City University of Hong Kong
Course Syllabus

offered by Department of Computer Science
with effect from Semester A 2020/21

Part I Course Overview

Course Title:	Machine Learning
Course Code:	CS4487
Course Duration:	1 semester
Credit Units:	3 credits
Level:	B4
Proposed Area: *(for GE courses only)*	☐ Arts and Humanities ☐ Study of Societies, Social and Business Organisations ☐ Science and Technology
Medium of Instruction:	English
Medium of Assessment:	English
Prerequisites: *(Course Code and Title)*	CS3481 Fundamentals of Data Science
Precursors: *(Course Code and Title)*	Nil
Equivalent Courses: *(Course Code and Title)*	Nil
Exclusive Courses: *(Course Code and Title)*	Nil

Part II Course Details

1. Abstract

(A 150-word description about the course)

The goal of this course is to introduce students to the field of machine learning. Machine learning algorithms allow computers to automatically learn to recognize complex patterns from empirical data, such as text and web documents, images, videos, sounds, sensor-data, and databases. This course is intended to give a broad overview of machine learning from both theoretical and practical standpoints, with emphasis on applying machine learning algorithms to real-world problems. At the end of the course, students will have both working knowledge of and practical experience with machine learning algorithms.

2. Course Intended Learning Outcomes (CILOs)

(CILOs state what the student is expected to be able to do at the end of the course according to a given standard of performance.)

No.	CILOs[#]	Weighting* (if applicable)	Discovery-enriched curriculum related learning outcomes (please tick where appropriate)		
			A1	A2	A3
1.	Identify and explain common machine learning algorithms.			✓	
2.	Apply machine learning algorithms to solve real-world problems.				
3.	Evaluate the effectiveness of different machine learning algorithms and discuss their advantages and disadvantages.		✓		
4.	Understand theoretical and practical aspects of machine learning algorithms.				
	** If weighting is assigned to CILOs, they should add up to 100%.*	100%			

[#] Please specify the alignment of CILOs to the Gateway Education Programme Intended Learning outcomes (PILOs) in Section A of Annex.

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to self-life problems.

A3: *Accomplishments*
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

3. Teaching and Learning Activities (TLAs)

(TLAs designed to facilitate students' achievement of the CILOs.)

Teaching pattern:

Suggested lecture/tutorial/laboratory mix: 2 hrs. lecture; 1 hr. tutorial

TLA	Brief Description	CILO No.				Hours/week (if applicable)
		1	2	3	4	
Lecture	The lectures will present selected machine learning algorithms, and the intuition and theory behind them. The algorithms will be illustrated with both toy and real-world examples to motivate the students' understanding. Available software toolboxes will also be discussed.	✓		✓	✓	2 hours
Tutorial	In each week's tutorial session, students will use machine learning algorithms on small examples to gain better understanding of the lecture material.	✓				1 hour
Assignment	Students will solve some theoretical and practical problems related to machine learning algorithms, and interpret the results. Students can then have a deeper understanding of the effectiveness of the algorithm, and evaluate the differences between various algorithms.			✓	✓	1 every 3 weeks
Course Project	Students will design a system based on a machine learning algorithm to solve a real-world problem. Students will report their results in a course report, and during a poster/presentation session held at the end of the semester.		✓	✓		

4. Assessment Tasks/Activities (ATs)

(ATs are designed to assess how well the students achieve the CILOs.)

Assessment Tasks/Activities	CILO No.				Weighting*	Remarks
	1	2	3	4		
Continuous Assessment: 70%						
Class participation	✓				10%	tutorial exercises
Assignments			✓	✓	30%	
Course Project^ and Presentation		✓	✓		30%	
Examination^: 30% (duration: 2 hours)						
** The weightings should add up to 100%.*					100%	

^ For a student to pass the course, at least 30% of the maximum mark for the examination AND course project must be obtained.

5. Assessment Rubrics

(Grading of student achievements is based on student performance in assessment tasks/activities with the following rubrics.)

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Fair (C+, C, C-)	Marginal (D)	Failure (F)
1. Class participation	1.1 CAPACITY for LEARNING about machine learning algorithms.	High	Significant	Moderate	Basic	Not even reaching marginal levels
2. Assignments	2.1 ABILITY to DERIVE and ANALYSE machine learning algorithms and INTERPRET the results. 2.2 ABILITY to COMPARE machine learning algorithms theoretically and empirically.	High	Significant	Moderate	Basic	Not even reaching marginal levels
3. Course Project and Presentation	3.1 ABILITY to APPLY machine learning to real-world problems and INTERPRET the results. 3.2 ABILITY to EVALUATE, COMPARE, and CONTRAST different machine learning algorithms.	High	Significant	Moderate	Basic	Not even reaching marginal levels
4. Examination	4.1 ABILITY to EXPLAIN, DERIVE and ANALYSE machine learning algorithms, and INTERPRET results from machine learning algorithms. 4.2 ABILITY to EVALUATE, COMPARE, and CONTRAST different machine learning approaches.	High	Significant	Moderate	Basic	Not even reaching marginal levels

Part III Other Information (more details can be provided separately in the teaching plan)

1. Keyword Syllabus

(An indication of the key topics of the course.)

Topics include statistical learning, data clustering, dimensionality reduction and data visualization, discriminative classifiers. Programming assignments will touch the following applications: document analysis, spam detection, document clustering, image segmentation, data visualization, face detection, face recognition.

Syllabus

1. Overview of machine learning with real-world examples

2. Statistical learning
    a. probability distributions (univariate)
    b. parameter estimation (maximum likelihood)
    c. Bayes' rule & MAP classifiers
    d. multivariate probability distributions
    e. linear and lasso regression

3. Data clustering
    a. k-means
    b. Gaussian mixture models and the EM algorithm

4. Dimensionality reduction and visualization
    a. subspace methods (PCA, LDA, NMF, SVD)
    b. independent component analysis

5. Discriminative classifiers
    a. k-nearest neighbours
    b. bayes optimal classifier
    c. logistic regression
    d. naive bayes
    e. linear discriminant analysis
    f. support vector machines (convex optimization and duality)

6. Deep learning and Neural Networks
    a. Perceptron, multi-layer perceptron
    b. Activation functions
    c. Backpropagation, stochastic gradient descent
    d. Convolutional neural networks
    e. Regularization, batch-norm, dropout
    f. Architectures: Resnet, Densenet, fully convolutional network
    g. Autoencoder
    h. Generative adversarial network, variational autoencoder

7. Recommender systems

2. Reading List

2.1 Compulsory Readings

(Compulsory readings can include books, book chapters, or journal/magazine articles. There are also collections of e-books, e-journals available from the CityU Library.)

1.	P. Harrington (2012). *Machine Learning in Action.* Manning.

2.2 Additional Readings

(Additional references for students to learn to expand their knowledge about the subject.)

1.	A. Rajaraman, and J. Ullman (2011). *Mining of Massive Datasets.* Cambridge University Press. (online: http://infolab.stanford.edu/~ullman/mmds.html)
2.	H. Daume III. *A course in Machine Learning.* (online: http://ciml.info/)
3.	C.M. Bishop (2006). *Pattern Recognition and Machine Learning.* Springer.
4.	R.O. Duda, P.E. Hart, & D.G. Stork (2001). *Pattern Classification.* Wiley-Interscience, 2nd edition.
5.	T. Hastie, R. Tibshirani, and J. Friedman (2009). *The Elements of Statistical Learning: Data Mining, Inference, and Prediction.* Springer-Verlag, 2nd edition.