IEMS 455: Machine Learning Syllabus

Spring 2018

Instructor: Jorge Nocedal

M-W: 4-5:20

Prerequisites: Calculus, linear algebra, probability, statistics; an introductory course to machine learning (in class or online); Python programming experience; knowledge of optimization, particularly concepts such as convexity and gradient descent.

Course Objectives: An intermediate-advanced course on machine learning. Focus is on machine learning models and concepts with an emphasis on formulation, computation and optimization. An introduction to statistical learning theory. Advanced optimization methods for training large machine learning models.

Syllabus

1. Basic Concepts
    a. Bias-Variance Tradeoff
    b. Overfitting
    c. Regularization
2. Machine Learning Models
    a. Linear Regression
    b. Logistic Regression
    c. Perceptrons
    d. Support Vector Machines and Kernels
    e. Generative Models
    f. Non-Negative Matrix Factorization and Dictionary Learning
3. Optimization for Machine Learning
    a. Stochastic Gradient Method
    b. Variance Reduced Methods
    c. Coordinate descent
    d. Second-order methods
4. Deep Learning
    a. Feed Forward Networks
    b. Forward and backpropagation
    c. Convolutional Neural Networks
    d. Residual Networks
    e. Dropout, Batch Normalization
    f. Tensorflow/PyTorch/Keras
5. Statistical Learning Theory
    a. Expected Risk vs. Empirical Risk
    b. Generalization
    c. VC Dimension
    d. Rademacher Complexity
6. Density Estimation

a. Univariate and Multivariate Gaussians
b. Mixture models
c. Expectation maximization

Homeworks, Project

- There will be 5 homework assignments, involving both computing and math problems.
- There will be a project on a topic of your choice: an application area, a study of machine learning models, or optimization methods. Project topic subject to Instructor's approval.

Reading Assignments

- There is not sufficient class time to cover all topics in the syllabus; you will be responsible for studying some topics through the notes that will be distributed in class.

Grading

- Homeworks 60%, project 40%. (No exams)

Textbook

- There is no textbook. The main references are:
- 1. Christopher Bishop, "Pattern Recognition and Machine Learning" Springer 2006
- 2. Online book by Goodfellow, Bengio and Courville "Deep Learning".