Department of Computer Science & Information Systems
Second Semester: 2020-2021
Course Handout: Part-II

Date: 15/01/2021

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

Computers have always been perceived as an intelligent machine. However, for a very long time, machine intelligence was challenging to achieve. Recent developments in statistical techniques, availability of large volume of data, and compute power have sufficiently advanced the state-of-the-art o 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 by devising methods for automated discovery of appropriate systems for very complex tasks that are not possible otherwise. The process of making the algorithm better based on data is typically called as 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. This course would be of introductory nature, and would not expect any prior exposure of machine learning from its audience. However, experience in programming would be useful. The course will cover major approaches to 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 if time permits.

2. Course Material

Text Book:

- **[TB]:** Tom M. Mitchell, Machine Learning, The McGraw-Hill Education(India) 2013.

Reference Books:

- **[R1]: Christopher M. Bhisop,** Pattern Recognition and Machine Learning, Springer, 2006.
  [R2]: N. J. Nilson, Introduction to Machine Learning, Stanford,
  Online Link http://robotics.stanford.edu/people/nilsson/mlbook.html
  [R3]: 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/
  [R4]: 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
  [R5]: Hal Daume III, A Course in Machine Learning, 2015. Online Link http://ciml.info/
  [R6]: Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012
  Online Link https://mitpress.mit.edu/books/machine-learning-0
  [R7]: 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], R7[Ch-1+2+3]	
2-5	ML Basics, Performance Evaluation, Bayesian Learning, MAP Hypothesis, ML Hypothesis, Bias-variance Decomposition	TB[Ch-6], R7[Ch-3], class notes,	To predict using simple linear model. Explore the hypothesis space.
6-8	Constrained optimization, Lagrange Multipliers, SSD, Mixture of Gaussians, Expectation Maximization (EM), Curse of Dimensionality, PCA and SVD, Eigenfaces	R1[Apdx-E], class notes	To explore ways to get insights from the data.
9-13	Concept Learning, Minimum Description Length (MDL), Hidden Markov Models (HMM)	TB[Ch-2], class notes	To learn properties of hypothesis space.
14-15	Non-linear Models: Model Selection & Decision Trees, Ensemble Classifiers – Random Forest, Instance-based Learning, K-NN, Case-based Reasoning	TB[Ch-3]	To explore interpretable models
16	Unsupervised Learning: Mixture Models, K-means Clustering, Self-organized Maps (SOM)	R1[Ch-6]	How to summarize data.
17	Bayesian Learning Techniques: Bayes optimal classifier, Gibbs Algorithm, Naive Bayes Classifier	R1[Ch-4], TB[Ch-6], R7[Ch-5],	To learn Bayesian Classification.
18-20	Liner Models for classification: Discriminant Functions, Probabilistic Generative Classifiers, and Probabilistic Discriminative Classifier. Liner Models for regression: Linear basis function models, Bayesian linear regression. Logistic Regression.	R1[Ch-3]	Learning to classify unseen data.
21-24	Graphical Models: Bayesian Belief Networks, PAC Learning, SOM, VC-Dimension and Monte Carlo Simulation	TB[Ch-6], TB[Ch-7], Class Notes	How only observation can be used to build models.
25-26	Margin/Kernel Based Approaches: Support Vector Machines	R1[Ch-7], Class Notes	Learning how transformation help
27	Ensemble Methods: Bagging and Boosting	Class Notes	How to combine
28	Genetic Algorithms: Hypothesis space search, Genetic programming, Models of evaluation & learning	TB[Ch-9]	How nature have inspired the learning.
29	Reinforcement Learning: Q Learning, Non-deterministic rewards & actions, Temporal difference learning, Generalization	TB[Ch-13]	Power of hit and trial methods.
30	Active Learning, Metric Learning	Class Notes	Learn better sampling.
31-33	Neural Networks, Multilayer Perceptron, Network training, Error back-propagation,	TB[Ch-4], R1[Ch-5], TB[Ch-8], TB[Ch-6]	Learn hierarchical classification
34-35	Deep Learning: Speech Recognition, Sequence Learning, RNN	R7[Ch-12], Class Notes	Handle series
36-38	Deep Learning: Image Retrieval, Computer Vision, CNN	R7[Ch-9], Class Notes	Learn vision and speech
39-40	Generative models: Autoencoders (VAE), Auto-Encoders,	R7[Ch-14+20], Class Notes	Learn making something unseen

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 proposed solution.
4. Comprehend and tune the model parameters to get better systems.

5. Evaluation Scheme

S.No.	Evaluation Component	Marks	Information
1.	Mid-Semester Test:	25%	Open Book (Expected duration 90 Min)
2.	Lab Submissions: *Expected to conduct 14 labs (one per week) on important ML problems. Coding would be done in **Python**.*	10%	Ask for any 7 to be evaluated. Marks in best 5 would be counted.
3.	Class Project: *Would be done individually. A list of problem statements would be provided. You would collect data, train model, get results and submit report.*	15%	Would be evaluated based on quality of data, preprocessing, model accuracy, work done and report.
4.	Assignment: *Two in number.*	5%	One on learning Latex and another on notes scribing.
5.	Term Project: *Could be done individually or in groups of two/three. A list of titles would be provided by the instructor. You would read and present the paper. Could require coding to understand the topic and re-generate results.*	10%	Would be evaluated based on the report/viva/presentation.
6.	Comprehensive Exam: 05 May 2021	35%	Open Book (Expected duration 120 Min)

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. Every component is individual until specifically specified.

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 Comprehensive Exam only.

9. Chamber Consultation Hours

Tuesday 10-11 AM (google meet link on course website)

Instructor-in-Charge