Department of Computer Science & Information Systems
Second Semester: 2016-2017
Course Handout: Part-II

Date: 02/01/2018

In addition to part-I (General handout for all courses appended to the timetable) this portion gives further specific details regarding the course:

Course No.	: BITS F464
Course Title	: Machine Learning
Instructor-in-Charge	: Kamlesh Tiwari, (Kamlesh.tiwari@pilani.bits-pilani.ac.in)

1. Objective and Scope of the Course

The notion of a computer directly corresponds to an intelligent machine from its very inception. Although for a very long time machine intelligence was difficult to achieve. Thanks to the recent developments in statistical techniques, availability of large volume of data and processing power that have advanced the state-of-the-art to realize such a machine soon. Data as a fuel leads to knowledge discovery in databases (KDD) and artificial intelligence (AI). Machine learning plays a central role here to develop efficient algorithms for very complex tasks that are not possible otherwise. The process of making algorithm better based on the data is typically called learning and is the prime subject matter of this course. We would see algorithms that allow itself to learn patterns and concepts from data without being explicitly programmed. This course will introduce some of the principles and foundations of Machine Learning algorithms along with their real world applications. The course would be of introductory nature, and would not expect any prior exposure of machine learning from its audience, however an experience in programming would be useful. The course will cover major approaches to the learning namely, supervised, unsupervised, and reinforcement. The topics covered would include regression, decision trees, support vector machines, artificial neural networks, Bayesian techniques, Hidden Markov models, genetic algorithms etc. Some advanced topics like active and deep learning will also be covered.

2. Course Material

Text Book:

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

Reference Books:

1. **Christopher M. Bhisop,** Pattern Recognition and Machine Learning, Springer, 2006.
2. **N. J. Nilson,** Introduction to Machine Learning, Stanford,
   Online Link http://robotics.stanford.edu/people/nilsson/mlbook.html

3. **D. Michie, D.J. Spiegelhalter, C.C. Taylor**, Machine Learning, Neural and Statistical Classification, Ellis Horwood publishers,
Online Link http://www.amsta.leeds.ac.uk/~charles/statlog/

4. **Trevor Hastie, Robert Tibshirani, Jerome Friedman,** The Elements of Statistical Learning, Springer, 2009.
Online Link
http://statweb.stanford.edu/~tibs/ElemStatLearn/printings/ESLII_print10.pdf

5. **Hal Daume** III, A Course in Machine Learning, 2015.
Online Link http://ciml.info/

6. **Kevin Murphy**, Machine Learning: A Probabilistic Perspective, MIT Press, 2012
Online Link https://mitpress.mit.edu/books/machine-learning-0

7. **Ian Goodfellow, Yoshua Bengio, Aaron Courville,** Deep Learning,
Online Link http://www.deeplearningbook.org/

3. Course Plan

Lecture	Topic(s) to be discussed	Reference	Learning Objective
1	Introduction to Machine Learning	TB[Ch-1]	To be able to identify problems where ML can be applied and appreciate the progress of the field.
	Probability theory, Decision theory, Information theory, Linear Algebra	Self Study + R1[Ch-2], TB[Apdx-C]	
2-5	MAP Hypothesis, Minimum Description Length (MDL) principle, Expectation Maximization (EM) Algorithm, Bias-variance Decomposition, Lagrange Multipliers, Mixture of Gaussians, PCA and SVD	TB[Ch-6], class notes, R1[Apdx-E]	To explore ways to get insight from the data.
6-8	Liner Models for regression: Linear basis function models, Bayesian linear regression	R1[Ch-3]	To predict using simple linear model.
9-12	Liner Models for classification: Discriminant Functions, Probabilistic Generative Classifiers, Probabilistic Discriminative Classifiers	R1[Ch-4]	Learning to classify unseen data.
13-14	Bayesian Learning Techniques: Bayes optimal classifier, Gibbs Algorithm, Naive Bayes Classifier	TB[Ch-6]	Classification when you know some statistics about data.
15-21	Non-linear Models: Model Selection & Decision Trees, Ensemble Classifiers, Neural Networks, Multilayer	TB[Ch-3], TB[Ch-4], R1[Ch-5],	Learn hierarchical classification

	Perceptron, Network training, Error back-propagation, Instance-based Learning, K-NN, Case-based Reasoning	TB[Ch-8]	techniques.
22-24	Margin/Kernel Based Approaches: Support Vector Machines	Class Notes, R1[Ch-7]	Learning how transformation of data could help in classification
25-28	Graphical Models: Bayesian Belief Networks, Hidden Markov Models	TB[Ch-6], Class Notes	How only observation can be used to build models.
29-30	Unsupervised Learning: Mixture Models, K-means Clustering, Self-organized Maps (SOM)	TB[Ch-6], R1[Ch-9]	How to summarize data.
31-32	Genetic Algorithms: Hypothesis space search, Genetic programming, Models of evaluation & learning	TB[Ch-9]	How nature have inspired the learning.
33-34	Reinforcement Learning: Q Learning, Non-deterministic rewards & actions, Temporal difference learning, Generalization	TB[Ch-13]	What is the power of hit and trial methods.
35-38	Advanced Topics: Active Learning, Deep Learning, Metric Learning	R7, Class Notes	How complex problems can be solved using special networks.
39-40	Application Examples: Speech Recognition, Image Retrieval	Class Notes	How to apply ML in speech and computer vision.
41-42	Big Data Challenges: Machine Learning for Big Data (3V: Volume, Variety, Velocity)	Class Notes	Learn and apply ML on data with 3V

4. Learning outcome

Students who complete this course would be able to

1. Understand the problems where machine learning could be applied.
2. Formulate/model entitled problem in hand as a machine learning problem.
3. Determine the effectiveness of the of the proposed solution.
4. Comprehend and tune the model parameters to get better systems.

5. Evaluation Scheme

S.No.	Evaluation Component	Marks	Information
1.	Mid-Sem Test: (Open Book)	50	Duration would be 120 Min. *Self handwritten sheets would be allowed. No printed material, mobile phones or laptop would be allowed.*
2.	Notes Scribing:	10	Take Home.
3.	Assignment: (Two in number)	20	Take Home.
4.	ML Competition: *24 hour ML competition would be organized where students would participate in teams. Top two teams would also get goodies.*	10	One Day. *Grading would be done based on the relative ranking and performance of the team*
5.	Term Project: *Would be done in groups of two or three. A list of titles would be provided by the instructor. This may require lot of coding, experimentation and mathematical analysis. Report need to be submitted in Latex. You may need to meet the instructor multiple times for refinement in the project work.*	50	Would be evaluated based on the report and viva for each of the following components *a) literature survey (Jan 29) 07 Marks* *b) Implementation (Feb 16) 15 Marks* *c) Innovation (Mar 16) 10 marks* *d) Results (Mar 30) 08 marks* *e) Final Report (April 13) 10 marks*
6.	Comprehensive Exam: (Partially Open Book)	60	Duration would be 180 Min. *Self handwritten sheets would be allowed for open book part. No printed material, mobile phones or laptop would be allowed.*

6. Honor Code

No form of plagiarism shall be tolerated (we would be using appropriate software tools). Student shall be awarded ZERO marks and case may be reported to the appropriate committee of the Institute for appropriate action.

7. Notices

All notices would be put on NALANDA and course website `www.ktiwari.in/ml`.

8. Make-up Policy

To be granted only in case of serious illness or emergency on case by case basis for Mid-sem Test and Comprehensive Exam only.

9. Chamber Consultation Hours

Mon/Wed 9-11 AM (6120-N @ NAB)

Instructor-in-Charge