HONG KONG UNIVERSITY OF SCIENCE & TECHNOLOGY

Course title: MSDM 5058 Information Science 3 credits course

Meeting Time and Venue: Venue for both on-campus lecture and tutorial: 5583
Lecture: Saturday at 9:30 – 11:20; tutorial 11:30 – 12:20

Course Preparation: (1) Knowledge of calculus and linear algebra; (2) Basic programming technique in at least one programming language (Python, C, etc.)

Course Topics

Part A: Information and Decision Theory
(Notes and Reference books in library for 2 hours loan)

(1) Introduction to Probability and Decision Theory (Ref. Hillier and Lieberman)
(2) Baye's decision criterion, Neyman-Pearson decision criterion with application to forecasting stocks (Ref. Chapter 11 of Ziemer and Tranter)
(3) Measure of Information, Shannon entropy, Maximum Entropy Method
(4) Introduction to various types of entropy (transfer entropy, Tsallis entropy, Kolmogorov entropy, von Neumann entropy, etc.)

Part B: Nonlinear Time Series Analysis

(5) Stationarity Test: Unit root test, e.g., Dickey-Fuller test
(6) Chaos, Hurst exponent, Multifractality in time series
(7) Detrending a time series: Detrended Fluctuation Analysis
(8) Causality and Information Flow
(9) Decomposing a time series: Empirical Mode Decomposition

Part C: Portfolio Management and Mathematical Finance
(Notes and J. Hull and Ingersoll)

(10) Introduction to Portfolio Management: Mean Variance Analysis on Minimum Risk Portfolio and Sharpe Ratio
(11) Options: Trading of Options, Bounds for Option Prices, Arbitrage, Options, Put-Call parity
(12) Binomial Trees: One step binomial model, Risk-Neutral Valuation
(13) Wiener Process, Ito Lemma, Black-Scholes-Merton Model

Reference books: (can be borrowed from the Reference Section of HKUST Library: 2 hours loan)

1. John C. Hull "Fundamentals of futures and options markets", 6th ed. (HG6024.A3 H84 2008)
2. Jonathan E. Ingersoll, Jr., Theory of financial decision making, Totowa, N.J. : Rowman & Littlefield, c1987. (HG173 .I54 1987)
3. R.E. Ziemer and W.H. Tranter, Principles of Communications, Systems, Modulation, and Noise, 6th Edition, John Wiley & Sons 2009 (TK5105 .Z54 2009)
4. P. Wilmott, S. Howison, and J. Dewynne, The Mathematics of Financial Derivatives (HG6024.A3 W554 1995)
5. Roy D. Yates, and David J. Goodman Probability and Stochastic Processes: A Friendly Introduction for Electrical and Computer Engineers, 2nd Edition, Rutgers Univ., NJ 2nd ed. (QA273 .Y47 2005)
6. Hillier/Lieberman; Introduction to Operational Research Boston: McGraw-Hill Higher Education. (c2005 T57.6 .H54 2005)

Assessment Scheme: (100%)

70% Projects: 35% for Project 1 (individual project)
35% for Project 2 (group project)

Objective: Allow students to have independent research ability through projects

Project 1: Basic Data Pre-processing and Statistical Analysis
Due Date: 23:59:59 April 23, 2022

Project 2: Portfolio management of Stocks Investment
Due Date: 23:59:59 May 14, 2022

25% Homework Assignments

Objective: Allow the students to learn through independent exercises

A total of 4 homework assignments. Each homework assignment will be put on canvas at least two weeks before due date. Attendance to tutorial is not compulsory and no attendance check for tutorial. However, the tutorial is very helpful in answering the homework assignments and the projects.

5% Attendance

According to the Continuing Education Fund (持續進修基金), all our courses must include class attendance in an assessment scheme. In this regard, the MSc-DDM task group resolved to let all MSDM courses include 5% class attendance to the assessment and such information has to be marked on the course outline/syllabus.

Teaching and Learning Activities –

a) Lectures: focus on clear exposition of concepts and basic techniques in problem solving

b) Tutorials/Laboratory: focus on detailed problems solution methodology and homework assignment help

Course Schedule

Meeting	Date	Remarks
Lect 1: Probability and Indicator	Feb 3	
Lect 2: Pattern Recognition/Decision Theory	Feb 17	
Lect 3: Information measure and Entropy I	Feb 24	
Lect 4: Information measure and Entropy II	Mar 2	1st homework assignment due
Lect 5: Information measure and Entropy III	Mar 9	
Lect 6: More on Entropy	Mar 16	
Lect 7: Nonlinear Time Series Analysis I	Mar 23	2nd homework assignment due
Mid Term Break (March 28 – April 5)		
Lect 8: Nonlinear Time Series Analysis II	Apr 6	3rd homework assignment due
Lect 9: Nonlinear Time Series Analysis III	Apr 13	
Lect 10: Nonlinear Time Series Analysis IV and Mathematical Finance I	Apr 20	4th homework assignment due
Lect 11: Mathematical Finance II	Apr 27	Project 1 due
Lect 12: Mathematical Finance III	May 4	
Project 2 due – May 11		

Intended Learning Outcomes: Course Objectives

This course introduces several computational methods based on information theory to analyze real data. The method includes decision theory, information entropy, evolutionary computation, and mean variance analysis of portfolio management.

(1) Through the transmission of knowledge on information science, the students will be able to use the theory of information entropy and mutual information in the evaluation of the importance of data.

(2) Students will learn how to implement theory learned (such as decision theory, mean variance analysis, evolutionary computation) to analysis complex data, such as the financial data used in the project. The computer projects and web-based teaching will help students adapt to the internet environment for data mining as well as processing.

(3) Development of a critical way of thinking. It will be beneficial to future career of

the students. In the projects, the students will have to decide the parameters used in their portfolio management of multiple time series. Such skill will surpass those who only learn how to run package programs, thereby incubating their creative potential in designing new tool for data modelling and analysis.

(4) Development of an interest in self-directed learning, such as the topics about multi-agent systems defined on a social network, with game theoretic interaction between agents and nonlinear time series analysis.

(5) By the end of this course, students should have created a sense of curiosity about information theory and various computation techniques, with application in science, engineering and finance. Students should be able to use mathematical methods and statistical physics on information entropy to analyze real data, besides the practice in data mining through the projects.

(6) This course is an introduction for the students to learn how to use statistical physics to model and analyze complex systems dynamics. This forms a popular section for students who like to extend the application in Finance to interdisciplinary research.

Hints for a successful course:

(1) Get the lecture notes, read them before class and read the textbook. Download reading materials from the web.

(2) Do the homework assignments and attend the tutorial. You will learn much more by doing the problems yourself.

(3) Try to make use of what you learn in the computational projects.