CS5691: Pattern Recognition and Machine Learning

Jul-Nov Semester 2025 (**Grads Section** - MTech/MS/PhD/Other students)
C Slot, Room CS25
Slots 50 mins. each and start: Mon 10am, Tues 9am, Weds 8am, Fri 12noon
Tutorials on most Fri slots
Instructor: Manikandan Narayanan (*nmanik@cse.iitm.ac.in*)
TAs (program/alphabetic order):
Ayushman Bhatt (*cs24m013@smail*), Debendra Kumar Pal (*cs24m016@smail*),
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(Email TAs/Instructor via Ed Discussion "Private" Email to Staff)

Updated on Jul 31, 2025

Note: Course-related communications will be on Ed Discussion and the IITM Moodle site (CS6024); so please regularly check both Ed Discussion and the moodle website and/or the email account linked to these accounts.

1 Course learning objectives

This course invites students to take a deeper look at diverse machine learning (ML) algorithms for solving pattern recognition (PR) problems like classification, regression and clustering. Specifically, the course should enable students to:

Primary/Key Objectives:

1. **(theory) Clearly understand the theoretical/statistical principles underpinning different ML algorithms (in particular), and what it means to learn from data (in general).**
2. **(practice) Implement/extend ML algorithms from first principles, tune associated parameters, and evaluate/interpret the results.**

Secondary/Implied Objectives:

- (concept) Appreciate the different paradigms of ML including supervised and unsupervised learning, and use them to unify my conceptual view of several existing ML algorithms.
- (implied) Identify the right ML algorithm for a given PR problem, by understanding the key differences/similarities and pros/cons of various algorithms.
- (implied) For a real-world task involving data, either solve it using a relevant PR/ML problem/algorithm (or) explain the unsuitability/limitations of a PR/ML approach to the task.

2 Prerequisites

Undergraduate-level Probability, Linear Algebra, and Calculus. Ability to do basic programming (CS2810 or equivalent).

3 Course style

Traditional class lectures on Mon-Weds, and tutorial/open hours on Fri (but certain Fri sessions will be converted to lectures). The lecture sessions will be complemented by conceptual/programming-based homework assignments to meet the key learning objectives.

4 Course contents

The planned course content shown below is a subset of topics from the course catalog that are in tune with the course learning objectives.

- Introduction to PR/ML approach/system (PR task/problem, ML algorithm, ML paradigms/scenarios)
- Decision theory (optimal (Bayes) classifier, loss functions, optimal regressor)
- Density estimation (Maximum likelihood, Bayesian estimation, Brief mention of additional topics (Expectation Maximization (EM) for mixture density, and Non-parametric methods))
- Linear models for regression and classification (Linear/polynomial/regularized/Bayesian regression, Naive Bayes classifier, Logistic regression, Brief mention of discriminant analysis (hyperplanes))
- Non-linear models for classification and regression (Support Vector Machines and Kernel methods, Neural networks)
- Combining models (Tree-based models, Ensemble methods like Boosting, and Bagging)
- Unsupervised learning methods for clustering and dimensionality reduction (E.g., hard/soft k-means clustering, Principal Component Analysis (PCA))

5 Course evaluation (tentative) and academic honesty

A student-friendly approach to evaluation, which offers students multiple testing opportunities of the same topic, has been taken as follows:

3%	Tutorial/Class participation
33%	Homework assignments (3 problems/programming-based assignments on dates: 25/08, 29/09, 24/10)
22%	Quiz-I and Quiz-II (closed-book, in-person exam on C slot Quiz-I date: Weds, Sep 3rd 2025, 8-8.50am and Quiz-II date: Weds, Oct 8th 2025, 8-8.50am)
42%	Endsem exam (closed-book, in-person exam on C slot Endsem date: Tues, Nov 18th 2025, 9am-12noon). Endsem exam will have three parts (1st part on Quiz-I topics (11%), 2nd on Quiz-II topics (11%), and 3rd on all other topics (20%)), to enable improvement of the 1st and 2nd parts' marks using respective marks (if higher) of Quiz-I and Quiz-II.

Homework assignments can be discussed with other students, but each student must write/code up solutions on her/his own, and mention who you collaborated with and what online or other resources if any you referred to solve the problem. Students will be held to the highest level of academic honesty and ethical standards, and plagiarism will be checked and strictly not be tolerated. Students are prohibited from using AI assistants like ChatGPT for doing any course activity due to various reasons mentioned in the class (and also explained here).

6 References

Primary - CMB Pattern Recognition and Machine Learning. C. M. Bishop. Springer, 2006.

Secondary - DHS Pattern Classification. R. O. Duda, P. E. Hart and D. G. Stork. John Wiley, 2001.

Tertiary - MRT Foundations of Machine Learning. M. Mohri, A. Rostamizadeh and A. Talwalkar. MIT Press, 2018.

Background - DFO Mathematics for Machine Learning. M. P. Deisenroth, A. A. Faisal and C. S. Ong. Cambridge University Press, 2020.

Additional references Please refer course moodle.