BITS PILANI, DUBAI CAMPUS
ACADEMIC-UNDERGRADUATE STUDIES DIVISION
FIRST SEMESTER 2023-2024
Course Handout (Part II)

Date: 28.08.2023

In addition to part-I (General Handout for all courses appended to the time table) this portion gives further specific details regarding the course.

Course No. : BITS F464 (3 0 3)
Course Title : Machine Learning
Instructor-in-charge: Dr. Pranav M. Pawar
Co-Instructor : Dr. Pranav M. Pawar

Catalog Description and Objectives:
Machine Learning is an exciting sub-area of Artificial Intelligence which deals with designing machines which can learn and improve their performance from examples/experience. This course introduces the student to the key algorithms and theory that forms the core of machine learning. The course will cover the major approaches to learning namely, supervised, unsupervised, semi-supervised, and reinforcement leaning. The course emphasizes various techniques, which have become feasible with increased computational power and our ability to produce and capture huge volumes of data. The topics covered in the course include regression, decision trees, support vector machines, artificial neural networks, Bayesian techniques, Hidden Markov models etc. Some advanced topics like active, deep & topological learning will also be covered.

Course Pre/Requisite (if any) & Catalogue / Bulletin Description: Please refer Bulletin 2023-2024.

Text Books [TB]
TB1. Tom M. Mitchell, Machine Learning, The McGraw-Hill Companies, 1st edition 2013.

Reference Books [RB]
RB1. Christopher M. Bhisop, Pattern Recognition & Machine Learning, Springer, 2006.
RB2. Marsland Stephen, Machine Learning – An Algorithmic Perspective, 2e, CRC Press, 2015.
RB3. Alpaydin Ethem. Introduction to Machine Learning, 3e, PHI, 2014.
RB4. Andrew Ng, Machine Learning Yearning, Draft Version.
RB5. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Deep Learning, MIT Press, 2016.

Prerequisites*

1. Probability theory **2.** Decision theory **3.** Information theory **4.** Linear Algebra **5.** Optimization & Search	Self Study	Ch.2, Appendix C – R1

**** A good understanding of the above topics is essential***

Course Plan

Topic	Topic Details	Lecture #	Chapter Reference
Overview	Introduction to Machine Learning **1.** Motivation/course objectives **2.** Recipe of a machine learning algorithm	1	Ch. 1 - TB Ch.1 – R1,R2,R3 Ch. 5 – R5
Types of Learning	Introduction to different types of Learning: **1.** Supervised, semi-supervised, and unsupervised learning **2.** Bayesian learning **3.** Instance-based learning **4.** Reinforcement learning **5.** Active learning **6.** Deep learning	2	Ch.1 – R2, R3
High-dimensional data & Curse of Dimensionality	Characteristics of High-dimensional data, Curse of Dimensionality (CoD) problem	3	Ch.1 – R1
Supervised Learning	Regression **1.** Polynomial regression **a.** Model flexibility/selection **b.** Overfitting/underfitting **c.** Regularization **2.** Linear basis function models Hands on Demonstration of Regression and Multiple Linear Regression	5-6	Ch. 3 – R1
Supervised Learning	Classification **1.** Discriminant Functions (two class and multiclass) **a.** Least Square **b.** Fisher's Linear Discriminant **c.** Perceptron Algorithm **2.** Probabilistic Generative Classifiers **a.** Bayes' classifier **3.** Probabilistic Discriminative Classifiers **a.** Logistic Regression **4.** Decision Tree Learning **5.** Artificial Neural Networks **a.** McCulloch & Pitts Model **b.** Perceptrons **c.** Multilayer Perceptrons (MLP) **d.** Network training **e.** Error back-propagation Mathematical Model Derivation Hands on Demonstration of MLP **6.** Ensemble Learning **a.** Boosting **b.** Bagging **c.** Random Forests **7.** Support Vector Machines (SVM)	7-9 10 11-12 13-15 16-18 19-20	**1.** Ch. 4 – R1 Ch. 10 – R3 **2.** Ch. 4 – R1 **3.** Ch. 4 – R1 **4.** Ch. 3 - TB Ch. 12 – R2 Ch. 9 – R3 **5.** Ch. 4 – TB Ch. 5 – R1 Chs. 3,4 – R2 Ch. 11 – R3 **6.** Ch. 13 – R2 Ch. 17 – R3 **7.** Ch. 8 – R2 Ch. 13 – R3

	a. Maximum margin hyperplanes **b.** Structural risk minimization **c.** VC dimension/Shattering **d.** Duality **e.** Kernels **f.** Regression Mathematical Model Derivation Hands on Demonstration of SVM and Bagging Boosting	21-22	
Kernel Methods	**1.** Kernels **2.** Kernel trick **3.** Kernel-based Machine Learning Algorithms	23-24	Ch. 6 – R1 Ch. 13 – R3
Bayesian Learning	**1.** Bayesian Probability **2.** Bayesian linear regression **3.** Bayes optimal classifier **4.** Gibbs Algorithm **5.** Naïve Bayes Learning Algorithm	25-26	Ch. 6 – TB Ch. 16 – R3
Instance-based Learning	**1.** Rote classifiers **2.** Case-based Reasoning **3.** *K*-NN Hands on Demonstration of K-NN	27-28	Ch. 8 - TB Ch. 8 – R3
Probabilistic Graphical Models (PGM)	**1.** Bayesian Belief Networks (BBN) **2.** Markov Random Fields (MRF) **3.** Hidden Markov Models (HMM) Application and Case Study	29-31	Ch. 6 - TB Ch. 8 – R1 Ch. 16 – R2 Ch. 14,15 – R3
Unsupervised Learning	Clustering **1.** *K*-means Clustering **2.** Mixture of Gaussians **3.** Expectation Maximization (EM) Clustering **4.** Self-organized Maps (SOM)	32-33	Ch. 9 – R1 Ch. 14 – R2 Ch. 7 – R3
	Dimensionality Reduction **1.** LDA **2.** PCA/SVD **3.** ICA **4.** Factor Analysis Hands on Demonstration of LDA, PCA	34-35	Ch. 6 – R2, R3
Reinforcement Learning	**1.** Motivation **2.** Exploration vs. Exploitation tradeoff **3.** Markov Decision Process (MDP) **4.** Action and state spaces **5.** Q Learning Algorithm **6.** Sarsa Algorithm Introduction to Deep Reinforcement Learning	36-37	Ch. 13 – TB Ch. 11 – R2 Ch. 18 – R3

Active Learning	**1.** Motivation **2.** Types of Active Learning **a.** Version space **b.** Membership query synthesis **c.** Pool-based sampling **d.** Stream-based sampling **3.** Query Strategy Frameworks **a.** Uncertainty sampling **i.** Least confident **ii.** Margin sampling **iii.** Entropy **b.** Query by committee (QBC) **i.** Vote entropy **ii.** KL divergence **4.** Analysis of Active Learning	38-40	Class Notes
Introduction to Advanced Learning Techniques	**1.** Deep Learning (Introduction to RNN and CNN) **2.** Topological Learning Hands on Demonstration of CNN	41-42	**1.** R5 **2.** Class Notes

Course Learning Outcomes (CLOs)

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

- **CLO1** To study the basic theory of machine learning and how computers can learn from experience.
- **CLO2** To be able to formulate machine learning problems corresponding to different applications and understand the different applications of machine learning with their strength and weaknesses.
- **CLO3** To know the various supervised learning algorithm for regression and classifications and how to solve real world problems by using them.
- **CLO4** To understand the structure of unlabeled data and working of unsupervised learning to be applied to unlabeled data.
- **CLO5** To learn advanced machine learning techniques such as reinforcement learning, active learning and deep learning, and also understand applications of it.

Evaluation Scheme [Legends: OB - Open Book, CB - Closed Book, TBA – To Be Announced]

Component	Duration	Weightage	Date (Time)	Venue
Mini Project – Part I (Problem definition, Literature survey) (OB)	Take home	10 %	On or Before 15-10-23	TBA
Mid-sem Test (CB)	90 Mins.	30 %	03-11-23 FN	
Mini Project – Part II (Design, Implementation, presentation and demonstration) (OB)	Take home	20 %	On or Before 10-12-23	
Comprehensive Exam (CB)	3 Hours	40 %	09-01-24 FN	

*Only prescribed text book(s) and hand-written notes are permitted

Labs. on R/python: No structured lab sessions, but students will be provided with lab applications on

important topics.

Objective of Mini Project
To understand application of ML algorithms in different areas like IoT, cloud computing, and other recent areas and write a detailed research article over a real time project.

Mapping of CLOs, PLOs, and CECs

CLOs	PLOs	Evaluation Components (ECs)			
		EC1	EC2	EC3	EC4
CLO1	1,2		✓		✓
CLO2	2,3,5,6,7,8	✓	✓	✓	✓
CLO3	2,3,4,5,8	✓	✓	✓	✓
CLO4	2,3,4,5,8	✓		✓	✓
CLO5	2,3,5			✓	✓

*** Please refer the link for the PLOs of the B.E. Computer Science programme**

Mid-Semester grading
Mid-semester grading will be displayed after two evaluation components or earlier when-ever about 40% of evaluation components are completed.

NOTE: A student will be likely to get "NC", if he/she doesn't appear / appear for the sake of appearing for the evaluation / scoring zero in comprehensive examination

Make up and attendance policies
Make-ups are not given as a routine. It is solely dependent upon the genuineness of the circumstances under which a student fails to appear in a scheduled evaluation component. In such circumstances, prior permission should be obtained from the Instructor-in-Charge (I/C). The decision of the course committee in the above matter will be final.

Attendance: Every student is expected to be responsible for regularity of his/her attendance in class rooms, to appear in scheduled tests and examinations and fulfill all other tasks assigned to him/her in this course. A student should have a **minimum of 60% of attendance** in a course to be eligible to appear for the Comprehensive Examination in the course. For the students under the purview of Academic Counseling Board (ACB), the Board shall prescribe the minimum attendance requirement on a case-to-case basis. Attendance in the course will be a deciding factor in judging the seriousness of a student which may be directly / indirectly related to grading.

General timings for consultation
CCH for Regular class: Wednesday hour-9, 02:50 pm -03:40 pm

Contact Details
Dr. Pranav M. Pawar, Room no: 238, Contact No: +9714-2753700 Ext: 304, email: pranav@dubai.bits-pilani.ac.in

General Instructions
Students should come prepared for classes and carry the materials that are prescribed by the Instructor.

Notices

All notices concerning the course will be displayed on the respective Notice Boards. Optionally, if there is a need, email to your BITS mail would be used on short notice and therefore you should activate your BITS mail. All official communications will be sent to your BITS email only.

Instructor-in-charge
BITS F464