**Pattern Recognition and Machine Learning**

**Course Placement:** It is a core course for M. Tech. 2nd semester & elective course for M.Sc. (Data Science) 2nd semester and B. Tech. students.

**Course format:** **Three hours’ lecture and two-hour lab** every week.

**Course Content**:

*A quick review of important mathematical concepts*  - Vector space, linear dependence and independence of vectors, matrix inverse, pseudo inverse, matrix diagonalization, singular valued decomposition. Convex/non‐convex functions, constrained/unconstrained optimization, gradient and steepest descent methods, Linear Programming Problem (LPP), Quadratic Programming Problem (QPP).

*Regression models*: - Multivariate Gaussian Distribution, Maximum Likelihood Estimate, Regression models assumptions, Least Square linear regression models, Basis functions for nonlinear least square regression models, Empirical Risk Minimization, Bias-variance Trade-off, Regularization. Kernel functions in Machine Learning models, Support Vector Regression models and its variants, Extreme Learning Machine.

*Classification models*: - Bayesian Classifier, Gaussian models, Naïve‐Bayes Classifier, Linear Discriminate Analysis, Kernel Discriminant Analysis, Logistic Regression, Support Vector Machine for binary classification and its variants, Multiclass Support Vector Machine.

Unsupervised Learning, Principal Component Analysis, K-nearest neighbor algorithms. Clustering methods.

**References:**

Suggested books:

* Deisenroth, Marc Peter, A. Aldo Faisal, and Cheng Soon Ong. *Mathematics for*

*machine learning*. Cambridge University Press, 2020.

* Chandra, Suresh, Jayadeva, and Aparna Mehra. *Numerical optimization with*

*applications*. Alpha Science International, 2009.

* Bishop, Christopher M. *Pattern recognition and Machine learning* 128.9 (2008).
* Friedman, Jerome, Trevor Hastie, and Robert Tibshirani. *The elements of statistical*

*learning*. Vol. 1. No. 10. New York: Springer series in statistics, 2001.

* Deng, Naiyang, Yingjie Tian, and Chunhua Zhang*. Support vector machines:*

*optimization based theory, algorithms, and extensions*. CRC press, 2012.

* Duda, Richard O., and Peter E. Hart. *Pattern classification*. John Wiley & Sons, 2006.
* Zaki, Mohammed J., and Wagner Meira Jr. *Data Mining and Machine Learning: Fundamental Concepts and Algorithms*. Cambridge University Press, 2020.

**Assessment method:** Assignments, One mid semester Exam, Presentation, Mini Project, One end semester Exam.

**Course Outcomes:** After completion of this course, students will

* develop the understanding of the fundamental mathematical concepts and mechanism used in machine learning models.
* learn to implement and apply the variants of modern regression models for prediction and select an appropriate model for a given task.
* learn to implement and apply the variants of classification models for pattern recognition task.
* know how to work with unlabeled data.
* acquire the skill to use different machine learning models in a given problem domain for efficient decision making.

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| **P1** | **P2** | **P3** | **P4** | **P5** | **P6** | **P7** | **P8** | **P9** | **P10** | **P11** | **P12** |
| X |  |  | X | X |  |  |  |  |  |  |  |

**Lecture Schedule**

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| **Sl. No.** | **Description** | **No. of Lectures** |
| **1.** | ***A quick review of important mathematical concepts*** | **9** |
|  | *A quick review of important mathematical concepts*  - Vector space, linear dependence and independence of vectors, matrix inverse, pseudo inverse, matrix diagonalization, singular valued decomposition. Convex/non‐convex functions, constrained/unconstrained optimization, gradient and steepest descent methods, Linear Programming Problem (LPP), Quadratic Programming Problem (QPP). |  |
| **2.** | **Probability & its applications** | **15** |
|  | *Regression models*: - Multivariate Gaussian Distribution, Maximum Likelihood Estimate, Regression models assumptions, Least Square linear regression models, Basis functions for nonlinear least square regression models, Empirical Risk Minimization, Bias-variance Trade-off, Regularization. Kernel functions in Machine Learning models, Support Vector Regression models and its variants, Extreme Learning Machine. |  |
| **3.** | ***Classification models*:-** | **12** |
|  | - Bayesian Classifier, Gaussian models, Naïve‐Bayes Classifier, Linear Discriminate Analysis, Kernel Discriminant Analysis, Logistic Regression, Support Vector Machine for binary classification and its variants, Multiclass Support Vector Machine. |  |
| **4.** | Unsupervised Learning, Principal Component Analysis, K-nearest neighbor algorithms. Clustering methods. | **6** |