Course Code: CSE2032	***Course Title***: Machine Learning
Credits: **3** *(2L-0D-2P per week with a total duration of 16-weeks)*	***Contact hours per week:*** **2** Lectures each of 55 mins duration **1** Lab of 2 hours duration (*approx.*)
Course Instructors and emails: Prof. Anantha Rao, anantha.rao@bmu.edu.in Dr. Devanjali Relan, devanjali.relan@bmu.edu.in Dr. Hirdesh Kumar Pharasi, hirdesh.pharasi@bmu.edu.in Dr. Shilpa Mahajan, shilpa.mahajan@bmu.edu.in (Course Coordinator) Dr. Manisha Saini, manisha.saini@bmu.edu.in	

Course Overview:

The aim of this course is to provide students with an in-depth understanding of Machine Learning algorithms and related applications. Machine learning is the core competency required for jobs in Data Science and Artificial Intelligence. Unlike most courses that are available currently that make students "users of libraries", this course provides a mix of a core understanding of how machines learn, making students implement some of the most popular machine learning algorithms from scratch in Python, as well as solving real world problems using existing implementations within Python. Students will learn to import data, visualize it, process it in different ways, transform it and prepare it for machine learning. They will also learn how to do hyperparameter tuning and model selection in statistically robust ways. The aim is to make them informed, Machine Learning resources that deployable in Industry when they graduate.

Prerequisite : Essential Libraries and Tools (SciPy, NumPy, Pandas, Graphviz, Seaborn, matplotlib Packages).

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Topics of the Course:

- **Introduction to Machine Learning**

  Types of learning - supervised and unsupervised learning. Types of problems - Regression, Classification and Clustering; Applications of machine learning. Discussion on the key concepts such as the cost function, optimization - Gradient Descent algorithm. Sampling, decision boundary, Under-fitting and Overfitting of models and Bias-Variance tradeoff, Cost-sensitive models, inductive bias.

- **Bayesian Learning:**

  Basics of Probability, Bayes Rule, Generative vs. Discriminative Models, Bayes rule - Parameter Estimation, Maximum Likelihood.

- **Supervised Learning:**

  Solving Regression Problems - Linear Regression, Regularization - Ridge and Lasso.

  Solving Classification Problems - Logistic Regression, SVM, Decision Tree.

- **Ensemble** - Decision Forest, Bagging and Boosting.

- **Unsupervised Learning:**

  Clustering - DBScan and BIRCH.

Anomaly Detection - Density Estimation

- **Introduction to Reinforcement Learning**
- **Dimension Reduction** with Principal Components Analysis, Kernel Principal Components Analysis.
- **Introduction to Artificial Neural Networks**
- **Model validation and selection**: Accuracy, confidence interval, Confusion Matrix, Precision, Recall and other metrics, Hyper-parameter tuning, Cross Validation, Bootstrap and ROC curves, R-squared etc.
- **Model Deployment** - deploying the machine learning model in a cloud-based server.

Course Outcomes:

By the end of the course, the students should be able to:

CO1 Understand different types of machine learning techniques and their applications.

CO2 Apply different machine learning algorithms for solving classification, and regression using feature engineering and feature selection.

CO3 Develop appropriate machine learning models for real-world problems

CO-PO Mapping

PO and PSO →	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
↓ CO Mapping || Course Mapping →																
CO1			1		2	2										
CO2	2	2	2	2	3	2		2		2	2		3	2	1	
CO3		3	3	3	3		3	3		2		3	3	3	1	

Course Competencies and Instruction schedule:

Competency	CO	No of sessions
Types of learning - supervised and unsupervised learning. Types of problems - Regression, Classification and Clustering; Applications of machine learning.	CO1	4
Discussion on the key concepts such as the cost function, and optimization - Gradient Descent algorithm. Sampling, decision boundary, Under-fitting and Overfitting of models and Bias-Variance tradeoff, Cost-sensitive models, inductive bias.	CO1	3

Basics of Probability, Bayes Rule, Generative vs. Discriminative Models, Bayes rule - Parameter Estimation, Maximum Likelihood.	CO1	3
Supervised learning – Solving Regression Problems - Linear Regression, Regularization - Ridge and Lasso. Solving	CO1 CO2 CO3	3
Supervised learning – Classification Problems - Logistic Regression, SVM, Decision Tree.	CO2 CO3	4
Ensemble Learning - Decision Forest, Bagging, and Boosting.	CO2 CO3	3
Unsupervised Learning: Clustering - DBScan and BIRCH. Anomaly Detection - Density Estimation	CO1 CO2	4
Introduction to Reinforcement Learning	CO1	2
Dimension Reduction with Principal Components Analysis, Kernel Principal Components Analysis. Introduction to Artificial Neural Networks	CO1, CO2	2
Model validation and selection: Accuracy, confidence interval, Confusion Matrix, Precision, Recall and other metrics, Hyper-parameter tuning, Cross Validation, Bootstrap and ROC curves, R-squared etc.	CO2 CO3	2
Model Deployment - deploying the machine learning model in a cloud-based server.	CO2 CO3	2

Learning Resources:

Textbooks:

1. Raschka, Sebastian, and Vahid Mirjalili. *Python machine learning: Machine learning and deep learning with Python, scikit-learn, and TensorFlow 2*. Packt publishing ltd, 2019.
2. Alpaydin, Ethem. *Introduction to machine learning*. MIT press, 2020.
3. Géron, Aurélien. *Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow*. " O'Reilly Media, Inc.", 2022.

Reference Books:

1. Bishop, Christopher M., and Nasser M. Nasrabadi. *Pattern recognition and machine learning*. Vol. 4. No. 4. New York: springer, 2006.
2. James, Gareth, et al. *An introduction to statistical learning: With applications in python*. Springer Nature, 2023.

E-Learning/Online Resources: Relevant study material, MOOCs (and other e-learning materials) will be suggested and discussed during the lecture session(s) as and when deemed suitable.

1. Machine Learning Specialization 2022 by Andrew Ng
2. Introduction to Statistical Learning

Youtube Playlist:
https://www.youtube.com/watch?v=XgNub00Uovs&list=PLOg0ngHtcqbPTlZzRHA2ocQZqB1D_qZ5V&index=28

3. NPTEL Resources

Introduction to Machine Learning, IIT Madras
Dr. Balaraman Ravindran
https://nptel.ac.in/courses/106106139

Introduction to Machine Learning, IIT Kharagpur
Prof. Sudeshna Sarkar
https://nptel.ac.in/courses/106105152

Assessment Pattern:

Assessment Pattern: The final grade will be based on the marks/ grades obtained in the end semester exam along with other assessments defined in the assessment table given below. Relative grading methods defined in the academic regulations of the university will be followed to grade the students.

Component	Duration	Weightage (%)	Evaluation Week	Remarks
Assignment	During Lab Sessions	20%	Continuous	Offline evaluation will be done based on the submissions followed by demo/viva.
Quiz	10-20 mins	20%	After mid semester	MCQ based
Mid-semester	2 Hours	20%	Scheduled by Exam office	–
End-semester Project	4 Weeks	40%	During the last two weeks of the course.	A comprehensive Project report is to be submitted by a student along with the coding solutions; this will be followed by presentation, demonstration & Viva. **There would be one pre-submission.**

Experiential Learning Component:

Project, as mentioned in the above table, is the experiential learning component for this course. Students will be given challenging real-life problems. They will be asked to build solutions by applying suitable machine learning algorithms. The students are also expected to implement and show results of the proposed solution and perform a comparative analysis with different available algorithms. A separate assessment will be conducted for evaluating the solution

provided by each student. A student needs to spend approximately 20 hours to finish this assignment. The weightage of this component is 40%.

Student Responsibilities:

→ Regular and attentive during lectures/tutorial classes
→ Write class notes and submit assignments on time.
→ Check announcements at Maitri / Google Classroom / Email on a regular basis.
→ Regularly check marks and attendance on the Maitri/Google Classroom and inform if any concerns.

Attendance Policy: As per institute policy

Assignments: Regular assignments will be given. Weightage and submission deadline for each of the assignments will be informed separately at the time of announcement.

Late Assignment Submission Policy:
Late submission in assignment is not allowed and any late submission will be awarded "0" marks in that assignment.

Recourse Examination Policy:
This is an applied course focused on real-world problem solving. Students will be given ample opportunities to score marks through multiple quizzes, programming assignments, projects etc. throughout the semester. Therefore, no recourse examination to be held.

Make-up Policy:
No make-up work will be given for unexcused absences. The faculty needs to be informed in advance in case the student is not going to be able to submit an assignment or take any evaluation component, and it is at the discretion of the faculty to sanction make up for an evaluation component.

Behavior Expectations:
Students must engage during lecture/tutorial sessions, must initiate course related discussions, (ask and) answer relevant questions.

Academic Dishonesty/Cheating/Plagiarism:

Plagiarism and dishonesty in any form in any evaluation component will lead to appropriate disciplinary action.