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

**WORK INTEGRATED LEARNING PROGRAMMES**

**COURSE HANDOUT**

**Part A: Content Design**

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| --- | --- |
| **Course Title** | Classification |
| **Course No(s)** |  |
| **Credit Units** |  |
| **Course Author** | Dr. N.L.Bhanu Murthy |
| **Lead Instructor** | Dr. Chetana Gavankar |
| **Version No** | 3.0  (Modified by Dr. Chetana Gavankar) |
| **Date** | 23/03/2020 |

**Course Description**

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| Classification is a type of supervised learning techniques wherein the target attribute takes discrete values. This course emphasizes the three types of techniques to solve classification problems – discriminant function, generative and probabilistic discriminative approaches. This course lays down a strong foundation on algorithmic perspective of popular classification algorithms - k-NN, Naïve Bayes, Decision Tree, Logistic Regression and SVM. The implementation details of these models along with tuning of parameters will be illustrated. The ensemble methods, bagging, boosting, Random Forest and eXtreme Gradient Boosting will be taught. The interpretability/explicability of the models will also be discussed. |

**Course Objectives**

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| **No** | Objective |
| **CO1** | Provide deeper understanding of three types of techniques to solve classification problems |
| **CO2** | Provide comprehensive algorithmic perspective of popular classification algorithms |
| **CO3** | Provide hands-on to solve real life classification problems |
| **CO4** | Provide the skill to interpret the predicted model |
| **CO5** | Provide the competence to build ensemble classifiers using well known techniques |

**Text Book(s)**

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| --- | --- |
| No | Author(s), Title, Edition, Publishing House |
| T1 | Christopher Bishop: Pattern Recognition and Machine Learning, Springer International Edition |
| T2 | Tom M. Mitchell: Machine Learning, The McGraw-Hill Companies, Inc.. |

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

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| --- | --- |
| No | Author(s), Title, Edition, Publishing House |
| R1 | An Introduction to Data Mining – Pang-Ning Tan, Michael Steinbach, Anuj Karpatne, Vipin Kumar - 2005 |

**Content Structure**

<List down the modular content structure of the course either in the tabular form given below or as bullets>

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| --- | --- | --- |
| **No** | **Title of the Module** | **Reference** |
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| M1 | Overview of the Classification Module   1. Introduction to Classification 2. Types of classification algorithms - Discriminant Functions, Probabilistic Generative models and Probabilistic Discriminative models, Tree based models 3. Classification Algorithms covered in the course and type of these algorithms 4. Applications of classification and case study of the course | Class Notes  T1 – Ch. 4 |
| M2 | Nearest-neighbour Meathods   1. kNN Classifier 2. Measures of prediction accuracies of classifiers – precision, recall, AUC of ROC etc. 3. Finding optimal k 4. Python Implementation of kNN | T2 – Ch. 8 |
| M3 | Naïve Bayes Classifier   1. Probability Foundations – Discrete & Continuous Random Variables, Conditional Independence, Bayes Theorem (1) 2. Probability Foundations – Discrete & Continuous Random Variables, Conditional Independence, Bayes Theorem (2) 3. Naïve Bayes Classifier – Derivation 4. An illustrative example 5. Python implementation of Naïve Bayes Classifier 6. Naïve Bayes Classifier is a generative model 7. Advantages of Naïve Bayes Classifier and when to use Naïve Bayes Classifier? 8. Interpretability of Naïve Bayes Classifier | T2 – Ch. 6 |
| M4 | Logistic Regression   1. Significance of Sigmoid function and finding its derivative 2. Statistics Foundations – Maximum likelihood estimation 3. Cross entropy error function for logistic regression and its optimal solution 4. Logistic Regression is probabilistic discriminative model and an illustrative example 5. Implementation of logistic Regression using Python 6. Decision boundary of logistic regression 7. Overfitting of logistic regression and counter measures 8. Interpretability of logistic regression | T1 – 4.3. |
| M5 | Decision Tree   1. Decision Tree Representation 2. Entropy and Information Gain for an attribute 3. Search in Hypothesis space, ID3 Algorithm for decision tree learning 4. Implementation of Decision Tree using Python 5. Prefer short hypothesis to longer ones, Occam’s razor 6. Overfitting in Decision Tree 7. Reduced Error Pruning and Rule post pruning 8. Alternative measures for selecting attributes 9. Interpretability of Decision Tree | T2 – Ch. 3 |
| M6 | Optimization Foundations for Support Vector Machines   1. Constrained and Unconstrained Optimization 2. Primal and Dual of an optimization problem 3. Quadratic Programming 4. KKT conditions 5. Lagrange Multiplier | Class Notes |
| M7 | Support Vector Machines   1. Understanding the spirit and significance of maximum margin classifier 2. Posing an optimization problem for SVM in non-overlapping class scenario 3. Converting the constrained optimization problem into unconstrained using Legrange multipliers 4. Dual of the optimization problem 5. Appreciation of sparse kernel machine and support vectors in the solution of the optimization problem 6. Implementation of SVM in python | T1 – 6.1, 6.2 and 7.1 |
| M8 | Support Vector Machines in overlapping class distributions & Kernels   1. Issues of overlapping class distribution for SVM 2. Posing an optimization problem for SVM in overlapping class scenario 3. Solving the optimization problem using Legrange multipliers, dual representations 4. Kernel Trick and Mercer’s theorem 5. Techniques for constructing Kernels and advantages of Kernels in SVM 6. Implementation of SVM using different kernels | T1 – 6.1, 6.2 and 7.1 |
| M9 | Ensemble Methods   1. Rational for Ensemble Method 2. Methods for constructing an Ensemble Classifier 3. Bagging, Boosting, AdaBoost 4. Random Forest 5. eXtreme Gradient Boosting (XGBoost) 6. Python Implementation of Random Forest and XGBoost 7. Class Imbalance Problem & approaches to solve it | R1 - 5.6 and 5.7 |
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**Weekly coverage of the course**

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| **Week** | **Content / Assignments / Exercises** |
| Week1 | Video Content: M1  Assignments : Nil  Evaluative Quiz : Nil |
| Week 2 | Video Content: M2  Evaluative Quiz : Q1(M1 and M2)  Assignments : Nil |
| Week 3 | Video Content: M3  Evaluative Quiz : Nil  Assignment 1 : kNN Implementation |
| Week 4 | Video Content:M4  Evaluative Quiz: Nil  Assignment 2 : Naïve Bayes and Logistic Regression Implementation |
| Week 5 | Video Content: M5  Evaluative Quiz : Q2 (M3, M4 and M5)  Assignments : Nil |
| Week 6 | Video Content: M6  Evaluative Quiz : Nil  Assignment 3 : Decision Tree |
| Week 7 | Video Content: M7  Evaluative Quiz : Q3 (M6 and M7)  Assignment : Nil |
| Week 8 | Video Content: M8  Evaluative Quiz : Nil  Assignment 3 : SVM Implementation |
| Week 9 | Video Content: M9  Evaluative Quiz: Nil  Assignment 4:Nil |

**Evaluation**

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| Evaluation Component | Marks | Type |
| Comprehensive Examination | 40% | Closed |
| Quizzes (3) | 24% | Open |
| Assignments (4) | 36% | Open |

**Learning Outcomes:**

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| No | Learning Outcomes |
| LO1 | Ability to build appropriate classifier for a given real life business problem |
| L02 | Demonstrate the capability to understand classification algorithms deeply and fine tuning the parameters therein to enhance performance of the classifier |
| LO3 | Ability to build ensemble classifier using well known techniques |
| LO4 | Ability to interpret the regression model |