CS559: Machine Learning: Fundamentals and Applications
Summer 2021

Instructor: In Suk Jang, Ph.D.
Course Web Address: https://sit.instructure.com/courses/50137
Course Schedule: Online [Lecture Recording Thursday Evening]
Contact Info: ijang@stevens.edu
Virtual Office Hours: Friday 10-11 AM or by Appointment
Virtual Office Hour URL: https://stevens.zoom.us/j/94917992354

Prerequisite(s): Math 222: Probability Theory
Corequisite(s): Math 222: Probability Theory
Cross-listed with:

COURSE DESCRIPTION

In this course we will talk about the foundational principles that drive machine learning applications and practice implementing machine learning algorithms. Specific topics include: maximum likelihood estimation, dimension reduction, supervised learning, unsupervised learning, neural networks, and non-parametric methods. The main goal of the course is to equip you with the tools to tackle new ML problems you might encounter in life.

STUDENT LEARNING OUTCOMES

This course is designed to familiarize the students with some basic learning algorithms and techniques and their applications, as well as general questions related to analyzing and handling data sets. Several software libraries and data sets publicly available will be used to illustrate the application of these algorithms. The emphasis will be thus on machine learning algorithms and applications, with some broad explanation of the underlying principles. The lectures will cover the current and emerging topics in machine learning:

- Maximum Likelihood Estimator
- Linear Regression and Linear Discriminant Analysis
- Logistic Regression, Dimension Reduction
- Perceptron Learning and Support Vector Machines
- Decision Trees and Boosting
- Neural Networks and backpropagation
- Clustering: K-means and Mixture of Gaussians
- Non parametric methods such as K nearest neighbors

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

    1. Decision Theory - Explain Bayesian decision theory, the likelihood ratio, and minimum risk classification.

    2. Maximum Likelihood Estimation - Implement Maximum Likelihood Estimation for Logistic Regression.

    3. Dimensionality Reduction - Apply dimensionality reduction using Principal Component Analysis.

    4 Linear Discriminant Functions - Implement classifiers using linear discriminant functions and Fisher's Linear Discriminant Analysis.

    5. Non-parametric Learning - Implement k-nearest neighbors, and perform non-parametric classification.

    6. Clustering – Implement k-means clustering, and perform EM for Gaussian mixtures.

    7. Support Vector Machines - Explain the advantages of Support Vector Machines and margin maximization.

    8. Boosting - Explain boosting and decision tree models.

    9. Neural Networks – Implement backpropagation for basic neural networks, and understand the concepts of deep neural networks.

COURSE FORMAT AND STRUCTURE

This course is fully online. To access the course, please visit stevens.edu/canvas . For more information about course access or support, contact the Technology Resource and Assistance Center (TRAC) by calling 201-216-5500.

Lecture Recording Session

The lecture will be recorded and posted **every Thursday night**. The class's general structure is the review and comments from the previous lecture for 15 minutes, lecture for about 90 minutes or less, and demonstration on the Jupyter notebook for 30 minutes or less. The lecture will focus on theory and algorithms than the code. The video will be available on Thursday before midnight or Friday morning, depending on the compiling time.

Course Logistics

All course materials such as lecture slides and assignments will be available on Canvas. Any course announcements or changes (e.g., assignment extensions, etc.) will be made via Canvas as well. Students are encouraged to have a daily notification set up.

Instructor's Online Hours

I will be available via email and will respond as soon as I am available (generally within 24-48) hours. For the online discussions, I will check in at least three times per week. Keep in mind that it is not possible for me to respond to every single posting every week (nor is it pedagogically appropriate), but I will be sure to respond to a variety of postings and students each week and attempt to assure equality in terms of responses to students. Furthermore, there is a specific discussion forum that you can use to ensure that you have my attention – to ask questions or to call my attention to a particular discussion you are engaged in that you would like me to take a look at. If you feel you are being neglected in any way, please contact me. When emailing me, please place in the subject line the course number/section and the topic of the email (i.e. XXX 240 – Assignment 2 Question). This will help me tremendously in locating your emails quicker when I scan the hundreds of emails that seem to make it into my box each day.

Virtual Office Hours

Online Etiquette Guidelines

Your instructor and fellow students wish to foster a safe online learning environment. All opinions and experiences, no matter how different or controversial they may be perceived, must be respected in the tolerant spirit of academic discourse. You are encouraged to comment, question, or critique an idea but you are not to attack an individual. Our differences, some of which are outlined in the University's inclusion statement below, will add richness to this learning experience. Please consider that sarcasm and humor can be misconstrued in online interactions and generate unintended disruptions. Working as a community of learners, we can build a polite and respectful course ambience. Please read the Netiquette rules for this course:

- Do not dominate any discussion. Give other students the opportunity to join in the discussion.
- Do not use offensive language. Present ideas appropriately.
- Be cautious in using Internet language. For example, do not capitalize all letters since this suggests shouting.
- Avoid using vernacular and/or slang language. This could possibly lead to misinterpretation.
- Keep an "open-mind" and be willing to express even your minority opinion.
- Think and edit before you push the "Send" button.
- Do not hesitate to ask for feedback.

TENTATIVE COURSE SCHEDULE

Week	Date Monday	Topics	Reading	Assignment Due
0	Aug. 23	Week 0: Orientation		
1	Aug. 30	Probability and Linear Algebra Review	GBC Ch2-3	
2	Sept. 6	Overview of ML Exploratory Data Analysis & Feature Engineering	Lecture Note	HW 1 open
3	Sept. 13	Unsupervised Learning	Bishop Ch9 GBC pg 142	Quiz 1 open Project 1 open
4	Sept. 20	Linear Regression	HTF Ch3 GBC Ch3	HW 2 open Quiz 2 open

5	Oct. 4	Linear Classifiers	Bishop Ch4 Lecture Note	
6	Oct. 11	Gaussian Process & SVM	Bishop Ch6,7	HW 2 Due Quiz 3 open Project 1 Due
7	Oct. 18	**Midterm Exam**		
8	Oct. 25	Decision Trees		Quiz 4 Open HW 3 open
9	Nov. 1	Ensemble Models I	Lecture Note Bishop Ch14	Project 2 Open
10	Nov.8	Ensemble Models II & Graphical Models	Lecture Note Bishop Ch8	Quiz 5 Open
11	Nov. 15	Neural Network & CNN		Quiz 6 Open Project 2 Due Final Project Open
12	Nov. 22	Thanksgiving Break		
13	Nov. 29	Times Series & Natural Language		Quiz 7 Open Project 2 Due
14	Dec. 6	Review		
15	Dec. 13	Final Project		Due

COURSE MATERIALS

1. Bishop, Christopher M., 2006. Pattern Recognition and Machine Learning. Springer-Verlag New York, Inc. A comprehensive reference for bayesian theory that we will cover.
2. Ian Goodfellow and Yoshua Bengio and Aaron Courville, 2016. Deep Learning, MIT Press. We will cover topics including basic neural networks, back propagation, and CNN.
3. Hastie, Trevor and Tibshirani, Robert and Friedman, Jerome, 2008. The Elements of Statistical Learning. Second Edition, Springer New York Inc.
4. **The main lecture will be following Bishop**. However, students are not required to purchase the book.

COURSE REQUIREMENTS

Quiz (10%): We will have a short online quiz, about 10 to 15 minutes long, for each topic. There are a total of 8 quizzes. Each quiz will be available for a week. The topic will come from the lecture and questions will be conceptual.

Homework (15%): There will be a total of three bi-weekly assignments. Each assignment is centered around an application and will also deepen your understanding of the theoretical concepts. Every homework will be available from Friday at 12 AM for two weeks and must be submitted in two weeks.

Project 1 (25%): The first project focuses on data pre-processing practices and applications of some supervised learning techniques.

Project 2 (25%): The second project focuses on data applications of some supervised learning and deep learning techniques.

Midterm Exam (10%): The midterm exam is to evaluate your understanding of the course up to SVM.

Final Exams (15%): The final exam is to evaluate your understanding of the whole course.

GRADING PROCEDURES

- Exceed expectations: This is representative of the quality of work we would expect to see from a ML professional within an organization. You demonstrate an expert ability to assess an organization and communicate your ideas for the application of different methods of analytics to solve business problems. Your analysis is thorough and well-written. Assignments in this category usually are A-range.
- Meets expectations: We can clearly understand your analysis. You are able to communicate ideas with gaps minor enough that we can figure out what it is you wanted to say. Your arguments and calculations are consistent. Assignments in this category usually are B-range.
- Nearly meets expectations: We understand, but we may need to follow up with a few questions about the details. There are some significant gaps in responding to the assessment criteria. Some of your explanations may not be articulated clearly or there may be some confusion in your assessment of an organization or communication of your ideas for the application of different

methods of analytics to solve business problems. Assignments in this category usually are C-range.
- Does not meet expectations: It is clear you do not understand the concepts being described in this course. Multiple frames have not been addressed or are addressed insufficiently. Your descriptions and analysis are not written clearly. Assignments in this category usually are D-range.
- No credit: No credit was earned for this assignment or no work was submitted. Assignments in this category usually are F-range.

Grades will be based on:

Quiz	10%
Homework	15%
Project 1	25%
Project 2	25%
Midterm	10%
Final Exam	15%

Late Policy

No credit is granted to any written assignment submitted after the due date. Late assignments must receive prior permission from me, and a penalty will be assessed. All written assignments must be submitted to the course website; email submissions or re-submissions are not accepted.

Academic Integrity

This is a graduate-level course. All students, regardless of the status (full-time or part-time) or rank (graduate or undergraduate), will have an equal amount of work and will be equally evaluated.

Undergraduate Honor System
Enrollment into the undergraduate class of Stevens Institute of Technology signifies a student's commitment to the Honor System. Accordingly, the provisions of the Stevens Honor System apply to all undergraduate students in coursework and Honor Board proceedings. It is the responsibility of each student to become acquainted with and to uphold the ideals set forth in the Honor System Constitution. More information about the Honor System including the constitution, bylaws, investigative procedures, and the penalty matrix can be found online at http://web.stevens.edu/honor/

The following pledge shall be written in full and signed by every student on all submitted work (including, but not limited to, homework, projects, lab reports, code, quizzes and exams) that is assigned by the course instructor. No work shall be graded unless the pledge is written in full and signed.

"I pledge my honor that I have abided by the Stevens Honor System."

Reporting Honor System Violations
Students who believe a violation of the Honor System has been committed should report it within ten business days of the suspected violation. Students have the option to remain anonymous and can report violations online at www.stevens.edu/honor.

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 to 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.

LEARNING ACCOMODATIONS

Stevens Institute of Technology is dedicated to providing appropriate accommodations to students with documented disabilities. The Office of Disability Services (ODS) works with undergraduate and graduate students with learning disabilities, attention deficit-hyperactivity disorders, physical disabilities, sensory impairments, psychiatric disorders, and other such disabilities 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 the ODS staff. The ODS staff will facilitate the provision of accommodations on a case-by-case basis.

For more information about Disability Services and the process to receive accommodations, visit https://www.stevens.edu/office-disability-services. If you have any questions please contact: Phillip Gehman, the Director of Disability Services Coordinator at Stevens Institute of Technology at pgehman@stevens.edu or by phone 201-216-3748.

Disability Services Confidentiality Policy

Student Disability Files are kept separate from academic files and are stored in a secure location within the Office of 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.

INCLUSIVITY

Name and Pronoun Usage

As this course includes group work and class discussion, it is vitally important for us to create an educational environment of inclusion and mutual respect. This includes the ability for all students to have their chosen gender pronoun(s) and chosen name affirmed. If the class roster does not align with your name and/or pronouns, please inform the instructor of the necessary changes.

Inclusion Statement

Stevens Institute of Technology believes that diversity and inclusiveness are essential to excellence in academic discourse and innovation. In this class, the perspective of people of all races, ethnicities, gender expressions and gender identities, religions, sexual orientations, disabilities, socioeconomic backgrounds, and nationalities will be respected and viewed as a resource and benefit throughout the semester. Suggestions to further diversify class materials and assignments are encouraged. If any course meetings conflict with your religious events, please do not hesitate to reach out to your instructor to make alternative arrangements.

You are expected to treat your instructor and all other participants in the course with courtesy and respect. Disrespectful conduct and harassing statements will not be tolerated and may result in disciplinary actions.

MENTAL HEALTH RESOURCES

Part of being successful in the classroom involves a focus on your whole self, including your mental health. While you are at Stevens, there are many resources to promote and support mental health. The Office of Counseling and Psychological Services (CAPS) offers free and confidential services to all enrolled students who are struggling to cope with personal issues (e.g., difficulty adjusting to college or trouble managing stress) or psychological difficulties (e.g., anxiety and depression) and who can visit the office in person. CAPS is open from 9:00 am – 5:00 pm Mondays, Wednesdays, Thursdays and Fridays and from 9:00 am – 7:00 pm on Tuesdays during the Fall and Spring semesters; appointments are highly encouraged. For those students who cannot visit the Stevens campus for an in-person appointment, you can contact a local mental health care provider for an in-person appointment, or if you are enrolled in the Stevens Student Health Insurance, you may call Care Connect for 24/7 mental health support at 1-888-857-5462.

EMERGENCY INFORMATION

In the event of an urgent or emergent concern about the safety of yourself or someone else in the Stevens community, please immediately call the Stevens Campus Police at 201-216-5105 or on their emergency line at 201-216-3911. These phone lines are staffed 24/7, year round. For students who do not reside near the campus and require emergency support, please contact your local emergency response providers at 911 or via your local police precinct. Other 24/7 national resources for students dealing with mental health crises include the National Suicide Prevention Lifeline (1-800-273-8255) and the Crisis Text Line (text "Home" to 741-741). If you are concerned about the wellbeing of another Stevens student, and the matter is *not* urgent or time sensitive, please email the CARE Team at care@stevens.edu. A member of the CARE Team will respond to your concern as soon as possible.