CSE3242: Machine Learning

Programme: B.Tech. (CSE) Year: 3 Semester: VI
Course: Specialization Core Credits: 3 Hours: 40

Course Context and Overview:
Machine Learning focuses on developing algorithms that adapt to data. Machine Learning has emerged mainly from artificial intelligence and draws on methods from a variety of inter-related subjects including Data Mining, Applied Mathematics. This course introduces the core mathematical and statistical techniques required to understand some of the most popular machine learning algorithms and then presents a few of these algorithms that span the main problem areas within machine learning: classification, clustering and projection.

Prerequisite Courses M1, M2 & IDS

Course Outcomes (COs):

On completion of this course, the students will have the ability to:
CO1: Understand the fundamental issues and challenges of machine learning: data, model selection, model complexity, etc.
CO2: Understand the paradigms of supervised and un-supervised learning.
CO3: Use the mathematical concepts of probability and statistics to implement and execute optimal models.
CO4: Analyze the implemented models to contrast them with other contemporary ML algorithms.

Course Topics:

Contents	Lecture Hours	
UNIT 1 **Linear Modeling: Least Square Methods**		7
1.1. Introduction to Machine Learning & learning Taxonomies,	1	

1.2 Defining linear modeling and measuring the performance of linear models, Loss function, Meaning of linear regression, Mathematical formulation of linear modeling using least square approach, making predictions for the linear models, Numerical example	3	
1.3 Nonlinear response from a linear model, Generalization and overfitting associated with linear model, Resolving the issue of overfitting through cross validation, Computational scaling of cross validation	2	
1.4 Regularized Least Squares	1	
UNIT 2 **Linear Modeling: A Maximum Likelihood approach**		7
2.1. Brief Introduction to random noise with associated probabilistic distribution, Generalization of linear modeling with random noise	1	
2.2. Generative linear models: Defining likelihood, dataset likelihood, Maximum likelihood, Significance of maximum likelihood into complex models, Bias Variance tradeoffs	3	
2.3. Effect of Noise in parameter estimation. Uncertainty handling in estimates	1	
2.4. Variability in model parameters, Variability in predictions, Expected values of estimators	2	
UNIT 3 **Bayesian Approach to Machine Learning**		10
3.1. Bayesian Methods along with prior, likelihood and posterior Analysis of posterior distributions with different scenario: No prior knowledge, fair coin scenario and biased coin scenario, Marginal likelihoods, Hyper parameters, Marginal likelihood for first and polynomial model order selection	4	
3.2. Probabilistic Graphical Models	1	
3.3. Non conjugate models for binary responses and MAP solution	2	
3.4. The Laplacian Approximation for binary responses	2	
3.5. Sampling Techniques	1	

UNIT 4 **Classification**		10
4.1. Naïve Bayesian Classifier	1	
4.2. Probabilistic Smoothing Techniques	1	
4.3. Logistic Regression	1	
4.4. Non Parametric Models	1	
4.5. K-NN classifier	1	
4.6. Support Vector Classifier: Mathematical formulation of hard and soft SVM, SVM for non linear cases using kernel tricks	3	
4.7. Introduction to ANN with perceptron learning and stochastic gradient descent learning	2	
UNIT 5 **Unsupervised learning and projection**		6
5.1. Proximity Measures, k- means algorithm. Kernalized k means	2	
5.2. Mixture Models :The Expectation Maximization algorithm	2	
5.3. Projection: Principal Component Analysis	2	

Textbook references:
Text Books:

- S. Rogers et al., A First Course in Machine Learning, 2nd Ed. CRC Press
- C.M. Bishop, *Pattern Recognition and Machine Learning*. 1st Ed, Springer

Reference books:.

- R.O. Duda et al., *Pattern Classification*. 2nd Ed., John Wiley & Sons.
- E. Alpaydin, *Introduction to Machine Learning*. 2nd Ed., MIT Press.
- P. Flach, *Machine Learning*. 1st Ed., Cambridge University Press.
- T. Mitchell, *Machine Learning*. 2nd Edition, McGraw Hill Education (India) Private Limited

Additional Resources (NPTEL, MIT Video Lectures, Web resources etc.):
During the course, additional literature (available online) will be recommended as additional reading.

Evaluation Methods:

Component	***Weightage (%)***
Programming Assignments	15
Quizzes	15
Seminar Presentation & Implementation	15
Mid term	20
End term	35

- Number of programming assignments depend on the lecture taught and the corresponding algorithms discussed.
- Quizzes will happen after the end of each unit. Here there are 5 units so, 5 quizzes will be conducted throughout the course. Students should be ready after each unit for the quiz without waiting for the announcement.
- Seminar presentations will happen before the end-term exam.

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