CS4487: MACHINE LEARNING

Effective Term
Semester A 2024/25

Part I Course Overview

Course Title
Machine Learning

Subject Code
CS - Computer Science
Course Number
4487

Academic Unit
Computer Science (CS)

College/School
College of Computing (CC)

Course Duration
One Semester

Credit Units
3

Level
B1, B2, B3, B4 - Bachelor's Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
CS3481 Fundamentals of Data Science or
SDSC3002 Data Mining

Precursors
Nil

Equivalent Courses
Nil

Exclusive Courses
Nil

Part II Course Details

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, 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.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Identify and explain common machine learning algorithms.			x	
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.		x		
4	Describe the theoretical and practical aspects of machine learning algorithms.				

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 real-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.

Learning and Teaching Activities (LTAs)

	LTAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lecture	Student will learn 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.	1, 3, 4	3 hours per week

2	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	8 hours per semester
3	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.	3, 4	After class, 1 every 3 weeks
4	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.	2, 3	After class

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Class participation	1	10	tutorial exercises
2	Assignments	3, 4	30	
3	Course Project and Presentation	2, 3	30	

Continuous Assessment (%)

70

Examination (%)

30

Examination Duration (Hours)

2

Additional Information for ATs

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

Assessment Rubrics (AR)

Assessment Task
Class participation

Criterion
1.1 CAPACITY for LEARNING about machine learning algorithms.

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
Assignments

Criterion
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.

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
Course Project and Presentation

Criterion
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.

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
Examination

Criterion
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.

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Part III Other Information

Keyword Syllabus
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

- Overview of machine learning with real-world examples
- Statistical learning
  - probability distributions (univariate)
  - parameter estimation (maximum likelihood)
  - Bayes' rule & MAP classifiers

- multivariate probability distributions
- linear and lasso regression

- Data clustering
  - k-means
  - Gaussian mixture models and the EM algorithm
  - Dimensionality reduction and visualization
  - subspace methods (PCA, LDA, SVD)
  - independent component analysis
- Discriminative classifiers
  - k-nearest neighbours
  - bayes optimal classifier
  - logistic regression
  - naive bayes
  - linear discriminant analysis
  - support vector machines (convex optimization and duality)
- Deep learning and Neural Networks
  - Perceptron, multi-layer perceptron
  - Activation functions
  - Backpropagation, stochastic gradient descent
  - Convolutional neural networks
  - Regularization, batch-norm, dropout
  - Architectures: Resnet, Densenet, fully convolutional networks
  - Autoencoders
  - Generative adversarial networks, variational autoencoders
  - Transformers
  - Diffusion models

Reading List

Compulsory Readings

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

Additional Readings

	Title
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.