Master Engineering ELITE Programme **Sabatino Costanzo & Loren Trigo**
University of Toronto
APS 1053 Winter 2024:
Jan 12-Apr 12/Fri 3-6 PM/WB119

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, modeling options strategies, investor's modeling, 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 5 sessions (theoretical foundations) will be delivered by the instructors, and (ii) the following 8 sessions will be delivered by the students. In each one of those 8 sessions, students will present to the class the cases assigned to them. They 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

A basic knowledge of Finance terminology and basic Python coding literacy.

TEXTBOOKS

Tatsat: Machine Learning and Data science Blueprits for Finance, 2021, by Hariom Tatsat.
Nyholm: Strataegic 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 Blueprits 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+, 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

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 you (Individual 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.

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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--SYLLABUS--

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SESSION 1

MANDATORY first meeting where case-studies will be assigned

LECTURE: Profitable Stock Trading: What is a Business Cycle and how do we use them to predict the stock market? (code provided!)

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SESSION 2

LECTURE: Profitable Bond Trading: Predicting the Yield Curve: contrasts between the "Old School" (traditional) model and the "Machine Learning" approach (code provided!)

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SESSION 3

LECTURE: Profitable Crypto Trading: Latest Bitcoin Price Prediction Models

(i) Santostassi's power law model of Bitcoin price (Code provided)

(ii) Bitcoin bubbles as a result of the predator prey model (Code provided)

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SESSION 4

LECTURE: Profitable Portfolio Management: how Funds are managed

(i) Hierarchical Risk Parity (code provided!)

(ii)The Janus System (code provided!)

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SESSION 5

LECTURE: Bonus Session: Reinforcement Learning and its Market Applications.

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READING WEEK

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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

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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: 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:
Jansen: chapter 13
Nyholm: chapter 6

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 :
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

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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

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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