City University of Hong Kong
Course Syllabus

offered by Department of Computer Science
with effect from Semester B 2018/19

Part I Course Overview

Course Title:	Machine Learning: Algorithms and Applications
Course Code:	CS5489
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
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, its algorithms and applications. 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 implementing and applying machine learning algorithms to real-world problems. At the end of the course, students will have both working knowledge of and practical experience implementing and applying machine learning algorithms on different domains.

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.			✓	
3.	Apply machine learning algorithms to solve real-world problems.			✓	
4.	Evaluate the effectiveness of different machine learning algorithms and discuss their advantages and disadvantages.		✓		
		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/seminar; 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 principles behind them. The algorithms will be illustrated with both toy and real-world examples to motivate the students' understanding. Implementation issues will be discussed, as well as available software toolboxes.	✓			✓	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
Assignments	Students will implement and apply machine learning algorithms to small datasets, and interpret the results. Students can then observe the effectiveness of the algorithms, and evaluate the differences among various algorithms.		✓	✓	✓	1 every 3 weeks
Course Project	Students will implement and apply machine learning algorithms 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%						
In-class exercises	✓				10%	
Assignments		✓	✓	✓	30%	
Course Project^		✓	✓	✓	30%	
Examination^: 30% (duration: 2 hours)	✓			✓	30%	
					100%	

^For a student to pass the course, at least 30% of the maximum mark for course project and examination 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. In-class exercises	1.1 CAPACITY for LEARNING about machine learning algorithms	High	Significant	Moderate	Basic	Not even reaching marginal levels
2. Assignments	2.1 ABILITY to IMPLEMENT and APPLY machine learning to small problems and INTERPRET the results 2.2 ABILITY to COMPARE the accuracy and efficiency of machine learning algorithms	High	Significant	Moderate	Basic	Not even reaching marginal levels
3. Course Project and Presentation	3.1 ABILITY to IMPLEMENT and 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 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.)

The course will mainly focus on the intuition of how machine learning algorithms work, implementation of algorithms, applying machine learning and analyzing the results. Topics include statistical learning, data clustering, dimensionality reduction and data visualization, discriminative classifiers, and deep learning . Programming assignments may involve 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 regression
3. Data clustering
    a. Gaussian mixture models and the EM algorithm
    b. mean-shift algorithm, KDE
    c. spectral clustering, normalized cuts
4. Dimensionality reduction and visualization
    a. subspace methods (PCA, LDA, NMF)
    b. non-linear manifold embedding (LLE, MDS, ISOMAP)
5. Discriminative classifiers
    a. logistic regression
    b. support vector machines
    c. boosting
    d. random forests
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.	H. Daume III (2017). *A course in Machine Learning*. (online: http://ciml.info/)
2.	A. Rajaraman, and J. Ullman (2011). *Mining of Massive Datasets*. Cambridge University Press. (online: http://infolab.stanford.edu/~ullman/mmds.html)
3.	C.M. Bishop (2006). *Pattern Recognition and Machine Learning*. Springer.
4.	I. Goodfellow, Y. Bengio, and A. Courville, "*Deep Learning*", MIT Press, 2016.