BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
INSTRUCTION DIVISION
SECOND SEMESTER 2019-2020
Course Handout Part II

Date: 06/01/2020

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**
Course Title **: Machine Learning**
Instructor-in-charge **: NAVNEET GOYAL (goel@)**
Lab. Instructor **: Stuti Chugh (p20170407@)**

Catalog Description

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 all 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.

Text Books:

Tom M. Mitchell, Machine Learning, The McGraw-Hill Companies, Inc. International Edition 1997.

Reference Books:

1. Christopher M. Bhisop, Pattern Recognition & Machine Learning, Springer, 2006.
2. Marsland Stephen, Machine Learning – An Algorithmic Perspective, 2e, CRC Press, 2015.
3. Alpaydin Ethem. Introduction to Machine Learning, 3e, PHI, 2014.
4. Andrew Ng, Machine Learning Yearning, Draft Version.
5. 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 these topics is essential*

LECTURE PLAN

Topic	Topic Details	Number of Lectures	Chapter Reference
Overview	**Introduction to Machine Learning** 1. Motivation/course objectives 2. Machine Learning and curve fitting	1	Ch. 1 - TB Ch.1 – R1,R2,R3 Ch. 5 – R5
Types of Learning	**Quick 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 7. Federated learning	2	Ch.1 – R2, R3 + Class Notes
High-dimensional data & Curse of Dimensionality	Characteristics of High-dimensional data, Curse of Dimensionality (CoD) problem and dimensionality reduction techniques	2	Ch.1 – R1
Supervised Learning	**Regression** 1. Polynomial regression a. Model flexibility/selection b. Overfitting/underfitting c. Regularization 2. Linear basis function regression	2	1. Ch. 3 – R1
	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 6. Ensemble Learning a. Boosting	3 1 2 2 4 2	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

	b. Bagging c. Random Forests 7. Support Vector Machines a. Maximum margin hyperplanes b. Structural risk minimization c. VC dimension/Shattering d. Duality e. Kernels f. Regression	2	
Kernel Methods	Kernel-based Machine Learning Algorithms	2	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	2	Ch. 6 – TB Ch. 16 – R3
Instance-based Learning	1. Rote classifiers 2. Case-based Reasoning 3. *K*-NN	2	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)	3	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-organizing Maps (SOM)	3	Ch. 9 – R1 Ch. 14 – R2 Ch. 7 – R3
	Dimensionality Reduction 1. LDA 2. PCA/SVD 3. ICA 4. Factor Analysis	2	Ch. 6 – R2, R3
Reinforcement Learning	1. Motivation 2. Exploration vs. Exploitation 3. Markov Decision Process (MDP) 4. Action and state spaces 5. Q Learning Algorithm 6. Sarsa Algorithm	2	Ch. 13 – TB Ch. 11 – R2 Ch. 18 – R3
Active Learning	1. Motivation: Learning threshold & interval functions 2. Active Learning Scenarios a. Membership query synthesis b. Pool-based sampling c. Stream-based sampling 3. Query Strategy Frameworks a. Uncertainty sampling	3	Class Notes

	i. Least confident ii. Margin sampling iii. Entropy b. Query by committee (QBC) i. Version spaces ii. Vote entropy iii. KL divergence c. Diversity sampling 4. Empirical & Theoretical Analysis of Active Learning 5. Applications of Active Learning		
Introduction to Advanced Learning Techniques	1. Deep Learning o CNN o RNN & LSTM 2. Federated Learning o Distributed learning o Privacy preservation learning o Model aggregation strategies	4 Extra Classes	1. R5 2. Class notes & research articles

Evaluation Scheme:

Component	Duration	Weightage	Date (Time)
Midsem Test (Closed Book)	90 Mins.	25%	
Quiz	45 Mins	10%	TBA
Assignments (02)	Take Home	25%	-
Comprehensive Exam (partly open)	3 Hours	40%	12/05 FN

Labs. on R: Supervised l-hour labs. will be conducted every week as per the time-table.
Notices: All notices will be displayed on NALANDA only.
Chamber Consultation Hour: M, W 5.45 to 6.30 pm (6121-K, NAB)
Makeup Policy: To be granted only in case of serious illness or emergency.
Email Policy: Communication through email is highly discouraged. If you want to discuss anything, you are most welcome to meet me during chamber consultation hours or immediately after the class. Academic queries/doubts can be posted on NALANDA.
NC Policy: Students securing 10% or less marks will get an NC grade. Students in the [10-15] bracket are also likely to get NC.

Instructor-in-charge
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