Text Book: *Learning From Data* by Abu-Mostafa, Magdon-Ismail, Lin.
Introduction to the theory and applications of *Machine Learning From Data*. The rough outline is:

1. Foundations

(i) *The Learning Problem*: What is learning?
(ii) *Training Versus Testing*: Can we learn?
(iii) *The Linear Model*: How to learn?
(iv) *Overfitting*: How to learn well?
(v) *Three Learning Principles*: Lessons learned: Occam; sampling bias; snooping.

2. Techniques (we will cover a few)

(vi) *Similarity Based Methods*
(vii) *Neural Networks*
(viii) *Support Vector Machines*
(ix) *Aggregation Methods*: methods for combining models.
(x) *Learning Aides*: methods for improving the performance.

3. Other Paradigms: ***Bayesian***; ***Graphical Models***; ***Reinforcement Learning***; ***Unlabeled Data***; ...

Prerequisites

Math: Self-test Assignment 0 (MATH 1020, 2010, 4100, MATP 4600.) Students without adequate preparation have had serious difficulty, with adverse effects on their grade.
CS: Ability to program and develop algorithms (eg. CSCI-2300). We do *not* offer "debugging help".

Learning Outcomes

4xxx-Level: The successful student will be able to:

1. Understand what it means to learn from data.
2. Formulate a learning problem precisely, in terms of inputs and outputs
3. Describe the basic tools for learning from data.
4. Understand the limits to which information can be learned from data.
5. Understand the basic tradeoffs in learning from data.
6. Understand the general pitfalls when learning from data.
7. Implement, as well as critique basic models for learning from data.
8. Select a learning model and algorithm, run it on the data, and interpret the results.
9. Provide some measures of how effective the learning was.

6xxx-level: In addition to the outcomes at the 4xxx-level, the succesful student will be able to:

10. Perform deep theoretical and experimental analysis of machine learning models.
11. Read and critique recent published literature in the field.

12. Apply advanced mathematical techniques to analyze suitably formulated learning tasks. These techniques include algorithms, discrete and continuous mathematics, linear algebra, probability and mathematical programming.
13. Derive new learning models and algorithms based on domain specific learning problem requirements.

Metrics

Learning outcomes 1-9: Homework assignments will be assigned to measure a students understanding of the theoretical foundations and ability to implement and deploy learning models.

Learning outcome 10: Solutions to homework assignments will be graded for quality of proofs and derivations, which include not only correctness but also rigor and completeness. At the 4xxx-level derivations will often suffice. At the 6xxx-level, to recieve full credit, complete, rigorous and logically correct proofs that demonstrate mastery of the techniques in Learning Outcome 12 are required.

Learning outcome 11: Student will pick a recent paper within the context of the class and write a report summarizing the paper, outlining the contributions, possible deficiencies and possible extensions of the work.

Learning outcomes 12,13: Additional problems on homework assignments will evaluate a students ability to apply advanced mathematical techniques to develop and analyze new models and algorithms.

Policies

Grade: homework 95%, in-class pop quizzes 5%, Paper-review (6xxx, P/F)

About 12 Homeworks that closely follow lectures. 6xxx students must solve additional problems and also demonstrate more advanced mastery of the techniques. In addition, 6xxx students must submit a paper-review (graded P/F) to pass the class. There will be separate curves for the 4100 level and the 6100 level courses. Historically, the threshold for A has been approximately 95%.

Collaboration and Academic Dishonesty

Discussion is allowed. Copying (from **anywhere** other than the class text) is not. Write and understand all solutions yourself. Do not destroy any of your code. We may ask you to submit your code.

You are expected to treat your work with pride, and to respect the work of others. If someone else's work is used to produce any work you will hand in to this course, to the extent that you use their results or techniques, you should: (i) indicate how this third party work was used to solve your tasks; and, (ii) acknowledge the original authors of the work in your submission.

Plagiarizing someone else's work is a **serious issue**. In cases of academic dishonesty, the minimum penalty will be an automatic grade of F, in addition to other institute mandated protocols.

Late Assignment Penalty: 20% per day (except in institute established illness or emergency)

RELATED TEXTS, LEARNING

Bishop, *Neural Networks for Pattern Recognition*
Mitchell, *Machine Learning*
Sutton, Barto, *Reinforcement Learning*
Vapnik, *Statistical Learning Theory*
Duda, Hart, *Pattern Classification and Scene Analysis*
Ripley, *Pattern Recognition and Neural Networks*
Murphy, *Machine Learning*
Mohri, et al., *Foundations of Machine Learning*

RELATED TEXTS, GENERAL MATHEMATICS

Olofsson, *Probability, Statistics and Stochastic Processes*
Pitman, *Probability*
Degroot, *Probability and Statistics*
Khuri, *Advanced Calculus with Applications in Statistics*
Lang, *Undergraduate Algebra*
Horn and Johnson, *Matrix Analysis*
Golub & Van Loan, *Matrix Computations*