Master of Science in Quantitative Finance

COURSE CODE: **QF624**
COURSE TITLE: **Machine Learning and Finance Application**

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COURSE AREA
Quantitative Finance

GRADING BASIS
Graded

COURSE UNIT
1 CU

FIRST OFFERING TERM
Academic Year: 2025
Academic Term: April

COURSE DESCRIPTION
The aim of this course is to introduce students to machine learning approaches with applications in quantitative trading, asset pricing, and portfolio optimization. The course covers a suite of machine learning algorithms, including linear regression, deep neural networks, and reinforcement learning. These algorithms can be used to boost predictive and prescriptive performance in many financial applications.

The course is targeted at students with a basic understanding of both quantitative methods and modeling, and are interested in further developing hands-on skills in constructing trading and portfolio management strategies using machine learning techniques. Although Python is used in group homework and final projects, it is not tested in the final exam. Students from this course will be able to explain the intuition behind machine learning methods and models applied, and why this method is chosen over many other methods on the same application.

LEARNING OBJECTIVES
There is a significant business impact of ML/AI in different industries. We would consider this course a success if, besides learning about core and practical ML/AI knowledge in investments,

students can understand the specific needs for such methodology and, in the end, are able to implement, evaluate and explain results.

- Understand common portfolio optimization strategies using ML.
- Learn advanced machine learning techniques such as deep reinforcement learning
- Learn how ML/AI can deal with some of the problems in formulating trading strategies and developing risk management models

ASSESSMENT METHODS

The key assessment components are as follows:

1. **Individual Assessment –** **60% of total**, consisting of
    a. Class Participation 20%
    b. Final Exam 40%

2. **Group Assessment:** **40% of total**, consisting of:
    a. Group homework and final project. 40%

INSTRUCTIONAL METHODS AND EXPECTATIONS

With reference to the above, assessments cover both the individual (60%) and group (40%) levels.

Individual Assessment (60% of total): this assessment is measuring the level of interest, creative thinking, the desire to learn and accumulate knowledge continuously.

Group Assessment (40% of total): The class will be grouped into teams, and the main purpose is to evaluate the capacity to add value through working in groups, and socializing ideas constructively. A high emphasis of the grading process is set on actual project participation and final presentation, expressed in the form of a client presentation based on an advanced investment methodology designed by each team.

The grading criteria for the presentation are:

- suitability and quality of content,
- analytical and inference abilities of ML models used
- level of understanding of the practical purpose of the project and presentation,
- teamwork,

- ability to answer questions posed.

ACADEMIC INTEGRITY

All acts of academic dishonesty (including, but not limited to, plagiarism, cheating, fabrication, facilitation of acts of academic dishonesty by others, unauthorized possession of exam questions, or tampering with the academic work of other students) are serious offences. All work (whether oral or written) submitted for purposes of assessment must be the student's own work. Penalties for violation of the policy range from zero marks for the component assessment to expulsion, depending on the nature of the offence.

When in doubt, students should consult the course instructor. Details on the SMU Code of Academic Integrity may be accessed at http://www.smuscd.org/resources.html.

ACCESSIBILITY

SMU strives to make learning experiences accessible for all. If you anticipate or experience physical or academic barriers due to disability, please let me know immediately. You are also welcome to contact the university's disability services team if you have questions or concerns about academic provisions: included@smu.edu.sg. Please be aware that the accessible tables in our seminar room should remain available for students who require them.

EMERGENCY PREPAREDNESS FOR TEACHING AND LEARNING (EPTL)

Where there is an emergency that makes it infeasible to have classes on campus, classes will be conducted online via WebEx or Zoom, with no disruption to the schedule. During this semester some students may have to take part of the course online due to Covid-19 situation. Instructions and arrangements are provided by the programme office. Your attendance will also be noted if you are doing the class online.

CLASS TIMINGS

The course is taught in one 3.0-hour session per week over ten weeks.

RECOMMENDED TEXT AND READINGS

- Quantitative Trading Strategies with Python, Apress, 2023, Liu Peng

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- The Statistics and Machine Learning with R Workshop, Packt, 2023, Liu Peng
- Bayesian Optimization: Theory and Practice Using Python, Apress, 2023, Liu Peng
- Quantitative Risk Management with Python, Apress, Liu Peng, upcoming in 2025
- Generalization in Deep Learning, CRC, Liu Peng, upcoming in 2025
- Deep Reinforcement Learning for Portfolio Optimization, CRC, Liu Peng, upcoming in 2025

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WEEKLY LESSON PLAN

WEEK	TOPICS
1	**Introduction to Machine Learning** • Different types of machine learning methods, including supervised learning, unsupervised learning, an reinforcement learning • Common applications of machine learning algorithms • Introduction to deep learning • Overview of state-of-the-art ML models
2	**Quantitative Trading Strategies** • Overview of common quantitative trading strategies • Hands-on practice in implementing trading strategies
3	**Modern Portfolio Management** • Risk and return tradeoff • Efficient frontier • Convex optimization
4	**Reinforcement Learning in Portfolio Optimization** • Introducing RL framework • Bellman optimality • Value functions • Policy gradients • Application of RL in portfolio optimization
5	**Linear Regression in Finance** • Least squares • Factor models in finance • Application in asset pricing
6	**Logistic Regression in Finance** • Classification principle • Cross entropy loss • Application in credit risk scoring
7	**Generalization in Deep Learning** • Generalization performance • Empirical risk minimization • Regularization techniques

8	**Deep Neural Networks** • Perceptron • Backpropogation mechanism • Stochastic gradient descent • Applications in finance
9	**Robust in Portfolio Optimization** • Robust formulation • Uncertainty set • Joint prediction and optimization
10	**Course Review and Final Team Presentation**