BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI

WORK INTEGRATED LEARNING PROGRAMMES

Digital

Part A: Content Design

Course Title	Machine Learning
Course No(s)	
Credit Units	5
Credit Model	1 - 0.5 - 1.5 1 unit for class room hours, 0.5 unit for Tutorial, 1.5 units for Student preparation. 1 unit = 32 hours
Content Authors	Dr. Sugata Ghosal
Version	1.0
Date	May 29th, 2019

Course Objectives

No	
CO1	Introduce students to the basic concepts and techniques of Machine Learning.
CO2	To gain experience of doing independent study and research in the field of Machine Learning

CO3	To develop skills of using recent machine learning software tools to evaluate learning algorithms and model selection for solving practical problems

Text Book(s)

T1	Tom M. Mitchell, Machine Learning, The McGraw-Hill Companies, Inc. International Edition 1997 **(http://personal.disco.unimib.it/Vanneschi/McGrawHill_-_Machine_Learning_-Tom_Mitchell.pdf)**
T2	Christopher M. Bhisop, Pattern Recognition & Machine Learning, Springer, 2006 **(http://www.rmki.kfki.hu/~banmi/elte/Bishop%20-%20Pattern%20Recognition%20and%20Machine%20Learning.pdf)**

Reference Book(s) & other resources

R1	CHRISTOPHER J.C. BURGES: A Tutorial on Support Vector Machines for Pattern Recognition, Kluwer Academic Publishers, Boston, pp. 1–43.

Content Structure

1. Introduction
   - 1.1. Objective of the course
   - 1.2. Design a Learning System
   - 1.3. Issues in Machine Learning

2. Mathematical Preliminaries
   - 2.1. Linear Algebra, Calculus, Probability theory
   - 2.2. Decision Theory
   - 2.3. Information Theory

3. Bayesian Learning
   - 3.1. MLE Hypothesis
   - 3.2. MAP Hypothesis
   - 3.3. Bayes Rule

4. Linear models for classification
   - 4.1. Probabilistic Generative Classifiers
   - 4.2. Naïve Bayes Classifier
   - 4.3. Discriminant Functions
   - 4.4. Probabilistic Discriminative Classifiers

5. Linear models for Regression
   - 5.1. Linear basis function models

5.2. Bayesian linear regression
5.3. Bias-variance decomposition

6. Decision Tree
   6.1. Avoiding Over-fitting
   6.2. Handling Continuous valued attributes, missing attributes
   6.3. Random Forest

7. Neural Networks
   7.1. Perceptron
   7.2. Back propagation network
   7.3. Convolutional network
   7.4. Recurrent network

8. Instance-based Learning
   8.1. k-Nearest Neighbor Learning
   8.2. Locally Weighted Regression (LWR) Learning
   8.3. Radial Basis Functions

9. Ensemble Learning
   9.1. Combining Classifiers
   9.2. Bagging
   9.3. Boosting

10. Support Vector Machine
    10.1. Theory of SVM
    10.2. Linearly separable data
    10.3. Non-linearly separable data

11. Unsupervised Learning
    11.1. Mixture Models
    11.2. Expectation Maximization (EM) Algorithm
    11.3. K-means Clustering

Learning Outcomes:

No	Learning Outcomes
LO1	A strong understanding of the basics of Machine Learning algorithms
LO2	Able to solve Machine Learning problems using appropriate learning techniques
LO3	Evaluate machine learning solutions to problems
LO4	Identify appropriate tools to implement the solutions to machine learning problems and implement solutions

Part B: Learning Plan

Academic Term	
Course Title	Machine Learning
Course No	
Lead Instructor	Dr. Sugata Ghosal

Session No.	Topic Title	Study/HW Resource Reference
1	**Introduction** Objective, What is Machine Learning? Application areas of Machine Learning, Why Machine Learning is important? Design a Learning System, Issues in Machine Learning	T1 – Ch1
2	**Mathematical Preliminaries** Linear Algebra, Calculus, Probability theory, Probability Densities, Gaussian Distribution, Decision Theory, Minimum Misclassification Rate, Information Theory, Measure of Information, Entropy	Lecture Notes, T2 – Ch2
3	**Bayesian Learning** MLE Hypothesis, Bayes Rule, MAP Hypothesis, Minimum Description Length (MDL) principle	T1 - Ch. 6
4	**Linear models for classification** Probabilistic Generative Classifiers, Bayes optimal classifier, Naïve Bayes Classifier	T1 - Ch. 6
5	**Linear models for classification** Discriminant Functions, Probabilistic Discriminative Classifiers, text classification model, image classification	T1 – Ch. 6 T2 - Ch. 4
6	**Linear models for Regression** Linear basis function models, Bayesian linear regression, Bias-variance decomposition	T2 - Ch. 3 T1 – Ch. 6
7	**Decision Tree** Handling over-fitting, continuous attributes, missing	T1 – Ch. 3

	attributes, random forest	
8	Review of Session 1 to 7	Books, Web references and Slides
9	**Neural Network** Perceptron, neural network architecture, Back propagation	T1 - Ch. 4 T2 - Ch. 5
10	**Neural Network** Convolutional network, recurrent network	T1 - Ch. 4 T2 - Ch. 5
11	**Instance-based Learning** K-Nearest Neighbor Learning, Locally Weighted Regression (LWR) Learning, Radial Basis Functions	T1 - Ch. 8
12	**Ensemble Learning** Combining classifiers, Bagging, Boosting, Ada-boost, Gradient Boosting	T2 – Ch. 14 Lecture Notes
13	**Support Vector Machine -I** Theory of SVM, VC dimension, Linearly separable data	R1
14	**Support Vector Machine - II** Non-linearly separable data, Kernel Trick	R1
15	**Unsupervised Learning** Mixture Models, K-means Clustering, EM algorithm	T1 - Ch. 6 T2 - Ch. 9
16	Review of session 9 to 15	Books, Web references and Slides

Detailed Plan for Lab work

Lab No.	Lab Objective	Lab Sheet Access URL	Session Reference
1	Linear Regression and Gradient Descent		2
2	Logistic Regression Classifier		4
3	Random Forest		7
4	Single layer Back propagation NN		9
5	Support Vector Machine (SVM)		13
6	K-nearest Neighbour, K-means clustering		11, 15

Evaluation Scheme:
Legend: EC = Evaluation Component; AN = After Noon Session; FN = Fore Noon Session

No	Name	Type	Duration	Weight	Day, Date, Session, Time
EC-1	Quiz-I	Online		5%	
	Assignment-I	Take Home		13%	
	Assignment-II	Take Home		12%	
EC-2	Mid-Semester Test	Closed Book	1.5 Hrs	30%	
EC-3	Comprehensive Exam	Open Book	2.5 Hrs	40%	

Note:
Syllabus for Mid-Semester Test (Closed Book): Topics in Session Nos. 1 to 8
Syllabus for Comprehensive Exam (Open Book): All topics (Session Nos. 1 to 16)
Important links and information:
Elearn portal: https://elearn.bits-pilani.ac.in or Canvas
Students are expected to visit the Elearn portal on a regular basis and stay up to date with the latest announcements and deadlines.
Contact sessions: Students should attend the online lectures as per the schedule provided on the Elearn portal.
Evaluation Guidelines:

1. EC-1 consists of either two Assignments or three Quizzes. Students will attempt them through the course pages on the Elearn portal. Announcements will be made on the portal, in a timely manner.
2. For Closed Book tests: No books or reference material of any kind will be permitted.
3. For Open Book exams: Use of books and any printed / written reference material (filed or bound) is permitted. However, loose sheets of paper will not be allowed. Use of calculators is permitted in all exams. Laptops/Mobiles of any kind are not allowed. Exchange of any material is not allowed.
4. If a student is unable to appear for the Regular Test/Exam due to genuine exigencies, the student should follow the procedure to apply for the Make-Up Test/Exam which will be made available on the Elearn portal. The Make-Up Test/Exam will be conducted only at selected exam centres on the dates to be announced later.

It shall be the responsibility of the individual student to be regular in maintaining the self study schedule as given in the course handout, attend the online lectures, and take all the prescribed evaluation components such as Assignment/Quiz, Mid-Semester Test and Comprehensive Exam according to the evaluation scheme provided in the handout.