

ELEC 378: Machine Learning: Concepts and Techniques
Rice University
Syllabus
Spring 2023

Overview

This course deals with machine learning, from its theoretical mathematical foundations to practical implementation in computer algorithms for data science applications. The course follows a deterministic rather than probabilistic approach to focus on the key concepts; linear algebra plays a starring role.

Goals

At the conclusion of ELEC 378, you should have a solid understanding of

- Machine learning concepts and theory
- Machine learning algorithms for supervised and unsupervised tasks
- The unifying role of linear algebra in machine learning
- How these tools are used in real applications

Prerequisites

Open to students at all levels who are comfortable with 1) linear algebra and 2) coding in Python (ideally), R, MATLAB. The ideal linear algebra preparation is via a course such as MATH/CAAM 335: Linear Algebra/Matrix Analysis.

Course Topics

Introduction

- What is machine learning, data mining, and data science?
- Mathematical preliminaries

Optimization

Unsupervised learning

- Principal components analysis
- k -means clustering
- Hierarchical clustering

Supervised learning – Regression

- Least squares
- Ridge regression
- Lasso

Supervised learning – Classification

- k -nearest neighbors
- Support vector machine (SVM)
- Logistic regression

- Feature engineering and learning

Kernel methods

- The kernel trick
- Kernel regression
- Kernel SVM

Decision trees

Deep (neural) networks

- Multilayer perceptron
- Backpropagation learning
- Deep networks

Course Textbooks

- Recommended: *An Introduction to Statistical Learning*, Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani (free at www.statlearning.com)
- Highly recommended: *Linear Algebra and Its Applications*, Gilbert Strang
- For the ambitious and mathematically inclined: *An Introduction to Hilbert Space*, N. Young, Cambridge Mathematical Textbooks, 1988

Grading

25% - Midterm Exam

25% - Final Exam

25% - Homework

25% - Group Project

Up to 3% bonus for outstanding class participation (see below)

Study Groups

Students will form formal study groups to discuss and work on the homework assignment together. We recommend that you meet as a group at least once per week. While group discussion of homework problems is highly encouraged, students must always submit their own work. Moreover, group work should not substitute for study on your own; at test time, only a pencil and a notes sheet will accompany you.

Team Project Competition

Students will organize into groups to conduct a team project that applies the concepts learned in the class. Teams will be mentored by an ECE grad student or postdoc researcher. The project will involve a competitive aspect using Kaggle; the grade on a competition project will be determined by (1) depth of exploration of the relevant concepts, and (2) quality of the competition report, (3) performance on the test data set.

Class Participation

Up to 3% bonus to your grade will be assessed based on (1) your attendance, (2) your participation in class, which includes posing and answering questions, (3) not using your laptop or smartphone during class, (4) completing group activities during class, (5) participating in office hours and Q/A sessions, and (6) finding errata in the course materials (see below).

Homework Policy

Homework will be posted each week on Piazza and is due by 5pm the following Friday. After the due date, 0% credit will be issued. However, ALL ASSIGNMENTS MUST BE COMPLETED AND TURNED IN, OR AN INCOMPLETE GRADE WILL BE ASSIGNED. Homework, tests, and solutions from previous offerings of this course are off limits, under the honor code.

Errata

You will receive a bonus in the class participation section of your course grade for sufficient contributions of errata to the course notes and CNX course text. Errata must be submitted on this google form: <http://bit.ly/301errata>

Testing Policy

Unless otherwise noted on the test instructions, all tests are timed (typically 3 hours), closed notes/books, and must be taken on your own (i.e., no collaboration with anyone else). Typically you will be allowed bring a hand-written note sheet to the exam. Homework, tests, and solutions from previous offerings of this course are off limits, under the honor code.

Honor Code

Homework, tests, and solutions from previous offerings of this course are off limits, under the honor code.

Students with Disabilities

Any student with a documented disability needing academic adjustments or accommodations is requested to speak with me during the first two weeks of class. All discussions will remain confidential. Students with disabilities should also contact Disabled Student Services in the Ley Student Center.

Suggestions

- Remember the big picture
- Read the textbooks and reference materials and explore the connections
- Learn linear algebra!
- Prepare your own summaries from texts and notes
- Work seriously in your study group for homework and studying; explain the main concepts to each other
- This course is not about solving specific problems but about developing a problem-solving process that you can apply to general problems