National University of Sciences & Technology (NUST)
School of Electrical Engineering and Computer Science (SEECS)
Department of Electrical Engineering

Machine Learning

Course Code:	CS-470	**Semester:**	7th
Credit Hours:	3+1	**Prerequisite Codes:**	Fundamentals of Programming, Probability Theory
Instructor:	Dr. Ahmad Salman	**Class:**	BEE-12
Office:	SEECS/IAEC B205	**Telephone:**	051-90852559
Lecture Days:	Monday, Tuesday	**E-mail:**	ahmad.salman@seecs.edu.pk
Class Room:	SEECS Lecture Hall	**Consulting Hours:**	Via prior appointment
Lab Engineer:	Munadi Ahmed Sial	**Lab Engineer Email:**	munadi.sial@seecs.edu.pk
Knowledge Group:	DSSP	**Updates on LMS:**	After every lecture

Course Description:

To develop intelligent software systems and information analysis from the pool of data, machine learning may provide key solutions. From a simple decision making to an advanced automatic computer vision challenges in engineering and data science, machine learning is a crux of attention these days. This course provides an introduction to the fundamental methods at the core of modern machine learning. Apart from theoretical foundation, it covers design and implementation of supervised and unsupervised learning algorithms.

Course Objectives:

1. To introduce students to the fundamental and basic concepts of machine learning and deep learning
2. To develop skills of using recent machine learning software for design and implementation purpose.
3. To gain experience of doing independent study and research.

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**PLO**	**BT Level***
1. Interpret and discuss the fundamental concepts of machine learning in its broad categories.	1	C-2
2. Implement and use core supervised and unsupervised algorithms to solve key problems of signal processing and computer vision.	2	C-3
3. Analyze and select relevant machine learning approach for a given challenge.	3	C-4
4. Conduct experiments as well analyze and interpret experimental data	4	P-4
5. Use Python and Colab to design, analyze and implement machine learning algorithms	5	P-4
6. Exhibit good professional and ethical behavior while adhering to lab safety rules	8	A-3
7. Function effectively both individually and as a member of a team	9	A-3
* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain		

Mapping of CLOs to Program Learning Outcomes

PLOs/CLOs	CLO1	CLO2	CLO 3	CLO4	CLO5	CLO6	CLO7
PLO 1 (Engineering Knowledge)	√						
PLO 2 (Problem Analysis)		√					
PLO 3 (Design/Developments of Solutions)			√				
PLO 4 (Investigation)				√			
PLO 5 (Modern Tool Usage)					√		
PLO 6(The Engineer and Society)							
PLO 7 (The Environment and Sustainability)							
PLO 8 (Ethics)						√	
PLO 9 (Individual and Team Work)							√
PLO 10 (Communication)							
PLO 11 (Project Management)							
PLO 12 (Life Long Learning)							

Mapping of CLOs to Assessment Modules and Weightages (In accordance with NUST statutes)

To be filled in at the end of the course.

Assessments/CLOs	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6	CLO7
Theory: 75%							
Quizzes: 10%	√	√	√				
Assignments: 5%		√	√				
Midterm: 25%	√	√	√				
End Semester Exam: 35%	√	√	√				
Lab: 25%			√	√	√	√	√
Total: 100 %							

Books:

Text Book:
1. Introduction to Machine Learning by Ethem Alpaydin, Third Edition.
2. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow by Aurelien Geron.
3. Pattern Recognition and Machine Learning by Christopher Bishop.

Reference Books:
1. Coursera ML course by Andrew Ng.
2. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow by Aurelien Geron.

Lecture Breakdown:

Week No.	Topics	Sections	Remarks
1	What is machine learning. Examples of machine learning applications	CLO 1	
2	Supervised learning: non-parametric classification with binary and multi-class problems	CLO 1	
3	Supervised learning: linear Regression	CLO 1	
4	Bayesian decision theory	CLO 1	
6	Univariate methods in classification and regression	CLO 1	
7	Multivariate methods for classification and regression	CLO 2	

9	Dimensionality reduction: PCA, LDA, NCA	CLO 2
	Midterm Exam	
11	Clustering with KNN and K-Means	CLO 2
12	Neural Networks and backpropagation	CLO 3
14	Introduction to Deep Neural Networks	CLO 3
15	Modern Architectures	CLO 3
16	Few-shot Learning	CLO 3
17	Execution of modern deep learning tool for practical examples	CLO 3
	ESE	

Week. No.	Lab Title	Lab Tasks
1	Introduction to Python	Difference between Matlab Arrays and Python lists Indexing in Python for 1D, 2D and 3D numpy arrays Conditional Statement in Python Functions in Python Installation and Usage of NumPy/SciPy/MatplotLib etc.
2	Introduction to Colab	Spyder and Jupyter Notebook Hello world example in Colab Upload custom data in Colab Command based navigation in system folders
3	Introduction to Python Imaging Library	Reading/writing images Image to array conversion, formatting, resizing etc. Using python image data generators
4	Introduction to Pandas	Reading and Writing Excel/CSV files Introduction and Usage of DataFrames Data Splits K-Fold cross validation
5	Unsupervised Learning – Clustering	Implementing K-means clustering Selecting optimal value of K Image compression using K Means
6	Linear Regression- I	Implementation custom cost function Using inbuilt optimization functions Bias variance trade off
7	Linear Regression- II	Feature normalization Contour plot visualization Selecting optimal regularization value
8	Neural Network -I	Implementing the forward pass Implementing the backward pass
9	Neural Network -II (CEP)	Introduction to Tensorflow Playground Introduction to inbuilt deep classifiers Introduction to Alex Net
10	Exploratory Data Analysis	Feature extraction/weightage/visualization Implementing SVD Data interpretation using PCA
11	Bias Variance Tradeoff	Compare and contrast the effects of bias and variance through different techniques in Regression and Classification Validation on MNIST Dataset
12	Practical Implication of	Implementing regularization in Regression and Classification Tasks

	Regularization	Validation on CEFAR Dataset
13	Support Vector Machine Classification/Regression	Implementation of Support Vector Machine Algorithm on a custom dataset for Classification and Regression Tasks
16	Lab Exam	Lab exam will be conducted in the week 16

Tools / Software Requirement:

- MATLAB, Python

Grading Policy:

Quiz Policy:	The quizzes will be unannounced and normally last for ten minutes. The question framed is to test the concepts involved in last few lectures. Number of quizzes (around 6) that will be used for evaluation is at the instructor's discretion. All assignments will count towards the total. No 'best-of' policy.
Assignment Policy:	In order to develop comprehensive understanding of the subject, assignments will be given. Late assignments will not be accepted / graded. All assignments will count towards the total (No 'best-of' policy). The students are advised to do the assignment themselves. Copying of assignments is highly discouraged and violations will be dealt with severely by referring any occurrences to the disciplinary committee. The questions in the assignment are meant to be challenging to give students confidence and extensive knowledge about the subject matter and enable them to prepare for the exams. The assignments will be **programming** based. Evaluation will be viva based.
Plagiarism:	NUST maintains a zero tolerance policy towards plagiarism. While collaboration in this course is highly encouraged, you must ensure that you do not claim other people's work/ ideas as your own. Plagiarism occurs when the words, ideas, assertions, theories, figures, images, programming codes of others are presented as your own work. You must cite and acknowledge all sources of information in your assignments. Failing to comply with the NUST plagiarism policy will lead to strict penalties including zero marks in assignments and referral to the academic coordination office for disciplinary action.