CS 551: Pattern Recognition

Spring 2007

Description: This course concentrates on statistical pattern recognition techniques. We will talk about Bayesian decision theory, parametric and non-parametric density estimation, feature reduction and selection, supervised and unsupervised learning, classifiers and discriminant functions, clustering and ensemble methods. We will also introduce structural and syntactic pattern recognition at the end of the semester.

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Schedule: Tue 8:40–10:30, Thu 9:40–10:30 (EA 502)

Web page: http://www.cs.bilkent.edu.tr/∼saksoy/courses/cs551/index.html

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Prerequisites: Probability theory, statistics, linear algebra

Texts:

- R. O. Duda, P. E. Hart, D. G. Stork, *Pattern Classification*, 2nd edition, John Wiley & Sons, Inc., 2000. (required)
- A. Webb, *Statistical Pattern Recognition*, 2nd edition, John Wiley & Sons, Inc., 2002.
- C. M. Bishop, *Pattern Recognition and Machine Learning*, Springer, 2006.
- T. Hastie, R. Tibshirani, J. Friedman, *The Elements of Statistical Learning*, Springer, 2003.
- K. Fukunaga, *Introduction to Statistical Pattern Recognition*, Academic Press, 1990.
- R. Schalkoff, *Pattern Recognition: Statistical, Structural and Neural Approaches*, John Wiley & Sons, Inc., 1992.
- A. K. Jain, R. C. Dubes, *Algorithms for Clustering Data*, Prentice Hall, 1988.

Grading (tentative):

Homework and quiz:	55%
Term project:	40%
Class participation:	5%

Assignments: There will be regular homework assignments that will involve both programming and essay type questions.

Tests: There will be in-class quizzes that will be announced in advance.

Term Project: There will be a term project that will involve application of multiple pattern recognition techniques on different datasets. The project will require interim progress reports, a final report written in a conference paper format, and a presentation at the end of the semester. I prefer you to work in groups for the project.

Lecture Schedule:

- Introduction to Pattern Recognition (DHS Ch 1, Appendix A.1–A.2, A.4–A.5)
  - Pattern recognition systems
  - The design cycle
  - An example
- Bayesian Decision Theory (DHS Ch 2.1–2.9; skip 2.3.1, 2.3.2)
  - Modeling using continuous and discrete features
  - Discriminant functions
  - The Gaussian density
  - Error estimation
- Parametric Models (DHS Ch Ch 3.1–3.5, 3.9, 10.2–10.4, 3.10, 2.11; skip 10.4.3, 10.4.4)
  - Maximum-likelihood estimation
  - Bayesian estimation
  - Expectation-Maximization and mixture density estimation
  - Hidden Markov Models
  - Bayesian Belief Networks
- Non-parametric Methods (DHS Ch 4.1–4.4; skip 4.3.5, 4.3.6)
  - Histogram-based estimation
  - Kernel-based estimation
  - Nearest neighbor estimation
- Feature Reduction and Selection (DHS Ch 3.7–3.8, 10.13–10.14)
  - Problems of dimensionality
  - Component analysis
    - Principal components analysis (PCA)
    - Linear discriminant analysis (LDA)
  - Feature selection
- Non-Bayesian Classifiers (DHS Ch 4.5–4.6, 5.1–5.3, 5.11, 6.1–6.3, 8.1–8.3; skip 4.5.1–4.5.3, 4.5.5)
  - k-nearest neighbor classifier
  - Linear discriminant functions
  - Support vector machines
  - Neural networks
  - Decision trees
- Unsupervised Learning and Clustering (DHS Ch 10.1, 10.6–10.7, 10.9–10.10, 10.12)
  - Criterion functions for clustering
  - k-means clustering
  - Hierarchical clustering
  - Graph-theoretic clustering
  - Cluster validity
- Algorithm-Independent Learning Issues (DHS Ch 9.1–9.2, 9.5–9.7; skip 9.2.2)
  - No Free Lunch Theorem
  - Resampling for classifier design
  - Comparing classifiers
  - Combining classifiers
- Structural and Syntactic Pattern Recognition (DHS Ch 8.5–8.6)
  - Recognition with strings
  - Grammatical methods
  - Graph-theoretic methods