**COLLEGE OF ENGINEERING, UIC**
**CS 412: Introduction to Machine Learning (CRN: 43875, 43876)**
**3 credit hours (undergraduates) or 4 credit hours (graduates)**
**Fall 2023**

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## I. Instructor & Course Details

### Prof. Xinhua Zhang
Email address: zhangx@uic.edu
Drop-In Office Hours (in-person and virtual): 4-5 PM, Thursday.  Starting from week 2.
Drop-In Hours location: Both Zoom and in person at North End, Level 3, Daley Library.  Zoom link: see Section II below.

### TA: Wenzhe Fan
Email address: wfan23@uic.edu
Drop-In Office Hours (in-person and virtual): 1-2 PM, Wednesday.  Starting from week 2.
Drop-In Hours location: Both Zoom and in person at North End, Level 3, Daley Library.  Zoom link: same as the professor's.

### 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, Wednesday, and Friday: 4-4:50 PM
-   LOCATION: LC C4

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## II. Course Information

### Catalog Course Description and Prerequisite/corequisite Statement

Machine learning is the study of systems that improve automatically based on past experience. This course will introduce common machine learning tasks (e.g., classification, density

estimation, clustering) and some of the successful machine learning techniques and broader paradigms that have been developed for these tasks. The course is programming- intensive and a large emphasis will be placed on tying machine learning techniques to specific real-world applications through hands-on experience.

**Prerequisite**: CS 251, IE 342 or STAT 381, or consent of instructor.

To ensure that all students understand the math required in course, a self-evaluation will be posted on Piazza, along with some background math readings.

How much linear algebra is needed?
Linear algebra is not a prerequisite because we will only use a fraction of it.  Make sure you can understand
1) Sections 2.1, 2.2, 2.3, 2.5, 2.6 of [GBC] (see textbook below)
2) Section 4.1 of this book up to Equation 4.8.

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 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:

1. Distinguish between the mechanisms of different machine learning task settings (e.g., classification, regression, dimensionality reduction, density estimation, clustering), and model real world applications using the appropriate learning frameworks.

2. Apply the underlying mathematical rationale of common machine learning models to derive the learning algorithms in a principled fashion.

3. Implement common machine learning algorithms for classification, dimensionality reduction, density estimation, and clustering using Python.

4. Apply common machine learning algorithms to real world datasets, and evaluate their performance measures.

**This is an elective course.**

**Brief list of topics to be covered:** basic linear algebra, probability and statistics; supervised learning, design and analysis of ML experiments & cross validation; Bayes decision theory; parametric methods; multivariate methods; naïve Bayes; Bayesian estimation applied to naïve Bayes; clustering; decision trees; linear discrimination; kernel machines; multilayer Perceptrons, convolutional networks**.**

## Required and Recommended Course Materials

**Required Texts (available electronically via UIC library or web)**

**Ethem Alpaydin, *Introduction to Machine Learning*, 3rd edition. MIT Press, 2014.**

**Reference:**

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

[**Murphy**] Kevin P. Murphy. ***Machine Learning: A Probabilistic Perspective***. MIT Press, 2012.   (PDF available from UIC library)

Besides lecture notes, there will also be four tutorials.  They are meant to help you understand the subject and work out the assignments.  It only for reference; nothing needs to be submitted for them. The scope of the final exam will be the union of lectures, assignments, and tutorials. Some questions in the tutorial are explicitly marked as "only to understand, not a requirement to derive by yourself"; they won't appear in the exam.

You will need to use numpy a lot in the labs. 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. Data used in this lab has been processed for your convenience.

## Required Technology

| Piazza | https://piazza.com/class/llbny1j3sbl5y1 |
| --- | --- |
| | You can register using your UIC netid with no need of instructor's approval. |
| **Master Schedule** | https://piazza.com/class/llbny1j3sbl5y1/post/6 |

| | First register on Piazza as above. This schedule is pinned on top of the left list. |
|---|---|
| **Gradescope** | https://www.gradescope.com/courses/572404 |
| | All your grades and feedback will be here. |
| | You can log in with School Credentials or via Blackboard (left banner). |
| **Zoom** | https://uic.zoom.us/j/83877346394?pwd=M1g3L09LRkp0cjYxTmh0ektCN2xNdz09 |
| | If needed, the password is: vMETige0    The meeting ID is: 838 7734 6394 |
| | This is for recitation and office hour.   In addition to in-person visits, you can also join office hours by Zoom, for both the instructor and the TA.  First come first served on a joint queue. |
| **Blackboard** | Announcement only |
| **Google Drive** | https://drive.google.com/drive/folders/1PkydrzKzDD8fGW9JPO5kvTl_0HyM7A-2?usp=sharing |
| | Questions of assignments and labs, along with rubrics and solutions. |
| | To access it, make sure you log in with your UIC netid (not your personal account). |

## 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 | Blackboard [4] | Registered + Auditing | Registered + Auditing |
| Echo 360 of lecture recordings (also streaming in real time) [5] | Blackboard | Registered + Auditing | Registered + Auditing |
| Office hour (not recorded) | **Zoom + In person** | Anyone | Anyone |
| Recitation (recorded) | Piazza | Anyone | Registered + Auditing |
| Assignment submission + grading | Gradescope | N.A. | Registered only |
| Assignment questions + solutions | Google Drive | Anyone | Registered only |
| iClicker | App | Anyone | Registered + Auditing |

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). 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 (homework and exam). The message will also be recorded on Blackboard in the announcement section.

5. We strongly recommend attending the lectures in person. The online option is only for those we really cannot make it due to health reasons, etc. In any case, we will use iClicker for quick quizzes at some random time of each lecture. This will ensure constant engagement.

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

## Software and hardware

1. Python for labs. You can use any language for the course project.

2. You are required to use collaborative tools for labs and course project, including

   a. Slack or Teams for messaging. UIC does not have license for slack, but the free version might be sufficient.

   b. Github or Bitbucket for code maintenance (free with their respective education packs).

   c. Box, Onedrive, or Google-cloud for file sharing (all free from UIC).

3. 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.

4. Time management by Google calendar, Outlook, etc.

5. Keep the iClicker app on your computer or mobile device up to date at spare time.

## 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

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

1. In-class quizzes conducted by iClicker. Each class may have multiple quiz questions that you will need to answer on the iClicker app.

2. Eleven (11) light-weight individual written assignments will be due approximately every week. They focus on conceptual understanding. For simplicity, I will henceforth just call them "assignments". Graduate students will have slightly more questions to solve.

3. A course project. Groups will be formed to conduct a course project, with four (4) students in each group. The project, which is open-topic, aims to apply machine learning techniques to "real world" datasets. It will have a **proposal** due in week 10, an **oral presentation** in the lectures of week 15, and a **report** due in week 15.

   **Each group can have a mix of graduate and undergraduate students**. You can find teammates by going to Piazza, and 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.

4. Seven (7) labs, due every 2 weeks. The language will be **Python** only. The topics and tasks will be given. Lab 1 is for individual work and is mandatory.

   For lab 2-7, you can either work individually or in groups (same groups as in the course project). To submit as a group, just specify your teammates on Gradescope. Undergraduates are expected to submit 5 individual or group labs (lab 1 included), and graduate students are expected to submit 6 individual or group labs. By expectation, it means how the total score of the entire course is calculated, based on which 85% will be A, etc; see below. So effectively, undergraduates have two labs to earn extra marks from, while graduates have one.

5. Two 50-min **mid-term** exams and a 120-min **final** exam.

Partial grading will be used in all assessments.

**Grading Policy**. The overall course grade of each student will be determined based on:

1. (4%) In-class iClicker quiz from week 3 to 14: 10 points * 23 lectures
2. (21%) Eleven (11) written assignments: 100 points each for undergraduates, and there are five assignments of 160 points for graduate students.
3. (19%) Seven (7) labs: 200 points each.  Undergraduate and graduate students are expected to submit 5 and 6 labs, respectively.
4. (15%) Course project: 800 points
5. (15%) Two midterm exams: 800 points for undergraduates and 880 points for graduates. That is, 400 or 440 points for each midterm exam.
6. (26%) Final exam: 1400 points for undergraduates and 1540 points for graduates.

The percentages in parenthesis are computed based on undergraduate's points.  The total earned points will be used to determine the final letter grade (A/B/…) **based on threshold**:

|  | Total points | A (85%) | B (70%) | C (55%) | D (40%) | F (<40%) |
|---|---|---|---|---|---|---|
| Undergraduate | X = 5330 | 4530.5 | 3731 | 2931.5 | 2264 | 0 |
| Graduate | Y = 6050 | 5142.5 | 4235 | 3327.5 | 2576 | 0 |

**X = 23*10 + 11*100 + 5*200 + 800 + 800 + 1400 = 5330**
**Y = 23*10 + 6*100 + 5*160 + 6*200 + 800 + 880 + 1540 = 6050**

**Important Note:**  In order to pass the course, undergraduate students must earn at least **1100** points from midterm and final exams combined, while graduate students must earn at least **1210** points.

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.

3. **Missed exams**: Missed exams cannot be made up unless there are extenuating circumstances (death, severe illness, etc.) **and** the student has e-mailed instructor **in**

**writing** at least 24 hours **before** the exam, unless the situation is an emergency. **Example reasons that do not qualify** include another exam/deadline/presentation/interview (and alike) due on the same day, an appointment/duty/flight/travel that can be rescheduled or booked to a later date.

A mark of 0 is earned for the exam if the above policy is not adhered to.

Week 16 is the week for the final exam. The date for the final exam will be announced later. The university will schedule it. An announcement will be posted on the Blackboard.

- This means that the final exam can take place as early as Monday at 8am or as late as Friday at 8pm.
- You have to be available in person for the final examination; do not schedule any conflicting and unavoidable compromises during the final's week (e.g., international flight on Friday at 12noon hoping that the final will take place before that). Special accommodations for students abroad and in different time zones must be requested during the **first two weeks of class**.

## 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 assignments:** Discussion of homework assignments and solutions with other students <u>is</u> 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 and labs:** 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. Find teammates for experiment & course project by "Search for Teammates!" on Piazza.

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.

**3. Exams: All work on the midterm and final exams must be individually performed.**


## 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).  Starting from week 3, written assignments are due almost every week, while the labs due almost every two weeks.

| Week | Topic | Readings |
|---|---|---|
| 1 | Introduction | Chapter 1 of Alpaydin |
| 1-2 | Basic linear algebra, probability and statistics | Chapter 2.1-2.3 of GBC<br>Chapter 2.1-2.3 of Murphy |
| 2 | Supervised learning | Chapter 2 of Alpaydin |
| 3 | Design and Analysis of ML Experiments & cross validation | Chapter 19 of Alpaydin<br>Supplementary slides |
| 3-4 | Bayes decision theory | Ch 3-3.4 of Alpaydin |
| 4 | Parametric methods | Chapter 4.1-4.5 of Alpaydin |
| 5 | Multivariate methods + Midterm | Chapter 5 of Alpaydin |
| 6 | Naïve Bayes | Chapter 5.7 of Alpaydin<br>Chapter 3.5.1, 3.5.2 of Murphy |
| 7 | Bayesian estimation applied to naïve Bayes | Chapter 16.1, 16.2 of Alpaydin |
| 8 | Clustering | Chapter 7 of Alpaydin |
| 9 | Revision and course project introduction | |
| 10 | Decision Trees + Midterm | Chapter 9 of Alpaydin |
| 11 | Linear discrimination | Chapter 10 of Alpaydin |
| 12 | Kernel machines | Chapter 13 of Alpaydin |
| 13 | Multilayer Perceptrons | Chapter 11 of Alpaydin |
| 14 | Convolutional networks | Chapter 9 of GBC |
| 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 *[she/her; he/him; they/them]*. 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.