College of Engineering
UNIVERSITY OF WISCONSIN-MADISON

Syllabus

CS/ECE/ME 532 – Matrix Methods in Machine Learning
LEC002 Spring 2023
Number of credit hours: 3cr

Course Information

Canvas Course URL: https://canvas.wisc.edu/courses/332855

Course Designations and Attributes:
Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement

Meeting Time and Location: 11:00AM-12:15PM in 311 Wendt Commons

Instructional Modality: In-person

How Credit Hours are met by the Course: The credit standard for this course is met by an expectation of a minimum of 135 hours of student engagement with the course learning activities (at least 45 hours per credit), which include time in lectures or class meetings, in person or online, labs, exams, presentations, tutorials, reading, writing, studying, preparation for any of these activities, and any other learning activities.

Staff and Office Hours

Name	Office Hours	Email
Pedro Morgado, Instructor	Wed, 2PM – 3PM @ ECB M1059	pmorgado@wisc.edu
Huanran Li, TA	Mo/Fr, 12PM – 2PM @ EH3622	hli488@wisc.edu

Additional office hours are available by appointment.

Official Course Description

Course Description

Linear algebraic foundations of machine learning featuring real-world applications of matrix methods from classification and clustering to denoising and data analysis. Mathematical topics include: linear equations, regression, regularization, the singular value decomposition, and iterative algorithms. Machine learning topics include: the lasso, support vector machines, kernel methods, clustering, dictionary learning, neural networks, and deep learning. Previous exposure to numerical computing (e.g. Matlab, Python, Julia, R) required.

Requisites

(MATH 234, 320, 340, 341 or 375) and (E C E 203, COMP SCI 200, 220, 300, 301, 302, 310, or 320), or graduate/professional standing, or declared in Capstone Certificate in Computer Sciences for Professionals

Course Environment & Logistics

This course has synchronous meetings on Tuesday and Thursday during the scheduled course period, and asynchronous discussion forums to facilitate communication, learning, and collaboration during the course. Regular and active student engagement is required throughout the course.

The course is taught using an active learning style. The active learning will take place as multiple layers. Very low stakes quizzes on the video lectures will contribute to your understanding of the concepts. Next, lightly-graded activities will be the focus of each class meeting and increase your mastery. Instructors, TA and peers will be available to help you overcome initial obstacles or misconceptions as you apply the material. You will reach the highest level of mastery on graded assignments.

Course Learning Outcomes

At the completion of this course, students will be able to:

1. Derive features from a data set using either intuition or standard feature sets.
2. Take a new sample and to classify the sample into one of a number of possible classes.
3. Appreciate the difference between supervised and unsupervised learning.
4. Implement classification systems in software and to assess the efficacy of their implementations.
5. Use matrices and vectors to represent data and functions
6. Set up, solve, and interpret the solution to systems of linear equations
7. Apply the singular value decomposition to solve a variety of machine learning problems
8. Apply ℓ_1, ℓ_2, and truncated singular value decomposition to regularize least squares problems
9. Derive and apply gradient descent-based techniques for solving a variety of machine learning problems
10. Demonstrate application of supervised learning techniques
11. Demonstrate application of unsupervised learning techniques

Key Topics to be Covered

- Machine learning and example problems
- Supervised and unsupervised learning
- Vectors, matrices, inner and outer products
- Orthogonality of vectors
- Inner products for representing polynomial and multi-dimensional functions
- Write classifier learning problem as a system of linear equations in matrix-vector form
- Conditions for exact solutions of systems of linear equations and rank of matrices
- Approximate solutions of systems of linear equations
- Cross validation for classification performance evaluation
- Tikhonov regularization
- Low-rank decomposition of matrices
- Applications of low-rank matrix decompositions
- Gram-Schmidt orthogonalization
- Singular Value Decomposition: finding the "best" subspace
- Principal Component Analysis (PCA) and best subspace approximation
- Page Rank algorithm
- Power iterations
- Matrix Completion
- Truncated SVD regularization
- Gradient descent
- Proximal gradient for regularized problems
- Stochastic gradient descent

- LASSO regularization
- Hinge Loss
- Neural networks and the backpropagation algorithm
- Kernel regression and the kernel trick
- Support vector machines

Required Textbook, Software & Other Course Materials

The course is organized and content is delivered through the course canvas page, which is available to enrolled students at https://canvas.wisc.edu/.

While there is no required textbook, the book Lars Elden, Matrix Methods in Data Mining and Pattern Recognition is recommended as supplemental material.

Software

Students are required to use Python for programming activities, and most will find it helpful to use Jupyter notebooks for an interactive Python environment. There are three primary options for using Jupyter notebooks – (1) installing Python/Jupyter locally on your machine, or (2) using online Python notebook environments services such as Google Colabs.

Course Engagement

Course engagement happens during the course meeting times and outside the meeting times through the course components.

Video lectures are assigned prior to each class meeting, and a corresponding quiz must be completed by 11:59 PM the day before class. The activities for the class meeting will be available at the start of class, and your work must be submitted by 11:59 PM. These activities should take less than 75 minutes to complete provided you have appropriate background, come to class prepared, and work on them with your peers during the live class meeting.

Assignments are to be completed outside of class meeting time. Please start looking them over early so that you have plenty of time to ask questions. You are welcome to ask assignment related questions during class meetings and office hours.

Class Meetings

This course has regularly scheduled meetings on Tuesday and Thursday from 11:00 AM – 12:15 PM in 324 Wendt Commons.

The class meetings are *active learning*, where you will work through activities in real-time, ask questions, get feedback, and engage with peers and faculty. You will work in small groups and are expected to participate in solving problems with your peers. Take this opportunity to meet some new people!

During online interactions (e.g., office hours), please share your video feed. Seeing your face is critical to teaching you effectively.

Regular and Substantive Student-Instructor Interaction

The instructor and students will interact every Tuesday and Thursday during the scheduled class time. The instructor will provide feedback on student work (flipped format) and will facilitate discussion of course content.

Piazza

We will use Piazza for class discussion and Q&A. To access Piazza, click on Piazza in the left navigation menu in Canvas. Piazza is designed to provide input fast and efficiently from classmates, the TAs, and the instructors. Rather than emailing questions to the teaching staff, please post your questions on Piazza. For additional Piazza questions, please see Piazza Support.

Course Components and Grading

The course consists of graded components. The components and their relative weighting for the final grade are show in the table below.

Component	Number of Assignments	Low-score drop policy	Percent of Final Grade	Due
Video Quizzes	40	Lowest 6	15	11:59 PM day before class
Classroom Activities	24	Lowest 3	25	1:00 PM day of class
Assignments	10	Lowest 1	30	11:59 PM one week after assigned
Unit Tests	5	None	30	In-class

Details for the components are provided below.

1. Video Lectures and Quizzes

Video lectures are the primary source of content delivery for the course. Video lectures are typically 10-15 minutes each, and there are 1-5 video lectures assigned per week. Videos lectures are followed by a short quiz. Video Lecture Quizzes contain around five questions and are not timed.

2. Classroom Activities

Activities are completed in small groups during the scheduled course time. The activities should take less than 75 minutes to complete provided you are prepared for the class, for the content, and are engaged during the class period. Activities must be scanned/saved as PDF and uploaded through Canvas. Learn more about how to use phone apps to scan to pdf.

3. Assignments

There are nine assignments. Assignments go deeper and are more involved than activities. Assignments must be scanned/saved as PDF and uploaded through Canvas. Learn more about how to use phone apps to scan to pdf.

4. Unit Tests

There will be five unit tests covering the six units. The unit tests will be timed and take place during the class meeting time. You are not permitted to consult with anyone other than the instructional staff.

Course Grading Scale

Assignment of letter grades is based on the following percentages. We reserve the right to curve the grade in exceptional circumstances, but only in a way that will improve the grade earned. Letter grades are assigned according to:

Grade	A	AB	B	BC	C	D	F
Score	≥ 92	≥ 86	≥ 80	≥ 72	≥ 65	≥ 58	< 58

Late Submission

Due dates are hard deadlines and extensions are not granted, as solutions are released shortly after the submission deadline. Note that your lowest assignments, activities, and video lecture quizzes will be dropped as specified in the Course Components and Grading table.

- Due dates are hard deadlines and extensions are not granted
- Late submissions are allowed, but reduced by 50% provided the late work is submitted prior to the release of solutions
- Work submitted after the release of solutions will receive no credit

- The reduction for late work may not occur automatically, but will be applied periodically or at the end of the semester
- The late work policy does not take effect in the first two weeks of the course

Subject to Change Notice

All material, assignments, and deadlines are subject to change. It is the student's responsibility to be aware of all course timelines, announcements, and communications pertaining to changes in course assignments and due dates. The instructor will communicate any changes to students well in advance.

How to Succeed in This Course

In summary, to succeed in this course, students are recommended to

- Check your UW (wisc.edu) email daily
- Login to the course site daily
- Check the course Piazza site daily
- Actively participate in the class meetings
- Be prepared for every class meeting by completing the pre-class work
- Be proactive seeking answers to your questions
- Create a study schedule and stay current on assignments
- Connect with classmates both in and out of class meetings
- Work on assignments during office hours so you can seek immediate help
- Talk with your instructor immediately if you are struggling or an unexpected issue arises
- Review the following Netiquette Guidelines

Student Participation, Preparation Time, and Attendance

- It is critical that you devote enough time to this course. **You should plan on spending an average of 10-15 hours per week** on the various course components.
- Create a study schedule to stay on track, and plan to visit the course daily to keep up with reading the announcements, participating in the online discussions, completing the activities, etc.
- Successful Participation involves regularly engaging in course learning activities and assessments during the course. It may also involve both individual and collaborative components and will call upon you to develop and practice real world communication, leadership, and teamwork skills by interacting with fellow students, instructors, and other experts.
- Don't wait to ask questions. Ask your peers and instructors in class or office hours.

Communicating with the Instructor

The "Three before me" policy encourages students to check the following sources of information before contacting the instructor: course syllabus, course Announcements, and Piazza posts. This eliminates redundancy and expedites the process. You are encouraged to answer questions from other students when you know the answer, in order to provide timely assistance. If you have questions of a personal nature, relating to a personal emergency, an assignment grade, or other private matter, you are welcome to contact your instructor via email. Please allow up to 24 hours for your instructor to respond.

Collaboration

You are encouraged to discuss activity and assignment problems with your classmates online or in person. However, the work you submit must be your own. This means you wrote all of the code you use and can explain or rederive all results you submit. The instructional staff is available to answer questions on activities and assignments.

Academic Integrity Statement

By virtue of enrollment, each student agrees to uphold the high academic standards of the University of Wisconsin-Madison; academic misconduct is behavior that negatively impacts the integrity of the institution. Cheating, fabrication, plagiarism, unauthorized collaboration, and helping others commit these previously listed acts are examples of misconduct which may result in disciplinary action. Examples of disciplinary action include, but is not limited to, failure on the assignment/course, written reprimand, disciplinary probation, suspension, or expulsion.

Common examples of academic misconduct include:

- Collaborating on or discussing a unit test with anyone other than the instructor
- Copying someone else's code – even with modifications
- Copying someone else's solution or text
- Submitting an assignment as your own work when a part or all of the assignment is the work of another person
- Submitting an assignment that contains ideas or research of others without appropriately identifying the sources of those ideas
- Posting course content on line, or submitting it to another party for posting online

Consequently:

1. Students may not submit their own previously submitted work from another without the permission of the course's principal instructor and with proper citation.
2. Students may not share their work with another student regardless of the forum or means, unless authorized by the principal instructor.
3. Asking a classmate for their advice on how to solve activities and assignments is acceptable. However, all work you submit must represent your own individual effort. This means that you did not copy (or copy with modifications) someone else's code, and that you can explain all answers you submit.
4. You are not allowed to discuss any content of unit tests with anyone other than the instructional staff.
5. It is the responsibility of the student to understand all the details of the syllabus and UW-Madison policies. Lack of understanding regarding how to properly cite, the presence of specific course policies, and University expectations, does not excuse behavior.

Links to Useful Resources

- University Health Services
- Undergraduate Academic Advising and Career Services
- Office of the Registrar
- Office of Student Financial Aid
- Dean of Student Office

Recommendation Letter Requests

Some of you will be applying for graduate school and need recommendation letters to support your application. With very few exceptions, we are unable to provide a recommendation based solely on our interaction in this class. A good recommendation letter - one that will help your application - needs to describe your characteristics and capabilities in detail. It is impossible to develop that level of knowledge based on interaction in a single, large enrollment course. It will be more helpful to your application to include a detailed letter from someone that knows you than to a brief, unspecific letter from the professor in your machine learning course. Depth of knowledge about you is far more important for your application than the expertise of the writer. Hence, we recommend you focus your requests for letters on individuals that have taught you in multiple classes or worked with you outside of the classroom.

Teaching & Learning Analytics & Proctoring Statement

The privacy and security of faculty, staff and students' personal information is a top priority for UW-Madison. The university carefully reviews and vets all campus-supported digital tools used to support teaching and learning, to help support success through learning analytics, and to enable proctoring capabilities. UW-Madison takes necessary steps to ensure that the providers of such tools prioritize proper handling of sensitive data in alignment with FERPA, industry standards and best practices.

Under the Family Educational Rights and Privacy Act (FERPA which protects the privacy of student education records), student consent is not required for the university to share with school officials those student education records necessary for carrying out those university functions in which they have legitimate educational interest. 34 CFR 99.31(a)(1)(i)(B). FERPA specifically allows universities to designate vendors such as digital tool providers as school officials, and accordingly to share with them personally identifiable information from student education records if they perform appropriate services for the university and are subject to all applicable requirements governing the use, disclosure and protection of student data.

Privacy of Student Records and the Usage of Audio Recorded Lectures

See information about privacy of student records and the usage of audio-recorded lectures.
Usage of Audio Recorded Lectures Statement: Lecture materials and recordings for ECE/CS/ME 532 are protected intellectual property at UW-Madison. Students in this course may use the materials and recordings for their personal use related to participation in this class. Students may also take notes solely for their personal use. If a lecture is not already recorded, you are not authorized to record our lectures without our permission unless you are considered by the university to be a qualified student with a disability requiring accommodation. [Regent Policy Document 4-1] Students may not copy or have lecture materials and recordings outside of class, including posting on internet sites or selling to commercial entities. Students are also prohibited from providing or selling their personal notes to anyone else or being paid for taking notes by any person or commercial firm without the instructors' express written permission. Unauthorized use of these copyrighted lecture materials and recordings constitutes copyright infringement and may be addressed under the university's policies, UWS Chapters 14 and 17, governing student academic and non-academic misconduct.

Students' Rules, Rights & Responsibilities

See: https://guide.wisc.edu/undergraduate/#rulesrightsandresponsibilitiestext

Course Evaluations: Digital Course Evaluation (AEFIS)

UW-Madison now uses an online course evaluation survey tool, AEFIS. In most instances, you will receive an official email two weeks prior to the end of the semester when your course evaluation is available. You will receive a link to log into the course evaluation with your NetID where you can complete the evaluation and submit it, anonymously. Your participation is an integral component of this course, and your feedback is important to us. We strongly encourage you to participate in the course evaluation.

Diversity & Inclusion Statement

Diversity is a source of strength, creativity, and innovation for UW-Madison. We value the contributions of each person and respect the profound ways their identity, culture, background, experience, status, abilities, and opinion enrich the university community. We commit ourselves to the pursuit of excellence in teaching, research, outreach, and diversity as inextricably linked goals. The University of Wisconsin-Madison fulfills its public mission by creating a welcoming and inclusive community for people from every background - people who as students, faculty, and staff serve Wisconsin and the world.

Accommodations for Students with Disabilities Statement

The University of Wisconsin-Madison supports the right of all enrolled students to a full and equal educational opportunity. The Americans with Disabilities Act (ADA), Wisconsin State Statute (36.12), and UW-Madison policy (Faculty Document 1071) require that students with disabilities be reasonably accommodated in instruction and campus life. Reasonable accommodations for students with disabilities is a shared faculty and student responsibility. Students are expected to inform the primary instructor of their need for instructional accommodations by the end of the third week of the semester, or as soon as possible after a disability has been incurred or recognized. We, will work either directly with the student or in coordination with the McBurney Center to identify and provide reasonable instructional accommodations. Disability information, including instructional accommodations as part of a student's educational record, is confidential and protected under FERPA. (See: McBurney Disability Resource Center)

Academic Calendar & Religious Observances

See: https://secfac.wisc.edu/academic-calendar/#religious-observances