BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE,PILANI
Hyderabad Campus, Hyderabad
Computer Science Dept, 2nd Semester 2023-2024
Course Handout (BITS F464: Machine Learning)

Date: 10th Jan 2024

Course Number : BITS F464 (Tues:4, Thur:4,10)
Course Title : Machine Learning
Instructor-In-Charge : **Chittaranjan Hota, Ph.D (hota[AT]hyderabad.bits-pilani.ac.in)**

Scope and Objectives of the course:

This course is an undergraduate course on Machine Learning. ML is the sub-field of Artificial Intelligence. It helps engineers build automated systems that learn from experiences or examples. It helps machines make data-driven decisions. For example, Google Maps for navigation uses the route network, real-time traffic characteristics, time of travel etc. to predict an appropriate path for you using ML algorithms. ML is a multi-disciplinary field, with roots in Computer science, and Mathematics. ML methods are best described using linear and matrix algebra and their behaviours are best understood using the tools of probability and statistics. According to the latest estimates, 328 million terabytes of data are created daily. With this increasing amounts of data, the need for automated methods for data analysis continues to grow. The goal of ML is to develop methods that can automatically detect patterns in data, and then use the uncovered patterns to predict the future outcomes of interest. This course will cover many ML models and algorithms, including linear models, multi-layer neural networks, support vector machines, density estimation methods, Bayesian belief networks, mixture models, clustering, ensemble methods, and reinforcement learning. The course objectives are the following:

- To select and apply an appropriate supervised learning algorithm for classification problems like Naïve Bayes, SVM, Logistic regression, Neural networks etc.
- To select and apply an appropriate supervised learning algorithm for regression problems like Linear regression, Ridge regression, Non-parametric kernel regression etc.
- To select and apply an appropriate un-supervised learning algorithm for clustering, linear and non-linear dimensionality reduction etc.
- To understand ML principles and techniques like Model selection, Under-fitting, Over-fitting, Cross-validation, Regularization etc.
- To test run appropriate ML algorithm on real and synthetic datasets and interpret their results.

Text Books:

T1: Christopher Bishop: Pattern Recognition and Machine Learning, Springer-Verlag New York Inc., 2006.

T2: Tom M. Mitchell: Machine Learning, The McGraw-Hill, Indian Edition, 2017.

Reference Books:

R1: Kevin Murphy: Machine Learning: A Probabilistic Perspective, MIT Press, 2012.

R2: Shai Shalev-Shwartz and Shai Ben-David: Understanding Machine Learning: From Theory to Algorithms, Cambridge University Press, 2014.

R3: Ethem Alpaydin: Introduction to Machine Learning, 3rd Edition, MIT Press, 2014.

Lecture Plan:

Lect. #	Learning objectives	Topics to be covered	Chapter in the Text Book
1	Course administration	Course Administration, Motivation and ML Frameworks.	T2(1), Lecture Slides
2	Overview of ML	Supervised/Unsupervised/RL, Classification/ Regression, General Approach.	R3(1.1, 1.2)
3 - 4	Supervised Learning - I	Concept Learning: Version space and Candidate elimination algorithm.	T2(2.2, 2.5)
5 - 6	Supervised Learning - II	Decision Tree Learning: Tree Representation, Types of problems suitable for DT learning, Learning algorithm.	T2(3.2, 3.3, 3.4)
7 - 8	Evaluating a model	Bias, Cross-validation, Precision-Recall, ROC Curve.	T1(1.3), R3(19.6, 19.7)
9 - 11	Linear Models for Regression	Linear regression, Logistic regression, Gradient Descent, GD Analysis, SGD.	T1(3.1, 3.2), R1(8.1-3, 8.6)
12 - 14	Linear Models for Classification	Discriminant functions, least squares, Fischer's Linear Discriminant.	T1(4.1)
15 - 17	Naïve Bayes	Generative Vs Discriminative models, Maximum A Posteriori (MAP) Vs Maximum Likelihood (ML)	T1(4.2, 4.3), T2(6.1-6.10)
18 - 21	Neural Networks-I	Perceptron Training, Multi-layer Perceptron(MLP): Components, Activations, Training: SGD, Computing Gradients, Error Backpropagation.	T1(5.1-5.4)
22 - 25	Neural Networks-II	Regularization, Data Augmentation, Convolutional Networks: CNNs, RNNs; Generative Models: Autoregressive, GANs.	T1(5.5), Lecture Slides
26 – 29	Instance-based Learning: Kernels & SVMs	k-Nearest Neighbour Learning, Constructing Kernels, Radial Basis Function Networks, Maximum margin classifiers.	T2(8.2), T1(6.1-6.3, 7.1)
30 - 33	Graphical Models	Bayesian Networks: Training, Structure learning, Inferences, Undirected models.	T1 (8.1, 8.4.1), T2(6)
34 - 35	Un-supervised Learning - I	Mixture Models and EM: K-means Clustering, Gaussian Mixture Models, EM for GMM.	T1 (9.1, 9.2)
36 - 37	Un-supervised Learning - II	Dimensionality Reduction, Principal Component Analysis (PCA).	T1(12.1)
38 – 39	Combining Models	Bayesian-model averaging, Boosting, Tree-based Models.	T1(14.1 - 14.4)
40 - 41	Reinforcement Learning	Markov Decision Process, Value Iteration, Policy Iteration, Q-learning.	T1 (13.1), T2(13.3)

Evaluation Scheme:

Component	Duration	Date & Time	Weightage	Nature of Component
Mid-Semester Exam	90 mins	14/03/3024 (2:00 to 3:30pm)	30%	Closed Book
Home Assignments/ Projects (coding)	-	To be announced	20%	Open Book
Two announced quizzes	30 mins each	Second week of Feb, and First week of April 2024.	10%	Open Book
Comprehensive Exam	3 Hrs	15/05/2024 (FN)	40%	Closed Book

(**Note:** Minimum 40% of the evaluation component will be conducted before the mid semester grading)

Chamber Consultation Hours: Would be announced in the class.

Make-up Policy:
Prior permission of the Instructor-In-Charge is required to get make-up on any evaluation component. Genuine requests will only be considered.

Notices: All notices about the course will be put on Course webpage.

Academic Honesty and Integrity Policy: Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

Instructor-In-Charge
BITS F464