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: AY2022-23
Academic Term: Term 3

COURSE DESCRIPTION
The aim of this course is to introduce students to machine learning approaches with applications in asset price prediction and portfolio optimization. The course covers a suite of machine learning algorithms, including linear regression, deep learning, and reinforcement learning. These algorithms are used to manage a portfolio of assets in order to maximize the risk-adjusted return compared to traditional approaches.

The course is targeted at students with a basic understanding of both portfolio management and modeling, and are interested in further developing hands-on skills in constructing automated trading strategies using advanced machine learning techniques.

The course is constructed in such a way that academic research and theoretical knowledge are supported by real-life practice, as well as relevant technical rigor. The plan is to use open-source software packages (R, Python) and provide students with means to develop personal skills and knowledge besides group interaction and communication.

LEARNING OBJECTIVES
There is a significant business impact of ML/AI in different industries, and so it stands for the financial industry. We would consider this course a success if, besides learning about core and

practical ML/AI knowledge in investments, students also understood the specific needs for such methodology and, in the end, were able to implement, evaluate and explain results (better than it usually happens).

- Understand the "Why?" in every process in order to appreciate the results.
- Understand modern and advanced portfolio management theory.
- Learn advanced machine learning techniques such as deep reinforcement learning and the end-to-end predict-then-optimize framework with applications in portfolio optimization
- Learn how ML/AI can deal with some of the problems in portfolio management
- Develop a practical understanding of the theory and practice behind factor models and portfolio diversification

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. Final presentation (including group work evaluation) 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,
- 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, Liu Peng (upcoming)
- The Statistics and Machine Learning with R Workshop, Packt Publishing, Liu Peng
- Regularization in Deep Learning, Manning Publications, Liu Peng
- Bayesian Optimization: Theory and Practice Using Python, Apress, Liu Peng

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WEEKLY LESSON PLAN

WEEK	TOPICS
1	**Introduction to machine learning** a. Different types of machine learning methods, including supervised learning, unsupervised learning, an reinforcement learning b. Common applications of machine learning algorithms c. Introduction to deep learning d. Overview of state-of-the-art ML models
2	**Quantitative trading and portfolio management** a. Overview of common quantitative trading strategies b. Portfolio management basics including the modern portfolio theory c. Hands-on practice in implementing trading strategies
3	**Asset price prediction using machine learning** a. Predicting asset price using supervised learning algorithms b. Two-stage predict-then-optimize framework c. Hands-on practice of two-stage prediction and optimization
4	**End-to-end smart predict-then-optimize portfolio optimization** a. Introducing the SPO framework b. Setting up end-to-end training pipeline c. Performance comparison
5	**Introduction to reinforcement learning** a. Introducing RL framework b. Code template walkthrough c. Case study
6	**Portfolio optimization using reinforcement learning** a. Environment setup d. Algorithm walkthrough b. Implementation and performance analysis
7	**Estimating factor models using machine learning** a. Introducing factor models

	b. Using factor models in portfolio construction c. Shrinkage methods
8	**Portfolio diversification using machine learning** a. Portfolio diversification measures b. Principle component analysis c. Graphical analysis
9	**Text mining with financial applications** a. Bag of words b. Word embedding c. Processing corporate filings
10	**Final Team Presentation - discussions, questions**