CS5489: MACHINE LEARNING: ALGORITHMS AND APPLICATIONS

Effective Term
Semester A 2025/26

Part I Course Overview

Course Title
Machine Learning: Algorithms and Applications

Subject Code
CS - Computer Science
Course Number
5489

Academic Unit
Computer Science (CS)

College/School
College of Computing (CC)

Course Duration
One Semester

Credit Units
3

Level
P5, P6 - Postgraduate Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
CS3334 Data Structures

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, 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.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Understand the basic mechanisms and concepts of common machine learning algorithms.				
2	Implement machine learning algorithms with Python.			x	
3	Apply machine learning algorithms to solve real-world problems.			x	
4	Distinguish between different machine learning algorithms and know when and how to apply them under varying settings.		x		

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	Students will engage with 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.	1, 4	2 hours

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	1 hour
3	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.	2, 3, 4	1 every 3 weeks
4	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.	2, 3, 4	

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	In-class exercises	1	10	-	No
2	Assignments	2, 3, 4	30	-	No

3	Course Project	2, 3, 4	30	For a student to pass the course, at least 30% of the maximum mark for the examination AND course project must be obtained. GenAI to be only partially used. Students can only use GenAI for editing the English of the report, debugging code, or brainstorming. GenAI cannot be used for other aspects, e.g., writing code or analyzing experiment results.	Yes

Continuous Assessment (%)

70

Examination (%)

30

Examination Duration (Hours)

2

Minimum Examination Passing Requirement (%)

30

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

In-class exercises (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

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 (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion
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

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 (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion
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

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 (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion
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

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
In-class exercises (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion
1.1 CAPACITY for LEARNING about machine learning algorithms

Excellent
(A+, A, A-) High

Good
(B+, B) Significant

Marginal
(B-, C+, C) Moderate to Basic

Failure
(F) Not even reaching marginal levels

Assessment Task
Assignments (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion
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

Excellent
(A+, A, A-) High

Good

(B+, B) Significant

Marginal

(B-, C+, C) Moderate to Basic

Failure

(F) Not even reaching marginal levels

Assessment Task

Course Project and Presentation (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

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

Excellent

(A+, A, A-) High

Good

(B+, B) Significant

Marginal

(B-, C+, C) Moderate to Basic

Failure

(F) Not even reaching marginal levels

Assessment Task

Examination (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

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

Excellent

(A+, A, A-) High

Good

(B+, B) Significant

Marginal

(B-, C+, C) Moderate to Basic

Failure

(F) Not even reaching marginal levels

Part III Other Information

Keyword Syllabus

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

a. Overview of machine learning with real-world examples
b. Statistical learning
    i. probability distributions (univariate)
    ii. parameter estimation (maximum likelihood)
    iii. Bayes' rule & MAP classifiers
    iv. multivariate probability distributions
    v. linear regression
c. Data clustering
    i. Gaussian mixture models and the EM algorithm
    ii. mean-shift algorithm, KDE
    iii. spectral clustering, normalized cuts
d. Dimensionality reduction and visualization
    i. subspace methods (PCA, LDA, NMF)
    ii. non-linear manifold embedding (LLE, MDS, ISOMAP)
e. Discriminative classifiers
    i. logistic regression
    ii. support vector machines
    iii. boosting
    iv. random forests
f. Deep learning and Neural Networks
    i. Perceptron, multi-layer perceptron
    ii. Activation functions
    iii. Backpropagation, stochastic gradient descent
    iv. Convolutional neural networks
    v. Regularization, batch-norm, dropout
    vi. Architectures: Resnet, Densenet, fully convolutional network
    vii. Autoencoder
    viii. Generative adversarial network, variational autoencoder
g. Recommender systems

Reading List

Compulsory Readings

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

Additional Readings

	Title
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.