**BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI**

**WORK INTEGRATED LEARNING PROGRAMMES**

**Digital**

Part A: Content Design

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| --- | --- |
| **Course Title** | Machine Learning |
| **Course No(s)** | **DSECL ZG565** |
| **Credit Units** | 4 |
| **Credit Model** |  |
| **Content Authors** | Dr. Sugata Ghosal |
| **Version** | 1.0 |
| **Date** | May 29th, 2019 |

**Course Objectives**

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| **No** |  |
| **CO1** | Introduce students to the basic concepts and techniques of Machine Learning. |
| **CO2** | To gain experience of doing independent study and research in the field of Machine Learning |
| **CO3** | To develop skills of using recent machine learning software tools to evaluate learning algorithms and model selection for solving practical problems |

**Text Book(s)**

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| --- | --- |
| T1 | Tom M. Mitchell, Machine Learning, The McGraw-Hill Companies, Inc. International Edition 1997  **(http://personal.disco.unimib.it/Vanneschi/McGrawHill\_-\_Machine\_Learning\_-Tom\_Mitchell.pdf)** |
| T2 | Christopher M. Bhisop, Pattern Recognition & Machine Learning, Springer, 2006  **(http://www.rmki.kfki.hu/~banmi/elte/Bishop%20-%20Pattern%20Recognition%20and%20Machine%20Learning.pdf)** |

**Reference Book(s) & other resources**

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| R1 | CHRISTOPHER J.C. BURGES: A Tutorial on Support Vector Machines for Pattern Recognition, Kluwer Academic Publishers, Boston, pp. 1–43. |

**Content Structure**

1. Introduction
   1. Objective of the course
   2. Design a Learning System
   3. Issues in Machine Learning
2. Mathematical Preliminaries
   1. Linear Algebra, Calculus, Probability theory
   2. Decision Theory
   3. Information Theory
3. Bayesian Learning
   1. MLE Hypothesis
   2. MAP Hypothesis
   3. Bayes Rule
4. Linear models for classification
   1. Probabilistic Generative Classifiers
   2. Naïve Bayes Classifier
   3. Discriminant Functions
   4. Probabilistic Discriminative Classifiers
5. Linear models for Regression
   1. Linear basis function models
   2. Bayesian linear regression
   3. Bias-variance decomposition
6. Decision Tree
   1. Avoiding Overfitting
   2. Handling Continuous valued attributes, missing attributes
   3. Random Forest
7. Neural Networks
   1. Perceptron
   2. Back propagation network
   3. Convolutional network
   4. Recurrent network
8. Instance-based Learning
   1. k-Nearest Neighbor Learning
   2. Locally Weighted Regression (LWR) Learning
   3. Radial Basis Functions
9. Ensemble Learning
   1. Combining Classifiers
   2. Bagging
   3. Boosting
10. Support Vector Machine
    1. Theory of SVM
    2. Linearly separable data
    3. Non-linearly separable data
11. Unsupervised Learning
    1. Mixture Models
    2. Expectation Maximization (EM) Algorithm
    3. K-means Clustering

**Learning Outcomes:**

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| No | Learning Outcomes |
| LO1 | A strong understanding of the basics of Machine Learning algorithms |
| LO2 | Able to solve Machine Learning problems using appropriate learning techniques |
| LO3 | Evaluate machine learning solutions to problems |
| LO4 | Identify appropriate tools to implement the solutions to machine learning problems and implement solutions |

**Part B: Learning Plan**

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| **Academic Term** | October 2019 |
| **Course Title** | Machine Learning |
| **Course No** | **DSECL ZG565** |
| **Lead Instructor** | Dr. Chetana Gavankar |

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| --- | --- | --- |
| Session No. | Topic Title | Study/HW Resource Reference |
| 1 | **Introduction**  Objective, What is Machine Learning? Application areas of Machine Learning, Why Machine Learning is important? Design a Learning System, Issues in Machine Learning | T1 – Ch1 |
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| 2 | **Mathematical Preliminaries**  Linear Algebra, Calculus, Probability theory, Probability Densities, Gaussian Distribution, Decision Theory, Minimum Misclassification Rate, Information Theory, Measure of Information, Entropy | Lecture Notes,  T2 – Ch2 |
| 3 | **Bayesian Learning**  MLE Hypothesis, Bayes Rule, MAP Hypothesis, Minimum Description Length (MDL) principle | T1 - Ch. 6 |
| 4 | **Linear models for classification**  Probabilistic Generative Classifiers, Bayes optimal classifier, Naïve Bayes Classifier | T1 - Ch. 6 |
| 5 | **Linear models for classification**  Discriminant Functions, Probabilistic Discriminative Classifiers, text classification model, image classification | T1 – Ch. 6  T2 - Ch. 4 |
| 6 | **Linear models for Regression**  Linear basis function models, Bayesian linear regression, Bias-variance decomposition | T2 - Ch. 3  T1 – Ch. 6 |
| 7 | **Decision Tree**  Handling overfitting, continuous attributes, missing attributes, random forest | T1 – Ch. 3 |
| 8 | Review of Session 1 to 7 | Books, Web references and Slides |
| 9 | **Neural Network**  Perceptron, neural network architecture, Back propagation | T1 - Ch. 4  T2 - Ch. 5 |
| 10 | **Neural Network**  Convolutional network, recurrent network | T1 - Ch. 4  T2 - Ch. 5 |
| 11 | **Instance-based Learning**  K-Nearest Neighbor Learning, Locally Weighted Regression (LWR) Learning, Radial Basis Functions | T1 - Ch. 8 |
| 12 | **Ensemble Learning**  Combining classifiers, Bagging, Boosting, AdaBoost, Gradient Boosting | T2 – Ch. 14  Lecture Notes |
| 13 | **Support Vector Machine -I**  Theory of SVM, VC dimension, Linearly separable data | R1 |
| 14 | **Support Vector Machine - II**  Non-linearly separable data, Kernel Trick | R1 |
| 15 | **Unsupervised Learning**  Mixture Models, K-means Clustering, EM algorithm | T1 - Ch. 6  T2 - Ch. 9 |
| 16 | Review of session 9 to 15 | Books, Web references and Slides |

**Detailed Plan for Lab work**

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| **Lab No.** | **Lab Objective** | **Lab Sheet Access URL** |
| 1 | Linear Regression and Gradient Descent |  |
| 2 | Naïve Bayes |  |
| 3 | Logistic Regression classifier |  |
| 4 | Classifier Decision Tree |  |
| 5 | Neural Network |  |
| 6 | Support Vector Machine |  |

**Evaluation Scheme**:

Legend: EC = Evaluation Component; AN = After Noon Session; FN = Fore Noon Session

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| --- | --- | --- | --- | --- | --- |
| No | Name | Type | Duration | Weight | Day, Date, Session, Time |
| EC-1 | Quiz-I | Online |  | 5% |  |
|  | Assignment-I | Take Home |  | 13% |  |
|  | Assignment-II | Take Home |  | 12% |  |
| EC-2 | Mid-Semester Test | Closed Book | 1.5 Hrs | 30% |  |
| EC-3 | Comprehensive Exam | Open Book | 2.5 Hrs | 40% |  |

**Note:**

Syllabus for Mid-Semester Test (Closed Book): Topics in Session Nos. 1 to 8

Syllabus for Comprehensive Exam (Open Book): All topics (Session Nos. 1 to 16)

**Important links and information:**

Elearn portal: <https://elearn.bits-pilani.ac.in> or Canvas

Students are expected to visit the Elearn portal on a regular basis and stay up to date with the latest announcements and deadlines.

Contact sessions: Students should attend the online lectures as per the schedule provided on the Elearn portal.

Evaluation Guidelines:

1. EC-1 consists of either two Assignments or three Quizzes. Students will attempt them through the course pages on the Elearn portal. Announcements will be made on the portal, in a timely manner.
2. For Closed Book tests: No books or reference material of any kind will be permitted.
3. For Open Book exams: Use of books and any printed / written reference material (filed or bound) is permitted. However, loose sheets of paper will not be allowed. Use of calculators is permitted in all exams. Laptops/Mobiles of any kind are not allowed. Exchange of any material is not allowed.
4. If a student is unable to appear for the Regular Test/Exam due to genuine exigencies, the student should follow the procedure to apply for the Make-Up Test/Exam which will be made available on the Elearn portal. The Make-Up Test/Exam will be conducted only at selected exam centres on the dates to be announced later.

It shall be the responsibility of the individual student to be regular in maintaining the self study schedule as given in the course handout, attend the online lectures, and take all the prescribed evaluation components such as Assignment/Quiz, Mid-Semester Test and Comprehensive Exam according to the evaluation scheme provided in the handout.