COLLEGE OF ENGINEERING, UIC
CS 512: Advanced Machine Learning (CRN: 43593)
4 credit hours
Spring 2026

I. Instructor & Course Details

Prof. Xinhua Zhang

Email address: zhangx@uic.edu
Drop-In Office Hours (in-person only) 2-3 PM, Monday. Starting from week 2.
Drop-In Hours location: CDRLC 5442

TA: none

~~Email address:~~
~~Drop-In Office Hours:~~
~~Drop-In Hours location:~~

Blackboard Course Site (should be automatically linked to your Blackboard account)

Students are expected to log into the course site regularly to learn about any developments related to the course, upload assignments, and communicate with classmates. For all technical questions about Blackboard, email the Learning Technology Solutions team at LTS@uic.edu.

Course Modality

This course is taught **ON CAMPUS**.

- Time: Monday and Wednesday: 12:30-1:45 PM
- LOCATION: **CDRLC 2407**

II. Course Information

Catalog Course Description and Prerequisite/corequisite Statement

This course studies theoretical principles and analysis of systems that make sense of data, along with their applications in real-world problems. It covers structured data modeling, probabilistic inference for big data, deep learning and large-scale optimization.
Prerequisite: MATH 310/320, STAT 401, CS 251, CS 412; or consent of the instructor.

For graduate students, these prerequisites are only advisory. A self-evaluation quiz with solution is available on Piazza, along with some math background readings. Do it yourself and you do not need to submit it.

If you would like to audit, please send an email to the instructor.

Course materials and assignments can be complex and challenging, but they are crucial to your intellectual and personal growth and development. There are times when you may need extra help. Students who attend class consistently, complete all assignments, thoughtfully engage with feedback on work, develop good study strategies, visit the tutoring center, and contact faculty when struggling can develop a thorough understanding of the course material and ultimately succeed in the course!

Course Goals and Learning Outcomes

By the end of this course, you will be able to:

• Have an in-depth understanding of the principle and characteristics of advanced machine learning task settings (e.g., structured prediction, probabilistic inference, convex optimization, deep learning for complex data).

• Scale machine learning techniques to big datasets, by leveraging new structures in the data and new computational tools that emerge even after the completion of the course.

• Develop and analyze novel problem formulations and machine learning techniques that adapt to data analysis problems emerging in new applications.

This is an elective course.

Brief list of topics to be covered: see the schedule on Piazza

Required and Recommended Course Materials

Required Texts (only a few chapters from each book)

[**Jordan**] Michael I. Jordan. Graphical Models. Unpublished lecture notes (Ch 2, 3, 4, 9, 10, 11). PDF available on Piazza under the Resources tab -> Readings.

[**Murphy**] Kevin P. Murphy. Probabilistic Machine Learning: **Advanced Topics**. https://probml.github.io/pml-book/book2.html

[**GBC**] Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Deep Learning. MIT Press, 2016.

Free book at: http://www.deeplearningbook.org
Single PDF (slightly different from the online version) for download (65 MB): https://uofi.box.com/s/nv6idmcb5w9pyqay4966cxwdaaz547jy

[**BV**] Stephen Boyd and Lieven Vandenberghe. Convex Optimization. Cambridge University Press, 2004. PDF available at https://web.stanford.edu/~boyd/cvxbook

[**Bishop**] Christopher M. Bishop and Hugh Bishop. Deep Learning Foundations and Concepts, 2024. PDF available from https://link.springer.com/book/10.1007/978-3-031-45468-4 through UIC library.

References:

[Dive] Dive into deep learning. https://www.d2l.ai

[PyTorch] Deep Learning with PyTorch.
https://pytorch.org/assets/deep-learning/Deep-Learning-with-PyTorch.pdf

We will also use recent research papers and excerpts of relevant background material from available textbooks, and supplemental notes for specific topics.

Besides lecture notes, there will also be three tutorials. They are meant to help you understand the subject and work out the assignments. They are only for reference; nothing needs to be submitted for them.

You will need to use numpy a lot in the lab. Here is a numpy primer: Python Data Science Handbook, covering numpy, Pandas, Matplotlib. You should at least know that y = xMatrix[0] is a shallow copy, where xMatrix is a 2-D numpy array. Understand how to make a deep copy. The book provides many notebooks for learning. You can create your Jupyter notebook to run on Google Cloud, or locally on your own machine via VS Code and Anaconda (as opposed to directly downloading Python from the official site). Anaconda is the choice for data science.

Required Technology

Piazza	https://piazza.com/class/mk8tny0qvdb6nx You can register using your UIC netid with no need of instructor's approval.
Master Schedule	https://piazza.com/class/mk8tny0qvdb6nx/post/6 First register on Piazza as above. This schedule is pinned on top of the left list.
Blackboard	Announcement + assignment release + Echo 360 recording

Use of Online Tools (see the URLs in the above table)

What	Where	Who can access	
		Week 1 and 2	Week 3 and onwards
Slides and other documents	Piazza	Anyone[1]	Registered + Auditing
Technical discussion, Q&A	Piazza [2, 3]	Anyone	Registered + Auditing
Announcement Assignment questions + solutions	Blackboard [4]	Registered + Auditing	Registered + Auditing
Echo 360 of lecture recordings (**NO** streaming in real time)[5]	Blackboard	Registered + Auditing	Registered + Auditing
Office hour (not recorded)	**Zoom + In person**	Anyone	Anyone
Assignment submission + grading	Blackboard	N.A.	Registered only

for collaboration within groups (but not for instruction)		
Teams, Slack	Github, Bitbucket	Box.com, Onedrive, Google drive

1. Anyone refers to anyone with a UIC netid. Contact the instructor if you do not have it.
2. Piazza is highly catered to getting you help fast and efficiently from classmates and the instructing team (professor and TA, if applicable). Rather than emailing questions to the instructing team, you are encouraged to post on Piazza your **technical questions**, general questions about the course content, assignments, grading rubric, etc. If you have any problems or feedback for the Piazza developers, email team@piazza.com.
3. If you have any personal or **non-technical questions** such as medical considerations, please send an email directly to the instructor or the TA (if instructed to do so, e.g., dispute plagiarism suspect). Re-grading of assignments should be requested on Gradescope (not email).
4. For general announcements and notifications, I will send emails to the whole class via **Blackboard**. Please check your email frequently, especially around deadlines (assignment and project). The message will also be archived on Blackboard in the announcement section.
5. We strongly recommend attending the lectures in person. The online option is only for those who really cannot make it due to health reasons, etc.

It is your responsibility to check emails frequently (at least once a day).

Software and hardware

1. You can use any language for the course project, but most likely, you will use Python.
2. You may want to use VS Code or Google Collab, along with Github.
3. You will need to use collaborative tools for the course project, including
    a. Slack or Teams for messaging. UIC does not have a license for slack, but the free version might be sufficient.
    b. Github or Bitbucket for code maintenance (free with their education packs).
    c. Box, Onedrive, or Google drive for file sharing (all free from UIC).
4. Scanner on phone/pad: scan your answer, NOT just take a photo. Use a scanner app on your mobile device, e.g., CamScanner (https://www.camscanner.com/). Register using your UIC email address, and it will remove a watermark. Feel free to use similar apps.

Respect for Copyright

Please protect the copyright integrity of all course materials and content. Please do not upload course materials not created by you onto third-party websites or share content with anyone not enrolled in our course.

III. COURSE POLICIES & CLASSROOM EXPECTATIONS

Grading Policy and Point Breakdown (tentative if the class size is < 32)

The understanding of course material and synthesis of knowledge will be evaluated using

1. (20%) Assignment 1 (individual): it will be due around week 5. It is on the conceptual understanding of graphical models and inference. Partial grading will be used.
2. (25%) Lab 1: you will build a classifier which recognizes “words" from images. This is a great opportunity to pick up practical experiences that are crucial for successfully applying machine learning to real world problems, and evaluating their performance with comparison to other methods. In particular, you will implement probabilistic inference algorithms such as message passing, train a CRF model using off-the-shelf solvers, compare with max-margin methods, and test the performance under transformations. This lab will be in Python (numpy indeed), and we will provide utility code. Grading will be based on your results.
3. (20%) Assignment 2 (individual): this **written** assignment will be focused on generative models.
4. (35%) A course project. Groups will be formed to conduct a course project, and we aim to create at most 10 groups.

    The project can be on any area of machine learning, including those not covered in class. It will consist of original research. Since this course focuses on machine learning methodology

rather than pure application, the project is **not** meant to apply some existing learning algorithms to a new application problem. Instead, **it requires nontrivial novelty in the method itself, which targets publishable quality at ICML, NeurIPS, COLT, UAI, ICLR** conference, instead of ICCV, CVPR, ECCV, ACL, EMNLP, NAACL, KDD, WSDM, SIGIR, or WWW.

Course projects are to be conducted in groups of 1-3 students, and will be proposed and completed throughout the semester. You can find teammates by yourselves or by going to Piazza. A random grouping will be organized as the last resort. To find the email address (i.e., netid) by first and last name, try https://www.uic.edu/apps/find-people. The evaluation criteria are invariant to the group size.

The submitted work must be the student's (or the group's) own work. If working in a group, each member of the team will receive the same grade; the group is responsible for making a fair division of work between its members. It is important that you keep the final project in mind throughout the entire semester. Groups that form and research ideas for topics early will have more time to realize their goals (and an easier time, too) than a group that devises their topic on the night before the project proposal is due.

One or multiple members of each group will give a presentation for 10–15 minutes on the last week of class about your project (final duration depends on final class size), and submit a short 5–8 page writeup in NeurIPS format. Only initial results will be needed for oral presentation, and the detailed results can be submitted in the final report. The goal is to have the resulting writeup to be of sufficient quality and novelty to submit to a workshop or conference in machine learning.

Deadlines

- One-page project proposal: Feb 21 at 23:59.
- Two-page project status update: March 20 at 23:59.
- Project presentations will take place in class on April 27 and 29.
- Final report: May 11 at 5 PM. If the project works out especially well, the NeurIPS deadline will be just around the corner by the end of the course.

5. There will be no final or midterm exams.

Grading Policy. **All the evaluation components will be graded out of 100**, and their weighted average will be used to determine the final letter grade (A/B/…) based on threshold:

A: 85 ~ 100

B: 70 ~ 84.9

C: 55 ~ 69.9

F: 0 ~ 55.9

I reserve the right to **raise** your letter grade.

Policy for Missed or Late Work

1. **Late submission**s: Unless specified otherwise, all deadlines will be Chicago time. Late submissions will not be accepted in any case, unless there is a **documented** personal emergency. Arrangements must be made with the instructor as soon as possible after the emergency arises, preferably well before the homework due date.

   Advice: If for whatever reason you don't manage to finish an assignment, hand in what you have. Partial credit will be given.

2. **Statute of limitations**: No grading questions or complaints — no matter how justified — will be listened to **TWO** weeks after the grade in question has been released.

Attendance / Participation Policy

We strongly recommend you attend the lectures in person. In case this is occasionally difficult, we have enabled streaming on Echo 360. We will have random i-Clicker quizzes during the lecture, which allows remote participation. This is meant to promote engagement even if you cannot attend in person.

Please email me if you face an unexpected situation that may impede your participation in required exam sessions, or timely completion of assignments.

Other Course Policies

Academic Integrity

As a student and member of the UIC community, you are expected to adhere to the Community Standards of academic integrity, accountability, and respect. Please review the UIC Student Disciplinary Policy for additional information.

Academic dishonesty will not be tolerated. Please see the CS department policy below on the topic; this policy specifies penalties for violations. Academic misconduct will be handled according to UIC's Student Disciplinary Policy: http://dos.uic.edu/conductforstudents.shtml

What is academic dishonesty? To hand in any work which is not 100% the student's creation, unless you are explicitly allowed to do so. The CS Department will not tolerate cheating by its students. The MINIMUM penalty for any student found cheating will be to receive an F for the course and to have the event recorded in a department and/or College record. The maximum penalty will be expulsion from the University. Cheating includes, but not limited to, the following:

- Copying or any other form of getting or giving assistance from another student during any

test, quiz, exam, midterm, etc.
- Plagiarism–turning in writing that is copied from some other source.
- Obtaining solutions to homework by posting to the Internet for assistance, purchasing assistance, obtaining copies of solutions manuals for instructors, and obtaining copies of previous year's homework solutions.
- Computer programs: Any time you look at another student's code, it is cheating. (Exception: If you are EXPLICITLY told that you may do so by the instructor.)

All the work you submit must be your own; you should not use paraphrasing software like (QuillBot), or AI software for writing (like ChatGPT), or any AI tool for content generation (spell-checkers are allowed) – unless explicitly allowed to do so. If in doubt about a specific tool, ask.

Collaboration Policy

1. Written assignment: Discussion of homework assignments and solutions with other students is permitted. However, each student must submit his or her own write-up for the homework assignment and fully understand what he or she submits. Each student should be prepared to explain his or her homework assignment submissions to the instructor and teaching assistant if his or her "full understanding" is in doubt.

2. Course project: all members of each group should make nearly the same amount of contribution to each lab and project. All members should be responsible for the whole submission of the team, not only his/her own contributed part. You are supposed to understand the work of your teammates inside out and be able to answer questions when asked. If one member plagiarized, then **all members** of the team will receive the **same** penalty.

For computer programs, if we cannot determine which team copied from which, we may, at our discretion, give failing grades to both groups. It is the responsibility of all engineering and computer science professionals to safeguard their company's "trade secrets." An employee who allows trade secrets to be obtained by competitors will almost certainly be fired. So, YOU are responsible for making sure that your directories have permissions set so that only you can read your files, for being sure to log out at the end of working in the computer lab, etc.

Email Expectations

Students are responsible for all information instructors send to your UIC email and Blackboard accounts. Faculty messages should be regularly monitored and read in a timely fashion.

IV. COURSE SCHEDULE

See the tentative schedule below. An up-to-date schedule is available on Piazza (link available on the first page of this syllabus).

Week	Topic	Reading
1	Course introduction	Syllabus
1	Feedforward networks	Chapter 6 of GBC Tutorial for deep learning
1	Back-propagation	Chapter 6 of GBC Tutorial for deep learning
2	Convolutional network (no class on Monday: MLK holiday)	Chapter 9 of GBC Tutorial for deep learning
3	Probability and graph basics	Chapter 2 and 10.1.1-10.1.4 of Murphy
3	Directed graphical models (Bayes nets) and Undirected graphical models	Chapter 2 of Jordan Tutorial on graphical model.
4	Max-likelihood learning on graphical models and Conditional Random Fields (CRFs)	Chapter 8 of Jordan (excluding section 8.3.4) Chapter 19.6 of Murphy (optional 9.3-9.4 of Murphy) Tutorial on graphical model.
4	Variable elimination	Chapter 3 of Jordan Chapter 19.1-19.4 of Murphy
5	Sum-Product algorithm (message passing)	Chapter 4 of Jordan Chapter 20 of Murphy
5	Mixture model and EM algorithm	Chapter 9.1 and 10 of Jordan

6	Restricted Boltzman machine, contrastive divergence Contrastive estimation in graphical models	Chapter 20 of GBC Paper on contrastive estimation
6	Recurrent and auto-regressive models (Transformer)	Chapter 10 of GBC Paper on Transformer Chapter 12 of Bishop
7	Secure deep learning	Papers and tutorials
7	Convex sets	Chapter 2 of BV Tutorial on convex optimization
8	Convex functions	Chapter 3 of BV
8	Convex problem and duality	Chapter 5 of BV
9	Variational inference	Chapter 10 of Murphy
9	Sampling	Chapter 11 of Murphy
10	Variational autoencoder	Chapter 21 of Murphy
10	GAN and normalizing flow	Chapter 23, 26 of Murphy
Spring Break		
11	Diffusion models	Chapter 25 of Murphy Chapter 20 of Bishop
12	Score function and flow	
13	Markov Decision Process (MDP)	Chapter 34.5 and 35.2 of Murphy
13	RL as graphical model inference	Paper and Chapter 35.6 of Murphy
14	GAIL: Generative Adversarial Imitation Learning, dual dice	GAIL DUALDICE
15	**Course project presentation**	

Disclaimer

This syllabus is intended to give the student guidance on what may be covered during the semester and will be followed as closely as possible. However, as the instructor, I reserve the right to modify, supplement, and make changes as course needs arise. I will communicate such changes in advance through in-class announcements and in writing via Blackboard Announcements.

V. ACCOMMODATIONS

Disability Accommodation Procedures

UIC is committed to full inclusion and participation of people with disabilities in all aspects of university life. If you face or anticipate disability-related barriers while at UIC, please connect with the Disability Resource Center (DRC) at drc.uic.edu, via email at drc@uic.edu, or call (312) 413-2183 to create a plan for reasonable accommodations. To receive accommodations, you will need to disclose the disability to the DRC, complete an interactive registration process with the DRC, and provide me with a Letter of Accommodation (LOA). Upon receipt of an LOA, I will gladly work with you and the DRC to implement approved accommodations.

Religious Accommodations

Following campus policy, if you wish to observe religious holidays, you must notify me **by the tenth day of the semester.** If the religious holiday is observed on or before the tenth day of the semester, you must notify me at least five days before you will be absent. Please submit this form by email with the subject heading: **"YOUR NAME: Requesting Religious Accommodation."**

VI. CLASSROOM ENVIRONMENT

Inclusive Community

UIC values diversity and inclusion. Regardless of age, disability, ethnicity, race, gender, gender identity, sexual orientation, socioeconomic status, geographic background, religion, political ideology, language, or culture, we expect all members of this class to contribute to a respectful, welcoming, and inclusive environment for every other member of our class. If aspects of this course result in barriers to your inclusion, engagement, accurate assessment, or achievement, please notify me as soon as possible.

Name and Pronoun Use

If your name does not match the name on my class roster, please let me know as soon as possible. My pronouns are *he/him*. I welcome your pronouns if you would like to share them

with me. For more information about pronouns, see this page: https://www.mypronouns.org/what-and-why.

Community Agreement/Classroom Conduct Policy

- Be present by turning off cell phones and removing yourself from other distractions.
- Be respectful of the learning space and community. For example, no side conversations or unnecessary disruptions.
- Use preferred names and gender pronouns.
- Assume goodwill in all interactions, even in disagreement.
- Facilitate dialogue and value the free and safe exchange of ideas.
- Try not to make assumptions, have an open mind, seek to understand, and not judge.
- Approach discussion, challenges, and different perspectives as an opportunity to "think out loud," learn something new, and understand the concepts or experiences that guide other people's thinking.
- Debate the concepts, not the person.
- Be gracious and open to change when your ideas, arguments, or positions do not work or are proven wrong.
- Be willing to work together and share helpful study strategies.
- Be mindful of one another's privacy, and do not invite outsiders into our classroom.

Content Notices and Trigger Warnings

Our classroom provides an open space for a critical and civil exchange of ideas, inclusive of a variety of perspectives and positions. Some readings and other content may expose you to ideas, subjects, or views that may challenge you, cause you discomfort, or recall past negative experiences or traumas. I intend to discuss all subjects with dignity and humanity, as well as with rigor and respect for scholarly inquiry. If you would like me to be aware of a specific topic of concern, please email or visit my Student Drop-In Hours.

VII. RESOURCES: Academic Success, Wellness, and Safety

We all need the help and the support of our UIC community. Please visit my **drop-in hours** for course consultation and other academic or research topics. For additional assistance, please contact your assigned college advisor and visit the support services available to all UIC students.

Academic Success

- UIC Tutoring Resources
- College of Engineering tutoring program
- Equity and Inclusion in Engineering Program
- UIC Library and UIC Library Research Guides.
- Offices supporting the UIC Undergraduate Experience and Academic Programs.
- Student Guide for Information Technology
- First-at-LAS Academic Success Program, focusing on LAS first-generation students.

Wellness

- **Counseling Services**: You may seek free and confidential services from the Counseling Center at https://counseling.uic.edu/.
- Access U&I Care Program for assistance with personal hardships.
- **Campus Advocacy Network**: Under Title IX, you have the right to an education that is free from any form of gender-based violence or discrimination. To make a report, email TitleIX@uic.edu. For more information or confidential victim services and advocacy, visit UIC's Campus Advocacy Network at http://can.uic.edu/.

Safety

- UIC Safe App—PLEASE DOWNLOAD FOR YOUR SAFETY!
- UIC Safety Tips and Resources
- Night Ride
- Emergency Communications: By dialing 5-5555 from a campus phone, you can summon the Police or Fire for any on-campus emergency. You may also set up the complete number, (312) 355-5555, on speed dial on your cell phone.