CS 551: Pattern Recognition

Fall 2014

Description: This course concentrates on statistical pattern recognition techniques. We will talk about Bayesian decision theory, parametric and non-parametric density estimation, probabilistic graphical models, feature reduction and selection, and non-Bayesian classifiers. We will also introduce structural and syntactic pattern recognition at the end of the semester.

Instructor: Selim Aksoy (Office: EA 422, Email: saksoy@cs.bilkent.edu.tr)

Schedule: Tue 13:40–15:30, Thu 15:40–17:30 (EA 502)

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

Prerequisites: Probability theory, statistics, linear algebra

Texts:

- K. P. Murphy, *Machine Learning: A Probabilistic Perspective*, MIT Press, 2012.
- C. M. Bishop, *Pattern Recognition and Machine Learning*, Springer, 2006.
- R. O. Duda, P. E. Hart, D. G. Stork, *Pattern Classification*, 2nd edition, John Wiley & Sons, Inc., 2000.
- S. Theodoridis, K. Koutroumbas, *Pattern Recognition*, 3rd edition, Academic Press, 2006.
- D. Koller, N. Friedman, *Probabilistic Graphical Models: Principals and Techniques*, MIT Press, 2009.
- A. Webb, *Statistical Pattern Recognition*, 2nd edition, John Wiley & Sons, Inc., 2002.
- 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):

Midterm exam:	25%
Homework:	40%
Project:	30%
Class participation:	5%

Exam: There will be one midterm exam.

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

Term Project: There will be a term project that will involve application of multiple pattern recognition techniques on different data sets. The project will require a project proposal, an interim progress report, and a final report written in a conference paper format at the end of the semester.

Lecture Schedule:

- Introduction to Pattern Recognition
  - Pattern recognition systems
  - The design cycle
  - An example
- Bayesian Decision Theory
  - Modeling using continuous and discrete features
  - Discriminant functions
  - The Gaussian density
  - Error estimation
- Parametric Models
  - Maximum-likelihood estimation
  - Bayesian estimation
  - Expectation-Maximization and mixture density estimation
  - Hidden Markov Models
- Non-parametric Methods
  - Density estimation
  - Histogram-based estimation
  - Parzen windows estimation
  - Nearest neighbor estimation
- Probabilistic Graphical Models
  - Directed graphical models — Bayesian networks
  - Undirected graphical models
  - Inference using graphical models
  - Learning graphical models
- Feature Reduction and Selection
  - Problems of dimensionality
  - Component analysis
    - Principal components analysis (PCA)
    - Linear discriminant analysis (LDA)
  - Manifold learning
  - Feature selection
- Non-Bayesian Classifiers
  - k-nearest neighbor classifier
  - Linear discriminant functions
  - Support vector machines
- Structural and Syntactic Pattern Recognition
  - Graph-theoretic methods
  - Recognition with strings
  - Grammatical methods