CS 559: Machine Learning: Fundamentals and Applications

School of Engineering and Science
Fall 2015

Meeting Times:	Thursday 6:15-8:45 PM
Classroom Location:	TBD
Instructor:	Philippos Mordohai
Contact Info:	Lieb 215, Philippos.Mordohai@stevens.edu, 201 216 5611
Office Hours:	Tuesday 5:00-6:00 PM and by appointment
Course Web Address:	http://www.cs.stevens.edu/~mordohai/classes/cs559_f15.html
Prerequisite(s):	MA 222
Corequisite(s):	N/A
Cross-listed with:	N/A

COURSE DESCRIPTION

In many fields (e.g., computer vision, speech recognition, data mining, and bioinformatics), machine learning has become a crucial ingredient in translating research into applications. The course is intended to provide an in-depth overview of recent advances in machine learning, with applications in fields such as computer vision, data mining, natural language processing. Fundamental topics that will be covered include supervised (Bayesian) and unsupervised learning, non-parametric methods, graphical models (Bayes Nets and Markov Random Fields) and dimensionality reduction. The course will also cover several of the most important recent developments in learning algorithms, including boosting, Support Vector Machines and kernel methods, and outline the fundamental concepts behind these approaches.

LEARNING OBJECTIVES

After successful completion of this course, students will be able to…

- Explain Bayesian decision theory, the likelihood ratio, and minimum risk classification.
- Implement Maximum Likelihood Estimation classifiers.
- Apply dimensionality reduction using Principal Component Analysis and the Fisher Linear Discriminant method.
- Implement density estimation using Parzen windows or k nearest neighbors, and perform non-parametric classification.
- Implement classifiers using linear discriminant functions.
- Explain the advantages of Support Vector Machines and margin maximization.
- Explain boosting.

FORMAT AND STRUCTURE

This course is comprised of weekly three-hour lectures.

COURSE MATERIALS

Textbook(s):	David Barber, Bayesian Reasoning and Machine Learning, Cambridge University Press, 2012. Trevor Hastie, Robert Tibshirani and Jerome Friedman, The Elements of Statistical Learning (2nd edition), Springer, 2009.
Other Readings:	Available on course web page
Materials:	None

COURSE REQUIREMENTS

Attendance	Attendance is not mandatory, but there will be at least 10 quizzes during the semester.
Participation	Participation is strongly encouraged.
Homework	There will be four homework assignments, which will be tentatively assigned in Weeks 3, 5, 9 and 12 and will be due one week later.
Quizzes	There will be at least 10 quizzes during the semester, at the beginning of each lecture.
Project	Each student will select a project related to machine learning, which has to be approved by me regarding relevance and feasibility. I will provide pointers and suggestions for potential projects. Students actively involved in machine learning research can select a project related to their research, but new work has to be done during the semester. Large projects can be performed by groups of two students. Each student will briefly present his or her project in 3-5 minutes during Week 9. Final project reports and presentations are due in Week 14.
Exams	The midterm is scheduled for Week 8 and the final exam will be held during the regular final exam period. Both are open book exams.

GRADING PROCEDURES

Grades will be based on:

Homework	(20%)
Quizzes	(10%)
Final Project	(25%)
Midterm Exam	(20%)
Final Exam	(25%)

ACADEMIC INTEGRITY

Graduate Student Code of Academic Integrity

All Stevens graduate students promise to be fully truthful and avoid dishonesty, fraud, misrepresentation, and deceit of any type in relation to their academic work. A student's submission of work for academic credit indicates that the work is the student's own. All outside assistance must be acknowledged. Any student who violates this code or who knowingly assists another student in violating this code shall be subject to discipline.

All graduate students are bound by the Graduate Student Code of Academic Integrity by enrollment in graduate coursework at Stevens. It is the responsibility of each graduate student to understand and adhere to the Graduate Student Code of Academic Integrity. More information including types of violations, the process for handling perceived violations, and types of sanctions can be found at www.stevens.edu/provost/graduate-academics.

Special Provisions for Undergraduate Students in 500-level Courses

The general provisions of the Stevens Honor System do not apply fully to graduate courses, 500 level or otherwise. Any student who wishes to report an undergraduate for a violation in a 500-level course shall submit the report to the Honor Board following the protocol for undergraduate courses, and an investigation will be conducted following the same process for an appeal on false accusation described in Section 8.04 of the Bylaws of the Honor System. Any student who wishes to report a graduate student may submit the report to the Dean of Graduate Academics or to the Honor Board, who will refer the report to the Dean. The Honor Board Chairman will give the Dean of Graduate Academics weekly updates on the progress of any casework relating to 500-level courses. For more information about the scope, penalties, and procedures pertaining to undergraduate students in 500-level courses, see Section 9 of the Bylaws of the Honor System document, located on the Honor Board website.

EXAM ROOM CONDITIONS

The following procedures apply to quizzes and exams for this course. As the instructor, I reserve the right to modify any conditions set forth below by printing revised Exam Room Conditions on the quiz or exam.

1. Students may use the following devices during quizzes and exams. Any electronic devices that are not mentioned in the list below are not permitted.

Device	**Permitted?**	
	Yes	No
Laptops		X
Cell Phones		X
Tablets		X
Smart Watches		X
Google Glass		X
Other		X

2. Students may use the following materials during quizzes, marked with Q, and exams, marked with E. Any materials that are not mentioned in the list below are not permitted.

Material	**Permitted?**	
	Yes	No
Handwritten Notes *Conditions*:	E	Q
Typed Notes *Conditions*:	E	Q
Textbooks *Conditions*:	E	Q
Readings *Conditions*:	E	Q
Other (specify) – Exams are open book, but no electronic devices are allowed	E	Q

3. Students are not allowed to work with or talk to other students during quizzes and exams.

LEARNING ACCOMODATIONS

Stevens Institute of Technology is dedicated to providing appropriate accommodations to students with documented disabilities. Student Counseling and Disability Services works with undergraduate and graduate students with learning disabilities, attention deficit-hyperactivity disorders, physical disabilities, sensory impairments, and psychiatric disorders in order to help students achieve their academic and personal potential. They facilitate equal access to the educational programs and opportunities offered at Stevens and coordinate reasonable accommodations for eligible students. These services are designed to encourage independence and self-advocacy with support from SCDS staff. The SCDS staff will facilitate the provision of accommodations on a case-by-case basis. These academic accommodations are provided at no cost to the student.

Disability Services Confidentiality Policy

Student Disability Files are kept separate from academic files and are stored in a secure location within the office of Student Counseling, Psychological & Disability Services. The Family Educational Rights Privacy Act (FERPA, 20 U.S.C. 1232g; 34CFR, Part 99) regulates disclosure of disability documentation and records maintained by Stevens Disability Services. According to this act, prior written consent by the student is required before our Disability Services office may release disability documentation or records to anyone. An exception is made in unusual circumstances, such as the case of health and safety emergencies.

For more information about Disability Services and the process to receive accommodations, visit https://www.stevens.edu/sit/counseling/disability-services. If you have any questions please contact:

> Lauren Poleyeff, Psy.M., LCSW - Diability Services Coordinator and Staff Clinician in Student Counseling and Disability Services at Stevens Institute of Technology at lpoleyef@stevens.edu or by phone (201) 216-8728.

INCLUSIVITY STATEMENT

Stevens Institute of Technology believes that diversity and inclusiveness are essential to excellence in education and innovation. Our community represents a rich variety of backgrounds, experiences, demographics and perspectives and Stevens is committed to fostering a learning environment where every individual is respected and engaged. To facilitate a dynamic and inclusive educational experience, we ask all members of the community to:

- be open to the perspectives of others
- appreciate the uniqueness their colleagues
- take advantage of the opportunity to learn from each other
- exchange experiences, values and beliefs
- communicate in a respectful manner
- be aware of individuals who are marginalized and involve them
- keep confidential discussions private

TENTATIVE COURSE SCHEDULE

Week Starting	Topic(s)	Readings	Assignment
August 31	Introduction; Probability theory review	Barber Ch. 1, 8 and 13	
September 7	Linear algebra review; Basic graph concepts; Belief networks	Notes and Barber Ch. 2 and 3	
September 14	Bayesian decision theory; Maximum Likelihood Estimation; Bayesian methods	Barber Ch. 8 and 13 and notes	Homework 1, due 9/24
September 21	Naïve Bayes; Non-parametric techniques	Barber Ch. 10 and 14	
September 28	Principal Component Analysis; Eigenfaces	Barber Ch. 15	Homework 2, due 10/8
October 5	Fisher's Linear Discriminant; Linear and Logistic regression	Barber Ch. 16 and 17	
October 12	Perceptron; Support Vector Machines	Barber Ch. 17 and notes	
October 19	**Midterm Exam**		
October 26	Bagging and Random Forests	HTF Ch. 8, 9 and 15 and notes	Project proposal presentations Homework 3, due 11/5
November 2	Boosting	HTF Ch. 10	
November 9	Unsupervised learning; Expectation Maximization	HTF Ch. 14 and Barber Ch. 11	
November 16	Hidden Markov Models	Barber Ch. 23 and notes	Homework 4, due 12/3
November 30	Deep Learning	Notes	
December 7	**Project Presentations**		
December 14	**Final Exam**		