IEOR E4525: Machine Learning for OR and FE
Spring 2107
Syllabus and Course Logistics

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Location: TBA
Time: Fridays
Office hours: TBA

1 Description

This will be a survey course on Machine Learning. We will cover the theory of Machine Learning, the practical implementation ML algorithms and their applications to real world problems.

2 Prerequisites

This is intended to be an advanced MS level course for MS students in Operations Research and Financial Engineering. Students should have a good background in either optimization, applied probability, statistics or simulation. Familiarity with Linear Regression methods and maximum likelihood (ML) techniques will also be useful.

You must have taken or be concurrently taking E4522: Python for Operations Research (or an equivalent course) to enroll into E4525.

We will make extensive use of numpy and sklearn during the course to illustrate the ideas discussed. Assignments will require implementing some of the algorithms discussed in class. Familiarity with basic programming, python and numpy in particular will be helpful.

3 Software Requirements

Homework assignments will require a computer and will involve Jupyter notebooks. You must have python and anaconda installed to complete the assignments. In the later part of the course (neural networks) we will use Tensor Flow.

I am personally using python 3.6 to develop the lessons, but python 3.5 should work fine too.

4 Textbooks

There will be no required textbook for this course. The course material will be covered in the lecture slides. Occasional lecture notes will be distributed when the topics require a bit more depth.

The following books are useful as reference:

- *An Introduction to Statistical Learning with Applications in R* (Springer) by James, Witten, Hastie and Tibshirani. This is a very nice introductory textbook. It covers most of the material on the first half of the course. It is freely available at `http://www-bcf.usc.edu/~gareth/ISL/ISLR%20First%20Printing.pdf`.
- *Pattern Recognition and Machine Learning* (Springer) by Christopher M. Bishop. We will follow this book for thr EM algorithm and the introduction to Neural Networks.
- *Learning from Data* (AMLBook) by Abu-Mostafa, Magdon-Ismail and Lin. This book offers an in-depth, very clear explanation of the statistical foundations of ML.
- *Introduction to Information Retrieval*(Cambridge University Press) by Manning, Raghavan and Schütze. Covers topics specific to text processing, and is freely available at `https://nlp.stanford.edu/IR-book/pdf/irbookonlinereading.pdf`
- *Hands-On Machine Learning with Scikit-Learn & Tensor Flow* (O'Reilly) by Aurélien Gerón. Contains demonstrations on how to use python to implement the techniques described in this book without covering any of the theory.

5 Grading

Tentative grading weights will be Homework 35%, Midterm 30 %, Final 35 %

6 Tentative Syllabus

1. **Introduction to Machine Learning**: Introduction to the Course

2. **Probabilistic Tools of Machine Learning**: Bayesian Statistical Inference, Maximum likelihood, Optimization
3. **Learning theory**: Bias-Variance decomposition. Generalization.
4. **Classification I**: k-nearest neighbours, Naive Bayes, ROI Curve, AUC.
5. **Model Selection**: Cross Validation methods for model selection, Regularization.
6. **Classification II**: LDA, QDA. Logistic Regression, Multivariate Logistic Regression
7. **Classification III**: Feature Selection, Applications in Text processing and Image recognition.
8. **SVMs**: classification and regression using Support Vector Machines, kernel methods and the kernel "trick".
   (a) **Support Vector Machines**: geometrical interpretation, primal problem.
   (b) **Dual Problem, Kernel trick**, non separable problems.
9. **Unsupervised Learning**:
   (a) Dimensionality Reduction and Clustering algorithms: PCA, k-means.
   (b) **The EM Algorithm**: applications include clustering via normal and Bernoulli mixture models
10. **Neural Networks and Deep Learning**:
    (a) **Neural Networks** and Back-propagation.
    (b) **Introduction to Tensor Flow** and optimization
    (c) **Convolutional Neural Networks** with applications to image processing
    (d) **Recurrent Neural Networks** with applications to Natural Language Processing