Course Plan

Name: Introduction to Machine Learning

Duration - (50 hours - 25 Sessions + 3-4 assignments)

Performance analysis – 4 assignments (Numericals / short coding) – 90%, 10% attendance

Objectives: We produce tremendous amounts of data all the time – from medical scans to social networking sites. This begs the question of whether we can harness the power of data to improve our precision in various walks of life. It turns out we can. We see chatbots like Chat-GPT, image generators like DALLE, and even models that can 'read the human mind' to decode the stimuli one sees. From your YouTube/OTT recommendations to rovers that land on the moon – AI is everywhere. We can only understand how AI impacts the world once we know how it works. This is the aim of this course.

This is a 50–hour comprehensive course that introduces the students to the foundations of Machine Learning and Artificial Intelligence. It is targeted at students who want to learn the foundations of AI – particularly Machine learning and Deep Learning. This is tailored for 1-3rd year UG students in Engineering and Sciences. It would be particularly helpful for students who want to pursue -

(i) a career in research in AI
(ii) want to write the GATE paper – Data Science and Artificial Intelligence.
(iii) Or apply for Data Science roles in the industry.

Schedule: [Start date: 23rd Feb (Friday), End date: By end of May; Session dates: Tuesdays & Fridays (8 pm – 10 pm); 25 sessions]

Prerequisites: Class 12 level - probability, Matrices, and calculus. If possible, please revise my previous course – Foundation of Mathematics for ML. It has covered the first 2 modules of the GATE course in detail. Basic coding skills.

Phase 1: Relevant Mathematics (20 hours; 9 sessions)

(a) Recap – Probability and Stats: Random variables, PMF, PDF, CDF, conditional distributions, expectations, central limit theorem, tests – confidence interval, z-test, chi2-test *(2 weeks, 8 hours)*

(b) Recap – Linear Algebra: Vector spaces, 4 fundamental subspaces, decompositions – eigenvalue, Gauss-Jordan, SVD *(1 week, 4 hours)*

(c) Recap – Calculus and Optimization: limits in epsilon-delta, continuity, differentiability, maxima-minima. optimization - convex functions, properties, gradient descent, Lagrangian multipliers. (2 weeks, 8 hours)

Assignment-cum-test 1 – (1 hour) 25%

Phase 2: Machine Learning (24 hours; 12 sessions)

(a) Supervised Learning – regression, classification – logistic and ordinal. Decision trees, k-nearest neighbour, LDA, SVM. Heuristics for training models – Bias-variance tradeoff, k-fold cv, and regularization. Probabilistic models – naïve Baye's, MLE, probabilistic view of regression *(6 sessions, 12 hours)*

(b) Unsupervised Learning - clustering – k-means/mediods, hierarchical, top-down, dimensionality reduction using PCA – a linear algebra view *(3 sessions, 6 hours)*

(c) Introduction to Generative models: Introduction, expectation-maximization – GMMs, VAEs *(3 sessions, 6 hours)*

Assignment-cum-test 2 (a and b) – (1 hour) 45% - can be divided into 2.

Phase 3: Artificial Intelligence and Logic (*6 hours; 3 sessions)*

Search – informed, uninformed and adversarial; propositional logic. Conditional independence representations. Inference using variable elimination, estimation using Monte Carlo methods.

Reference Books:

0) Session handwritten notes
1) Introduction to Probability by Joseph K. Blitzstein, Jessica Hwang
2) Introduction to Linear Algebra by Gilbert Strang
3) Pattern Recognition and Machine Learning, Cristopher Bishop (selected)
4) Pattern Classification, Duda Hart (selected)
5) Matrix Analysis by Roger Horn and Charles Johnson (advanced)

Instructor – Mainak Biswas (https://mainak-biswas1999.github.io/)
3rd year PhD student, Cognition Lab, IISc.
Department of Brain and Artificial Intelligence.