CS512: Machine Learning

Syllabus, Fall 2022

Machine Learning is centered on automated methods that improve their own performance through learning patterns in data. In many data-rich domains, machine learning provides cost-effective solutions in business (image processing, speech recognition, recommendation and information retrieval systems) and in science (folding of protein structure, annotation of the genome, predicting disease biomarkers, etc.). In this graduate-level class, students will get an introduction to the methodologies, technologies, and algorithms for machine learning. Topics include supervised learning, unsupervised learning, evaluating performance and model selection, a basic introduction to deep learning and reinforcement learning. The course will also discuss recent applications of machine learning. Programming and analytical assignments include hands-on practice with various learning algorithms, and a larger course project will give students an opportunity to work on a problem of their interest. Students entering the class are expected to have a pre-existing working knowledge of probability, statistics, linear algebra, programming, and algorithms.

Schedule

Tue 11:40 – 13:30	FASS G018
Wed 14:40 - 15:30	FENS G035

Contact Information

Instructors:	Oznur Tastan, `otastan@sabanciuniv.edu`
Office Hours:	Oznur Tastan, by appointment via e-mail and online.
TA:	Ali Enver Bilecen
`bilecen@sabanciuniv.edu`	
Office Hours:	By appointment via e-mail.

Delivery format

We will have physical lectures. Your active participation is expected. There will be no recording.

Course Webpage

We will be using SuCourse. Please check regularly the SuCourse of the course for lecture notes, homework assignments, project information, discussions and announcements.

Textbook: No required textbooks. There will be **required readings, videos** posted on SuCourse.

Some reference textbooks:

- Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani. An Introduction to Statistical Learning: with Applications in R (online version available).
- Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 2011.
- Ethem Alpaydin, Introduction to Machine Learning, 2e. The MIT Press, 2010.
- Kevin P. Murphy, Machine Learning: a Probabilistic Perspective, The MIT Press, 2012.

- Tom Mitchell, Machine Learning, McGraw Hill, 1997.
- Introduction to Machine Learning with Python, Andreas C. Müller & Sarah Guido, 2016.
- Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques for Building Intelligent Systems, Aurélien Geron, 2017.

For further reading lists, please check here: `https://machinelearningmastery.com/machine-learning-books/`.

Tentative Topics

Introduction
Basic concepts
Probability and statistics review
Model selection and evaluation
Performance metrics
Handling imbalance

Supervised learning
Naive bayes classifier
Gausian naive bayes classifier
Perceptron
Logistic regression
Linear regression
Support vector machines
Kernels
Decision trees
Ensemble methods: Bagging, boosting
Neural networks
Basic introduction to deep learning

Unsupervised Learning
Clustering; k-means, spectral clustering, DBScan
Principal components analysis

Additional Topics (if time permits)
Active learning
Matrix factorization and collaborative filtering
Explainability and Interpretability

Grading

The final grades will be based on the following:

- Two midterms, 20 % each.
- Three or four homework assignments, including programming (40%).
- One term project topic of your choice, deliverables include project proposal, progress and final reports and two presentations (progress and final) (20%).
- One make-up examination, covering the whole course material, will be given after the second midterm. You can take a make-up only if you have a valid health report approved by the

University Health Services.

IMPORTANT: One of the following conditions will result with an automatic NA (Not attended) regardless of other grades:

1. Not submitting more than one assignment (empty homework do not count as a submission)
2. Average of the homework grade is below 30.
3. Not submitting a project report.
4. Being absent in a project presentation without a medical report.
5. Missing an exam without a medical report.

*** Not falling in one of the conditions does not guarantee passing the course, if your overall performance is poor, you will fail the course.

Homework submissions: You may program in any programming language of your choice. We recommend using Python as there are many useful libraries available. Your answers to a homework assignment, including plots and mathematical work, should be submitted as a single PDF file. Please follow the submission formats carefully, this course is understuffed in terms of TAs. Your cooperation is expected.

It is recommended that you use software that typesets mathematics (e.g. LATEX). . However, if you need to you, you may scan your handwritten answers, convert to a PDF and submit. It should be legible. Whenever you need to include source code in your LATEX document, you may find the minted package convenient.

Late day policy (IMPORTANT: Each student will have 4 free late days to use for homework assignments. 4 days is the total number of late days not for each homework. Late days can only be used on the homework, and not on the project deliverables. You do not need to explain why you are submitting late and no need to notify us. <= 24 hours late counts as 1 day late, etc. Once these total of four late days are exhausted, any assignments turned in late will be penalized and will incur a reduction of 33% in the final score, for each day (or **part thereof**) it is late. For example, if an assignment is up to < 24 hours late, it incurs a penalty of 33%. Else if it is up to more than 24 hours and less than 48 hours late, it incurs a penalty of 66%. And if it is 72 or more hours late, it will receive no credit.

Regrade policy: Important: You may object a grade only within 14 days after the grades are announced. If you feel that an error was made in grading your homework or midterm, please get an appointment to discuss.

Honor code: Students are expected to comply with Sabanci University Academic Integrity Statement. Any form of academic dishonesty will be penalized with a failing grade and disciplinary actions will be taken. Students may discuss and work on homework problems in groups in an abstract way. However, each student must write down the solutions independently, and without referring to written notes from the joint session. In other words, each student must understand the solution well enough in order to reconstruct it by him/herself. In addition, each student must write on the problem set the names of the people with whom s/he collaborated or discussed.

Project

The purpose of the project is to increase your knowledge about machine learning and get hands on practical experience. Any project in the machine learning field that is feasible to accomplish in the given time can be proposed. You will work groups of three people. The project can involve applying known methods to solve an interesting question, or it can also involve coming up with a new methodology to solve an existing problem on an existing data set.

You are responsible of proposing the data and the algorithm. The deliverables are (i) a proposal write up, presentation, (ii) a progress report and presentation (iii) and final report and presentation. The grade for the project will include a peer grade.

Proposal Write Up: Maximum one page (single spaced) proposal write up. Identify the data set or data sets that you will be using. You should give a clear description of the characteristics of the data (how many examples, what kinds of features do we have for each example, are there issues with missing data or bad data, etc.). How will you evaluate performance? In certain settings, you may want to try a few different performance measures. Identify a few "baseline algorithms". These are simple algorithms for solving the problem, such as always predicting the majority class for a classification problem, using a small set of decision rules designed by hand, or using a ridge regression model on a basic feature set. Ideally, you will be able to report the performance of a couple baseline algorithms in your proposal. The goal will be to beat the baseline, so if the baseline is already quite high, you will have a challenge. What methods do you plan to try to solve your problem, along with a rough timeline. Methods include data preprocessing, feature generation, and the ML models you'll be trying. Once you start your investigation, it's best to use an iterative approach, where the method you choose next is based on an understanding of the results of the previous step.

It should contain the following information: (1) project title, (2) team mates, (3) a high-level description of the problem you are trying to solve (4) The data sets you will be using. You should give description of the characteristics of the data (how many examples, what kinds of features do we have for each example, are there issues with missing data or bad data, etc.)(5) what you plan to achieve by the milestone.

Progress Report: The progress stage will significantly affect the final grade of the project. You are expected to have results by the progress date. At least three pages (single spaced). Include: (1) a high quality introduction and background information, (2) a clear description of the datasets you have used (3) methods you have used, data preprocessing, feature generation, and the ML models you have tried (4) the next steps, along with a rough timeline and (5) a clear description of the division of work among teammates.

Progress Presentation: There will be a 8 + 2 minute in class progress presentations on the work done so far.

Final Project Presentation: There will be a 8 + 5 minute in class final project presentation. Be prepared to answer questions not only what you have done but also on the details of the techniques.

Final Report: A final write-up of the project. You should submit a PDF file electronically. It should have the following format:

- Introduction: A quick summary of the problem, methods and results.

- Problem description: Detailed description of the problem. What question are you trying to address?
- Methods: Description of methods and datasets used.
- Results: The results of applying the methods to the data set. Include the list of questions your experiments are designed to answer. Details of the experiments; observations.
- Discussion: Interpretation and discussion of the results.
- Conclusions: What is the answer to the question? What did you learn about the methods? Mention any future directions of interest.
- Appendix: A clear description of the contribution of each person. You may also include extra material (results, methods details) if needed in the appendix.

Peer Grade: When submitting the final project report, you are required to email your peer grades for each of your teammates. The peer grades will be 0 to 5. 5 being the highest grade. If you do not email, yourself will receive peer grade 0.

Disclaimer

- This syllabus and course details might need to be updated throughout the semester because of the uncertainties of pandemic brings. Any modification will be announced at SUCourse and also during the class. Students are responsible from following the announcements.
- Each of us is responsible for creating a safe and inclusive classroom experience for everyone in the class.
- I have two unvaccinated kids at home, I would appreciate if you could mask up especially when you are sick.