CS489/698: Introduction to Machine Learning
Fall 2017
TTh 1:00 – 2:20 (STC 0010, session 1) or 4:00 – 5:20 (MC 2038, session 2)

Web: https://cs.uwaterloo.ca/~y328yu/mycourses/489

Piazza: https://piazza.com/uwaterloo.ca/fall2017/cs489cs698/home

Syllabus

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Course Description
This course introduces students to the design of algorithms that enable machines to “learn.” In contrast to the classic paradigm where machines are programmed by specifying a set of instructions that dictate what exactly a machine should do, a new paradigm is developed whereby machines are presented with examples from which they learn what to do. This is especially useful in complex tasks such as natural language processing, information retrieval, data mining, computer vision and robotics where it is not practical for a programmer to enumerate all possible situations in order to specify suitable instructions for all situations. Instead, a machine is fed with a large collection of examples from which it automatically learns suitable rules to follow. The course will introduce the basics of machine learning and data analysis.

Course Objectives
At the end of the course, students should have the ability to:

• Recognize and formalize a task as a machine learning problem;
• Identify suitable algorithms to tackle different machine learning problems;
• Understand and implement a plethora of foundational machine learning algorithms;
• Apply machine learning algorithms to real datasets.

Course Overview
• Introduction
• Statistical Learning Basics
• Perceptron
• Multi-layer Perceptron (Neural Networks)
• Linear Regression
• Logistic Regression
• K-nearest Neighbours
• Support Vector Machines
• Structured Prediction
• Kernels
• Gaussian Processes
• Fast Kernel Approximations
• Mixture of Gaussians
• Hidden Markov Models
• Deep Neural Networks
• Convolutional Neural Networks
• Recurrent Neural Networks
• Autoencoders
• Generative Adversarial Networks
• Decision Trees
• Bagging, Boosting and Random Forest
• Sparse Methods
• Online Learning
• Collaborative Filtering
• Ranking

Prerequisites

Good knowledge of linear algebra (vector space, eigenvalue, matrix multiplication, etc.) and basic probability (random variable, distribution, expectation, conditional probability, Bayes rule, etc.). Exposure to numerical computing and optimization is a plus but not required. Basic programming language such as Python, Matlab, or Julia (can learn in a few hours).

Textbooks

There is no required textbook. We will pose lecture notes or slides before or after class. You are encouraged to check out the following classical books.

• Elements of Statistical Learning (2nd edition, 2009) [Trevor Hastie, Robert Tibshirani and Jerome Friedman]
• Deep Learning (2016) [Ian Goodfellow, Yoshua Bengio and Aaron Courville]
• Machine Learning: A Probabilistic Perspective (2012) [Kevin Murphy]
• Understanding Machine Learning: From Theory to Algorithms (2014) [Shai Shalev-Shwartz and Shai Ben-David]
Grading

**CS489 (undergraduate students)**: There will be five homework assignments, each worth 10% of your final grade, hence in total $5 \times 10\% = 50\%$. There will be a final open book exam worth another 50% of your final grade. *Optionally, you can also conduct a course project worth 5% of your grade maximum, capped at 100% in total.*

**CS698 (graduate students)**: There will be five homework assignments, each worth 5% of your final grade, hence in total $5 \times 5\% = 25\%$. There will be a final open book exam worth another 40% of your final grade. *You are also required to conduct a course project worth 35% of your grade (5% proposal + 30% report).*

Homework

Five homework assignments will be posted at the following dates (small variations may apply):

- assignment 1: out September 12, due September 26
- assignment 2: out September 28, due October 12
- assignment 3: out October 17, due October 31
- assignment 4: out October 31, due November 14
- assignment 5: out November 16, due November 30

For graduate students, the following due dates also apply:

- proposal: due October 17
- report: due December 3

For programming questions, choose one of the following three languages: [Matlab](https://www.mathworks.com), [Python](https://www.python.org) or [Julia](https://julialang.org).

Completed assignments (and project proposal and report) will be submitted through LEARN. Submit early and often!

As usual, it is OK to seek for help, but you must write your solutions independently and individually, and you should always acknowledge any help you get (book, friend, internet, etc.).

Mark appeals should be requested within two weeks of receiving the mark. The appeal could go either ways, so request only if you truly believe something is wrong.

Late Policy

We do **NOT** accept any late homework submissions, unless you have a legitimate reason with formal proof (e.g. hospitalization, family urgency, etc.). Traveling, busy with other stuff, or simply forgetting to submit, are not considered legitimate.

Project

Each graduate student in CS698 is required to conduct a research project: it could be a survey of a subfield of machine learning, or an empirical comparison of several related algorithms on an interesting dataset, or an application of machine learning algorithms to a different field, or designing a novel algorithm to address a need in machine learning, or theoretically analyzing the performance of a machine learning algorithm (new or old). Some possible projects will be suggested as we progress in the course, but you are highly encouraged to choose your own project (that interests you the most).  

You project should

- relate to machine learning (obviously)
• allow you to learn something new (and hopefully significant)

• be interesting and nontrivial, preferably publishable in a top machine learning conference

The project proposal will be due on October 17. Please concisely describe what your project is about, what are the related works, what is your execution plan, what do you expect to learn/contribute, and how are you going to evaluate your results. I expect the proposal to be more or less one page (excluding references).

The project report will be due on December 3. Please summarize all your findings (empirical, algorithmic, theoretical) in a scientific report. I expect there is an introduction section, a background section, a main result section, and a conclusion section. Depending on your project, you may include an experimental section and/or discussion section. Please always give proper citations to prior work or results. Be precise and concise. I expect the report to be less than 8 pages (everything included).

Your project report will be evaluated by its clarity, significance, rigor, presentation, and completeness.