapters 14, 15, 16

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SESSION 12 (PART A)

Case Study 19: Document Summarization
Blueprint for Using NLP for Document Summarization

Ref:

Jansen: chapters, 14, 15, 16

SESSION 12 (PART B)

Advanced Applications

Cases from: Machine Learning for Financial Risk Management with Python

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Where to find Jansen's Tatsat's, Jansen's and Nyholm's materials?
At UofT library: all are downloadable. We have translated Nyholm's Matlab programs to Python.
Also at:
GitHub: <https://github.com/tatsath/fin-ml>
Free access to Tatsat's book (lasts 10 days) in
<https://www.oreilly.com/online-learning/>
Tatsat's book also here for a few days (only for reading, not downloading):
<https://drive.google.com/file/d/11U4Eko39A38tpb9BYiLnM5xWdeQwbQaI/view?usp=sharing>
Where to find Jansen's materials?
GitHub: <https://github.com/stefan-jansen/machine-learning-for-trading>
Jansen's book also here for a few days (only for reading, not downloading):
<https://drive.google.com/file/d/1dbnebOXhfl3Dx5VuwFRs00LcFZa3daGu/view?usp=sharing>