COURSE SYLLABUS

1. COURSE TITLE

Machine Learning

2. COURSE CODE

DS4023

3. PRE-REQUISITE

COMP1013 Structured Programming, or
GCIT1013 Foundations of C Programming, or
COMP1023 Foundations of C Programming, or
STAT2043 Structured Programming (for STAT Students), or
COMP2013 Object-Oriented Programming, or
COMP3153 C++ Programming Language

4. CO-REQUISITE

Nil

5. NO. OF UNITS

3

6. CONTACT HOURS

42

7. OFFERING UNIT

Applied Mathematics Programme, Computer Science and Technology Programme, Data Science Programme, Financial Mathematics Programme, Faculty of Science and Technology

8. SYLLABUS PREPARED & REVIEWED BY

Prepared by Dr. Yuhui DENG
Reviewed by Dr. Ping HE, Dr. Sherry ZHOU, Dr. Zhe XUANYUAN, Prof. Amy ZHANG

9. AIMS & OBJECTIVES

The course will provide an introduction to Machine Learning and its core models and algorithms. The aim of the course is to give the student the basic ideas and intuition behind modern machine learning methods as well as a bit more formal understanding of how, why, and when they work.

10. COURSE CONTENT

1. Introduction to Machine Learning
   a. examples of Machine Learning Application
2. Statistical learning
   a. parameter estimation (maximum likelihood)
   b. Bayes' rule & MAP classifiers
   c. multivariate probability distributions
   d. linear regression
3. Unsupervised learning
   a. K-means and hierarchical clustering
   b. Gaussian mixture models and the EM algorithm
   c. self-Organizing Maps
   d. mean-shift algorithm, KDE
   e. spectral clustering, normalized cuts
4. Dimensionality reduction and visualization
   a. subspace methods (PCA, LDA, NMF)
   b. non-linear manifold embedding (LLE, MDS, ISOMAP)
5. Supervised learning
   a. logistic regression
   b. support vector machines
   c. boosting
   d. random forests
   e. neural networks, deep learning

11. COURSE INTENDED LEARNING OUTCOMES (CILOS) WITH MATCHING TO PILOS

For AM students:

Programme Intended Learning Outcomes (PILOs)

Programme Title: Bachelor of Science (Honours) in Applied Mathematics	
PILO	**Upon successful completion of the Programme, students should be able to:**
PILO 1	Evaluate the principles, concepts and theories of fundamental mathematics;
PILO 2	Identify problems solvable by applied mathematics in business or other fields and develop critical solutions using appropriate academic and professional knowledge;
PILO 3	Use mathematical software and computer programming/algorithms to solve problems in scientific, engineering, business and other practical fields;

Programme Title: Bachelor of Science (Honours) in Applied Mathematics	
PILO	**Upon successful completion of the Programme, students should be able to:**
PILO 4	Develop appropriate mathematical models and enhance performance of such models through comparisons and refinements of alternative approaches;
PILO 5	Communicate and practice effectively as a professional mathematician both in team and independent working context.

CILOs-PILOs Mapping Matrix

Course Code & Title: DS4023 Machine Learning		
CILO	**Upon successful completion of the course, students should be able to:**	**PILO(s) to be addressed**
CILO 1	**Explain** the concept, definition, theory and applications of different major types of machine learning.	PILO 3
CILO 2	**Compare** the different machine learning methods according to their common performance criteria.	PILO 3
CILO 3	**Use** proper machine learning methods to solve real problems.	PILOs 3, 4

For CST students:

Programme Intended Learning Outcomes (PILOs)

Programme Title: Bachelor of Science (Honours) in Computer Science and Technology	
PILO	**Upon successful completion of the Programme, students should be able to:**
PILO 1	**analyse** the basic principles of computer science and technology;
PILO 2	**translate** real world problems into IT requirements;
PILO 3	**design** and **develop** complex software;
PILO 4	**apply** up-to-date technology to **solve** general problems in specific areas;
PILO 5	**communicate** effectively and **collaborate** in a team.

CILOs-PILOs Mapping Matrix

Course Code & Title: DS4023 Machine Learning		
CILO	**Upon successful completion of the course, students should be able to:**	**PILO(s) to be addressed**
CILO 1	**Explain** the concept, definition, theory and applications of different major types of machine learning.	PILOs 1,5

Course Code & Title: DS4023 Machine Learning		
CILO	**Upon successful completion of the course, students should be able to:**	**PILO(s) to be addressed**
CILO 2	**Compare** the different machine learning methods according to their common performance criteria.	PILOs 1,4
CILO3	**Use** proper machine learning methods to solve real problems.	PILO 4

For DS students:

Programme Intended Learning Outcomes (PILOs)

Programme Title: Bachelor of Science (Honours) in Data Science	
PILO	**Upon successful completion of the Programme, students should be able to:**
PILO 1	Describe and explain the fundamental knowledge required to support the study and applications of Data Science;
PILO 2	Competently apply a wide range of programming concepts to software development in data collection and analysis;
PILO 3	Formulate novel methods in data information gathering and analysis to solve real world problems;
PILO 4	Collaborate and function effectively in team work with proficient communication and effective interpersonal skills;
PILO 5	Stay abreast of contemporary issues in Data Science and develop life-long effective learning skills to meet the needs of the Data Science discipline.

CILOs-PILOs Mapping Matrix

Course Code & Title: DS4023 Machine Learning		
CILO	**Upon successful completion of the course, students should be able to:**	**PILO(s) to be addressed**
CILO 1	**Explain** the concept, definition, theory and applications of different major types of machine learning.	PILO 1
CILO 2	**Compare** the different machine learning methods according to their common performance criteria.	PILOs 2,3
CILO3	**Use** proper machine learning methods to solve real problems.	PILOs 2,3

For FM Students:

Programme Intended Learning Outcomes (PILOs)

Programme Title: Bachelor of Science (Honours) in Financial Mathematics	
PILO	**Upon successful completion of the Programme, students should be able to:**

Programme Title: Bachelor of Science (Honours) in Financial Mathematics	
PILO	**Upon successful completion of the Programme, students should be able to:**
PILO 1	Apply the basic principles of financial mathematics to clearly explain the phenomena and problems in financial markets;
PILO 2	Interpret quantitative models for pricing derivatives, managing trading strategies and simulating market scenarios;
PILO 3	Employ theories and tools of financial mathematics for the construction of the financial product, asset pricing and risk management;
PILO 4	Use mathematical and financial software to perform computation of financial data analysis and pricing and valuation of financial instruments;
PILO 5	Conduct independent research in financial management and exploring business opportunities in financial markets;
PILO 6	Develop the capacity to work as part of a team.

CILOs-PILOs Mapping Matrix (for FM students)

Course Code & Title: DS4023 Machine Learning		
CILO	**Upon successful completion of the course, students should be able to:**	**PILO(s) to be addressed**
CILO 1	**Explain** the concept, definition, theory and applications of different major types of machine learning.	PILO 1
CILO 2	**Compare** the different machine learning methods according to their common performance criteria.	PILOs 2,3
CILO3	**Use** proper machine learning methods to solve real problems.	PILOs 2,3

12. TEACHING & LEARNING ACTIVITIES (TLAS)

CILO No.	**TLAs**
CILO 1	● **Lectures:** Three hours of lectures and one hour of tutorials will be given per week. This is an introduction course on machine learning. Instructor will explain the concept, definition, theory and applications to students. ● **Assignments:** Assignments will be distributed to the students. These assignments will be marked and analysed by the lecturer (or TA). The problems and weak points arising from the assignments will be discussed in class to ensure the students' full understanding of the lecture materials.

CILO 2	● **Assignments:** Assignments will be distributed to the students. These assignments will be marked and analysed by the lecturer (or TA). The problems and weak points arising from the assignments will be discussed in class to ensure the students' full understanding of various machine learning methods. ● **Group Project:** To enhance students' ability in applying machine learning methods to real-world application, group projects will be given. Students will be required to evaluate machine learning methods according to their common performance criteria.
CILO 3	● **Online group discussion:** Some topics about advanced technology in machine learning and challenging questions will be posted on the iSpace. Students will be encouraged to discuss them through online forum on iSpace and instructors will guide students to solve problems. ● **Group project:** Some group projects could be arranged so that students can use the newly learned skills and techniques to solve some real world problems.

13. ASSESSMENT METHODS (AMS)

Type of Assessment Methods	**Weighting**	**CILOs to be Addressed**	**Description of Assessment Tasks**
Continuous performance: Assignments In-class Exercises	30%	1-2	Assignments are designed to measure students understanding of the basic theory and the ability to analyze data by applying proper data analysis strategies. In-class exercises will test and reward students' facility with computational techniques and concepts from lectures and readings, and aims to assess how well students have achieved their intended learning outcomes, so as to provide feedback for teachers and students alike.
Group project	30%	2-3	Group project will test students' ability in how to design machine learning process, how to carry it out and to make a

Type of Assessment Methods	Weighting	CILOs to be Addressed	Description of Assessment Tasks
			technical reports.
Final examination	40%	1-2	The examination will test the students' understanding of concepts and theorems, and the ability to apply his/her comprehensive knowledge to some practical problems.

14. TEXTBOOKS / RECOMMENDED READINGS

Textbook:

P. Harrington. *Machine Learning in Action*. Manning, 2012.

References:

1. E. Alpaydin, *Introduction to Machine Learning, 3rd edition*. MIT Press, 2014.
2. K. P. Murphy. *Machine Learning: A Probabilistic Perspective*. MIT Press, 2012.
3. C.M. Bishop. *Pattern Recognition and Machine Learning*. Springer, 2006.
4. T. Mitchell. *Machine Learning*. McGraw Hill, 1997.
5. D. Richard, P. Hart and D. Stork. *Pattern Classification, 2nd edition*. Wiley-Interscience, 2000.
6. M. Kubat. *An Introduction to Machine Learning*. Springer, 2015.
7. C.M. Bishop. *Neural Networks for Pattern Recognition*. Oxford University Press, 1995.
8. T. Hastie, R. Tibshirani and J. H. Friedman. *The Elements of Statistical Learning: Data Mining, Inference and Prediction*. Springer, 2001.
9. S. Marsland. *Machine Learning: An Algorithmic Perspective, 2nd edition*. Chapman & Hall/CRC, 2015.
10. T. Hastie, R. Tibshirani and J. Friedman. The Elements of Statistical Learning, 2nd edition. Springer, 2009.

15. MEDIUM OF INSTRUCTION (MOI)

English

Revised on: <2023-05-05>