City University of Hong Kong
Course Syllabus

offered by Department of Computer Science
with effect from Semester A 2017/18

Part I Course Overview

Course Title:	Machine Learning
Course Code:	CS5487
Course Duration:	One semester
Credit Units:	3 credits
Level:	P5
Medium of Instruction:	English
Medium of Assessment:	English
Prerequisites: *(Course Code and Title)*	CS3334 Data Structures AND [MA2176 Basic Calculus and Linear Algebra or MA2170 Linear Algebra & Multi-variable Calculus or MA2172 Applied Statistics for Sciences & Engineering]
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

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, sound, sensor-data, and databases. This course is intended to give a broad overview of machine learning from the practical standpoint, with a focus on designing and implementing machine learning algorithms for real-world problems. At the end of the course, students will have both working knowledge of and practical experience with machine learning algorithms, as well as a theoretical understanding of machine learning concepts.

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.	Implement machine learning algorithms and apply them to solve real-world problems.		✓		
3.	Analyze and evaluate the effectiveness of different machine learning algorithms, and assess their relative merits.		✓		
4.	Design and create new machine learning algorithms to address algorithmic shortcomings and solve particular problems.			✓	✓
		100%			

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	5	
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. Implementation details will also be discussed.	✓		✓			2 hours/ week
Tutorial	Each week, students will work on problem sets during the tutorial sessions to gain better understanding of the lecture material.	✓	✓	✓			1 hour/ week
Programming Assignment	Students will develop skills implementing selected machine learning algorithms, applying them to small datasets, and interpreting the results. Students can then observe the effectiveness of the algorithm, and evaluate the differences between various algorithms.		✓	✓			
Theory Assignment	Students will analyze algorithms theoretically, and derive solutions to various machine learning problems.				✓		
Course Project	Students will design and create 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 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	5		
Continuous Assessment: 70%							
Assignments		✓	✓	✓		40%	
Course Project^		✓	✓	✓		30%	
Examination^: 30% (duration: 2 hours)							
						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. Assignments	1.1 ABILITY to APPLY machine learning to problems and INTERPRET the results. 1.2 ABILITY to COMPARE the accuracy and efficiency of machine learning algorithms. 1.3 ABILITY to DESIGN and DERIVE new machine learning algorithms.	High	Significant	Moderate	Basic	Not even reaching marginal levels
2. Course Project	2.1 ABILITY to APPLY machine learning to real-world problems and INTERPRET the results. 2.2 ABILITY to EVALUATE, COMPARE, and CONTRAST different machine learning algorithms. 2.3 ABILITY to DESIGN and DERIVE new machine learning algorithms.	High	Significant	Moderate	Basic	Not even reaching marginal levels
3. Examination	3.1 ABILITY to EXPLAIN machine learning algorithms, and INTERPRET results from machine learning algorithms. 3.2 ABILITY to EVALUATE, COMPARE, and CONTRAST different machine learning approaches. 3.3 ABILITY to DESIGN and DERIVE new machine learning algorithms.	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, and regression. 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. Naive Bayes classifier
    e. multivariate probability distributions
    f. Bayesian classifiers
    g. exponential family distributions & conjugate priors
3. Data clustering
    a. K-means clustering
    b. Gaussian mixture models and the EM algorithm
    c. KDE and mean-shift clustering
    d. Spectral clustering, normalized cuts
4. Dimensionality reduction and visualization
    a. subspace methods: unsupervised (PCA, LSA); supervised (LDA)
    b. non-linear manifold embedding (LLE, MDS, ISOMAP)
    c. Nystrom extension
    d. exponential family PCA and pLSA
5. Discriminative classifiers
    a. nearest neighbors
    b. linear classifiers
        1. Fisher linear discriminant (LDA)
        2. logistic regression, conditional LL
        3. linear SVM
    c. non-linear classifiers
        1. kernel SVM
        2. boosting
    d. kernel PCA, kernel K-means, and kernel machines
6. Regression
    a. least-squares regression
    b. generalized linear models

c. Bayesian regression & Gaussian processes

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.	Bishop, *"Pattern Recognition and Machine Learning"*, Springer-Verlag New York, 2006.

2.2 Additional Readings

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

1.	Duda, Hart, & Stork, *"Pattern Classification"*, Wiley-Interscience; 2 edition, 2000.
2.	Schölkopf and Smola, *"Learning with kernels: support vector machines, regularization, optimization, and Beyond."*, The MIT Press, 2001.
3.	Rasmussen and Williams, *"Gaussian Processes for Machine Learning"*, The MIT Press, 2006.