EE645
Machine Learning
Fall 2009
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Preliminaries

- Class Meeting Time: MW 9:10-10:25(389 Holmes) after this week
- Website: Laulima
- Office Hours: MW 10:30-12 or by appointment
  - Probability: EE342 or equivalent
    - Random variables, Bayes analysis, Gaussian RVs and Gaussian processes
  - Linear Algebra: vector and matrix operations
  - Programming: Matlab or C experience
Objectives and Grading

Topics: Machine learning, pattern recognition, signal processing, neural networks, applications

Objectives: obtain basic understanding and knowledge of fundamental concepts of machine learning, learn about current research in area, conduct project on topic of current research

Grading:
- Homework: 30%
- Exam: 30%
- Final project: 40% (oral presentation and written report)
Motivation

- Develop paradigms for learning that mimic features of natural learning for applications in engineering and science
- Processing data: CPUs and storage device technology have improved dramatically, algorithm development to process data has not increased nearly as rapidly
- Multidisciplinary area requiring tools from EE, CS, Statistics, Physics, Math, Biology
Overview of Course Material

- Linear algorithms for classification and regression
  - Linear Threshold Unit (Perceptron Learning Algorithm)
  - Optimum margin classifiers
  - Linear Unit
    - LMS Algorithm
    - Least Squares Algorithm
Overview Continued

- **Kernel Methods**
  - Optimization methods
  - Kernels
  - Support Vector Machines
  - Least Squares kernel algorithms
  - On-line algorithms

- **Other learning algorithms**
  - Generative classifier: Naive Bayes
  - Discriminative classifier: Logistic regression
  - Multilayer networks: Backpropagation
Overview Continued

● **Learning Theory Tools**
  - Bayesian decision theory
  - Learning and generalization
  - Structural risk minimization
  - Dimensionality and generalization bounds

● **Graphical Models**
  - Bayesian Networks
  - Conditional independence
  - Inference
Overview Continued

- Other Topics
  - Mixture Models and EM
  - Ensemble Learning and boosting

- Unsupervised Learning
  - Component Analysis: PCA, Kernel PCA, ICA
  - Competitive Learning
    - Self – Organizing Feature Maps
    - Vector quantization
Overview Continued

- Reinforcement learning:
  - Markov decision processes and dynamic programming
  - TD learning, Q learning
Historical Notes

- 1940s: Hebb, *The organization of behavior*, McCulloch-Pitts model, Von Neumann
- 1970s-1980s: Pioneers (Grossberg, Amari, Kohonen), Hopfield, PDP Group
- 1990s-2000s: Multidisciplinary area (machine learning, statistics, physics, biology), mathematical rigor (learning theory, kernel methods, reinforcement learning, Bayesian learning, unsupervised learning)
Applications

- Character recognition
- Text classification
- Biomedical classification: disease diagnosis
- Bioinformatics: gene sequencing and protein classification
- Time series prediction
- Communication applications
References

- Websites: IEEE CIS, INNS, Neural Computation, NIPS, IJCNN, kernel machines, machine learning