CS559: Machine Learning: Fundamentals and Applications
Spring 2023

Instructor: In Suk Jang, Ph.D.
Course Web Address: https://sit.instructure.com/courses/63256
Course Schedule: Online Live Monday 8 to 10 PM (Records available on Tuesday morning)
Lecture Zoom Link: https://stevens.zoom.us/j/96661300340
Contact Info: ijang@stevens.edu
Virtual Office Hours: Wednesday 10-11 AM or by appointment
Virtual Office Hour URL: https://stevens.zoom.us/j/5516841287

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 Monday night** from 8 to 10 PM and students are more than welcome to join. The class's general structure is the review and comments from the previous lecture for 15 minutes, a lecture for about 90 minutes or less, and a 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 Monday night or Tuesday 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. Students are encouraged to have a daily notification set up.

Office Hours

I will be available via email and 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 ensure 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.

- The office hour will be on Wednesday from 10 to 11 AM. This is a regular office hour using the link provided above. Making an appointment is always possible except on Monday and Tuesday.

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.

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, 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

1. **Quizzes (10%):** There will have a total of 10 short online quizzes, about 10 to 15 minutes long, for each topic starting from Week 1. Each quiz will be available in Canvas for six days, from Tuesday at 12 AM until Monday at 11:59 PM. The topic will come from the lecture, and questions will be conceptual.
2. **Assignments (20%):** There will be five assignments. Each assignment is centered around an application and will deepen your understanding of the theoretical concepts. Every homework will be available from Tuesday at 12 AM for two weeks and must be submitted in two weeks. Due dates will be specified otherwise.
3. **Projects (40%):** There will be two projects. Each project will be 20% of the semester's grade. Each project will be a three-week project, and the due date will be specified.
4. **Final Project (30%):** There will be a final group project, and the topic of the project will be announced during the semester.

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.

TENTATIVE COURSE SCHEDULE

Week Number	Monday Date	Topics	Reading (Bishop)	Assignments/Quizzes
0	1/9	Orientation		
	1/16	**Martin Luther King Jr. Day** **Semester Begins on 1/18**		
1	1/23	Machine Learning Overview	Lecture Note	Quiz1, HW1
2	1/30	Mathematics Review	Ch 1 & 2	Quiz 2
3	2/6	Linear Regression	Ch 3	Quiz 3, HW 2
4	2/13	Linear Classifiers	Ch 4	Quiz 4
5	2/20	Neural Networks (NNs)	Ch 5	Quiz 5, Project 1
6	2/27	Kernel Methods	Ch 6	Quiz 6
7	3/6	**Project Week (Project 1 Due on 3/12)**		
8	3/13	**Spring Recess (3/12 – 3/19)**		
9	3/20	Support Kernel Machine	Ch 7	Quiz 7, HW 3, Project 2
10	3/27	Graphical Models	Ch 8	Quiz 8,
11	4/3	**Project Week (Project 2 Due on 4/9, Final Project Open)**		
12	4/10	Mixture Models and EM	Ch 9	Quiz 9, HW 4
13	4/17	Continuous Latent Variables	Ch 12	Quiz 10
14	4/24	Combining Models	Ch 14	HW5
15	5/1	Deep Learning	Lecture Note	
16	5/8	**Final Project Week**		

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 ACCOMMODATIONS

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.