Form 2B

City University of Hong Kong

Information on a Course
offered by Department of Computer Science
with effect from Semester A in 2012 / 2013

Part I

Course Title: Machine Learning

Course Code: CS5487

Course Duration: One Semester

No. of Credit Units: 3 credits

Level: P5

Medium of Instruction: English

Prerequisites: 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: Nil

Equivalent Courses: Nil

Exclusive Courses: Nil

Part II

Course Aims:

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.

Course Intended Learning Outcomes (CILOs)

Upon successful completion of this course, students should be able to:

No.	CILOs	Weighting (if applicable)
1.	identify and explain common machine learning algorithms;	
2.	implement machine learning algorithms and applying 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.	

Teaching and learning Activities (TLAs)

(Indicative of likely activities and tasks designed to facilitate students' achievement of the CILOs. Final details will be provided to students in their first week of attendance in this course)

Teaching pattern:

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

ILO No	TLAs	Hours/week (if applicable)
CILO 1 CILO 3	**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
CILO 1 CILO 2 CILO 3	**Tutorial** - each week, students will work on problem sets during the tutorial sessions to gain better understanding of the lecture material.	1 hour
CILO 2 CILO 3	**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.	1 every 2 weeks
CILO 4	**Theory Assignment** - students will analyze algorithms theoretically, and derive solutions to various machine learning problems.	
CILO 2 CILO 3	**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.	

Assessment Tasks/Activities

(Indicative of likely activities and tasks designed to assess how well the students achieve the CILOs. Final details will be provided to students in their first week of attendance in this course)

ILO No	Type of assessment tasks/activities	Weighting (if applicable)	Remarks
CILO 1	**Tutorial:** Students will work on tutorial problem sets each week to gain familiarity with each algorithm. **Exam:** Final exam will include questions to assess the student's ability to explain and analyze machine learning algorithms.		
CILO 2	**Assignment/Project:** In the programming assignments, students will develop skills implementing machine learning algorithms and applying them to small problems. In the course project, students will design a larger machine learning system for solving real-world problems. In both cases, the accuracy and efficiency of their implementations, along with written reports and poster presentation, will be used to assess this ILO.		
CILO 3	**Assignment/Project:** Students will experiment with various machine learning algorithms in the programming assignment and course project. Their ability to evaluate, compare and contrast different algorithms will be assessed in their written reports. **Exam:** The final exam will include questions assessing the students' ability to evaluate, compare and contrast different machine learning approaches.		
CILO 4	**Assignment/Project:** The theory assignments contain derivation and theory problems. The correctness and elegance of their solutions will be used to assess this ILO. **Exam:** The final exam will include questions to assess the student's ability to derive solutions to machine learning problems.		

Grading of Student Achievement: Refer to Grading of Courses in the Academic Regulations for Taught Postgraduate Degrees.

Examination duration: 2 hours
Percentage of coursework, examination, etc.: 40% Assignments; 30% Project; 30% Exam.
Grading pattern: Standard (A+AA-…F)

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

Part III

Keyword Syllabus:

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 (if time)
    a. least-squares regression
    b. generalized linear models
    c. Bayesian regression & Gaussian processes

Recommended Reading:

Essential Text

- *Bishop, "Pattern Recognition and Machine Learning".*

Supplementary Reading

- *Duda, Hart, & Stork, "Pattern Classification".*
- *Schölkopf and Smola, "Learning with kernels: support vector machines, regularization, optimization, and Beyond."*
- *Rasmussen and Williams, "Gaussian Processes for Machine Learning".*