BITS Pilani
K K Birla Goa Campus
Dept. of Computer Science and Information Systems

Department of Computer Science & Information Systems
Course Handout

Date: 29 August 2022

Course No. : BITS F464
Course Title: Machine Learning
Instructor-in-Charge: Harikrishnan N B
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First Degree Teaching Assistants: Biyani Param Hemant Kumar, Devale Tanmay Abhijit

1. Objective and Scope of the Course

This course covers the foundations of Machine Learning. This includes the theoretical foundations and applications of various algorithms. The following topics shall be covered: Decision Tree, Naive Bayes, Logistic Regression, Linear Regression (both matrix and matrix free methods), Bias -Variance Trade off, k-Nearest Neighbours, Principal Component Analysis, Singular Value Decomposition, Dynamic Mode Decomposition for time series forecasting, Learning Theory, Boosting, Kernels, Support Vector Machine, Unsupervised learning. After the successful completion of the course, the student will learn (a) the principled way to do machine learning, (b) confidence to read, and understand Machine Learning research papers.

2. Course Material

Textbook (T)

1. **Textbook (T1):** Tom M. Mitchell. *Machine learning*. Vol. 1, no. 9. New York: McGraw-hill, 1997.
2. **Textbook (T2):** Bishop, Christopher M., and Nasser M. Nasrabadi. *Pattern recognition and machine learning*. Vol. 4, no. 4. New York: springer, 2006.
3. **Textbook (T3)**: James, Gareth, Daniela Witten, Trevor Hastie, and Robert Tibshirani. An introduction to statistical learning. Vol. 112. New York: springer, 2013.
4. **Textbook (T4):** Soman, K. P., R. Loganathan, and V. Ajay. *Machine learning with SVM and other kernel methods*. PHI Learning Pvt. Ltd., 2009.

Reference Books (R)

1. **Reference (R1):** Hastie, Trevor, Robert Tibshirani, Jerome H. Friedman, and Jerome H. Friedman. The elements of statistical learning: data mining, inference, and prediction. Vol. 2. New York: springer, 2009.

2. **Reference (R2):** Brunton, Steven L., and J. Nathan Kutz. Data-driven science and engineering: Machine learning, dynamical systems, and control. Cambridge University Press, 2022.
3. **Reference (R3):** Strang, Gilbert. "Introduction to linear algebra." (2020).

Reading Materials (RM)

1. **RM 1:** Mitchell, Melanie. *Artificial intelligence: A guide for thinking humans*. Penguin UK, 2019.
2. **RM 2:** Selesnick, Ivan. "Least squares with examples in signal processing." *Connexions* 4 (2013).
3. **RM 3:** Tu, Jonathan H. "Dynamic mode decomposition: Theory and applications." PhD diss., Princeton University, 2013.
4. **RM 4:** Schapire, Robert E. "The boosting approach to machine learning: An overview." *Nonlinear estimation and classification* (2003): 149-171.

Tutorials

1. **Tutorial 1:** Shlens, Jonathon. "A tutorial on principal component analysis." *arXiv preprint arXiv:1404.1100* (2014).
2. **Tutorial 2:** Kalman, Dan. "A singularly valuable decomposition: the SVD of a matrix." *The college mathematics journal* 27, no. 1 (1996): 2-23.
3. **Tutorial 3:** Abdi, Hervé. "Singular value decomposition (SVD) and generalized singular value decomposition." *Encyclopedia of measurement and statistics* (2007): 907-912.

3. Course Timing:

DAY	TIME	VENUE
Tuesday	09:00 AM - 09:50 AM	DLT8
Thursday	09:00 AM - 09:50 AM	DLT8
Friday	02:00 PM - 02:50 PM	DLT8

4. Course Plan

Lecture No.	Title	Reference
1	The Roots of Artificial Intelligence and Course Logistics	(RM1: Ch1)
2-3	What is Machine Learning and Introduction to Decision Tree	(T1: Ch3)
4-6	Probability and Estimation: Bayes Rule, MLE, MAP	Notes-MLE, MAP
7-8	Naive Bayes: Conditional Independence	(T1: Ch 6),

		Notes-Naive Bayes
9-10	Gaussian Naive Bayes	(T1: Ch 6)
11-12	Logistic Regression	Notes-Logistic_Regression
13-15	Linear Regression Least Square Bias-Variance Decomposition	(T3: Ch 3)
16-17	Classification Models - k-Nearest Neighbours, Classification performance evaluation metrics	(T1: Ch 8)
18-20	Vector Space, Matrix methods for Data Science, Singular Value Decomposition	(R3: Ch 3, 6 and 7), RM2, Tutorial 2, Tutorial 3
21-22	Principal Component Analysis	Tutorial 1
23	Dimensionality Reduction: Dynamic Mode Decomposition	RM3, R2
24	Application of Dynamic Mode Decomposition	R2
25-26	Learning Theory: PAC Learning, VC Dimension	(T1: Ch 7)
27-28	Boosting	RM4
29-30	AdaBoost	RM4
31	Perceptron	TBA
32	Proof of Convergence of Perceptron	TBA
33-34	Kernels	T4
35-36	Support Vector Machine	T4
37	Unsupervised Learning - Clustering	TBA
39-40	Introduction to Neural Networks, Gradient Descent, Backpropagation	T1
41	Recent Trends	Notes

5. Evaluation Scheme

Components	Duration	Weightage	Date & Time	Remarks
Mid Semester Exam	90 mts	30%		Closed Book
Assignment(s)/ Quizz(es)	-------	20%		Open Book/ Closed Book
Term Project		10%		Presentation
Comprehensive Examination	180 mts	40%		Closed Book

6. Honour Code

"I affirm that I have not given or received any unauthorised help on this assignment, and that this work is my own. Any part of the text or material of the assignment submission, if copied from internet sources, need to be cited and quoted, without which I will be held liable to have committed plagiarism. For group projects, I accept responsibility for my role in ensuring the integrity of the work submitted by the group in which I participated. I understand that any violation of the stated policies, as determined by the FIC, shall be subject to scrutiny by the FIC and is liable for punishment." Zero marks will be awarded if any malpractice is found.

7. Notices

Notice concerning this course will be displayed on Moodle (Quanta).

8. Make-up Policy

Make-up for any component of evaluation will be given only in genuine cases of absence. If the absence is anticipated prior permission of the instructor-in-charge before the examination is necessary. There is no make-up policy for quiz and assignments. The best N-1 out of N quiz and assignments will be considered for grading. Make-up policy is granted only in case of serious illness or emergency on a case by case basis for Mid-sem Test and Comprehensive Exam only.

9. **Chamber Consultation Hours**: Wednesday **03:30 PM - 04:30 PM**, Chamber No.: D-262.