Course: 11751(9): Machine Learning

Instructor: Dr. Walid Gomaa and Dr. Noha Yousri

Lectures: Mon 10am-1:30pm and Thur 10am-1:30pm

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Course description: This course provides a broad overview of the current paradigms and techniques of machine learning, in particular statistical learning and modeling and self-organizing systems. By the end of the term the students should be familiar with the central and modern concepts of machine learning.

1. Bayessian Learning:
   (a) Bayes theorem
   (b) MAP algorithm and application to concept learning
   (c) Maximum Likelihood and least-squared error optimization
   (d) Bayes optimal classifier
   (e) Naive Bayes classifier
   (f) Bayesian belief networks
2. Artificial Neural Networks:
   (a) Perception training rule
   (b) Gradient descent and the backpropagation algorithm
3. Linear methods for regression:
   (a) Residual Sum of Squares RSS objective function
   (b) Variance reduction methods including subset selection, forward stepwise and backward stepwise
   (c) Shrinkage methods including ridge regression and Lasso regrission
4. Non-linear methods for regression: piecewise polynomials and splines
5. Decision tree learning:
   (a) The ID3 algorithm
   (b) The C4.5 algorithm
6. Case-Based Reasoning
7. Classification:
   (a) Introduction to basic classifiers: Euclidean distance classifiers, $k - NN$ classifiers
   (b) Linear discriminants: reward-punishment, least mean square, Ho-Kashyap

(c) A brief lecture on SVMs

(d) Non-parametric density estimation: histogram, k-NN and parzen windows

(e) Classifier evaluation

(f) Bagging and Boosting

8. Clustering:

   (a) Clustering problem, and challenges

   (b) Classical algorithms: k-means, k-medoids, single, average and complete linkage, divisive algorithms

   (c) Graph-based and density-based algorithms: Zahn's MST algorithm, DBScan, Mitosis

   (d) Cluster validity: Dunn's index, Xie-Beni, novel validity measures

9. Applications: Selected topic: Bioinformatics

References:

1. 'Machine Learning', Thomas Mitchell, McGraw Hill Higher Education, 1st edition, 1997.

2. 'The Elements of Statistical Learning: Data Mining, Inference, and Prediction', Trevor Hastie, Robert Tibshirani, and Jerome Friedman, Springer, 2nd ed. 2009.

Grading: Presentations, term papers, exams, and class participation.