UCLA Samueli Computer Science

CS M146 Discussion: Week 1
Course logistics, Math Review Exercise

Junheng Hao

Friday, 1/8/2021

Roadmap

- Course Logistics
- Math Prep: Calculus, linear algebra, probability and optimization
- Q & A

Course Information & Resources

- **Course schedule and logistics**
  - Syllabus (tentative) on CCLE
  - Logistics discussed in the first lecture (Week 1, Monday)
- **CCLE**
  - Slides, lecture recordings, and other private course materials
- **Online forum (Campuswire)** → ***Invitation sent!***
  - Link: https://campuswire.com/p/GB5E561C3 Passcode: 3428
  - Slides, QA and chat rooms.
  - If you have any questions, you may DM me on Campuswire or write me emails.
- **GradeScope** → ***Invitation sent!***
  - Submissions of problem set (total 4) and quizzes
  - Final exam

Course logistics

- Office hours & Zoom links (time in PST)
  - Sriram Sankararaman (sriram@cs.ucla.edu) Wednesday 3:00-4:00pm @Zoom
  - **Junheng Hao (haojh.ucla@gmail.com) Mondays 3:00-5:00 pm @Zoom**
  - Danfeng Guo (lyleguo@ucla.edu) Tuesdays 4:00pm-6:00pm @Zoom
  - Andrei Storozhenko (storozhenko@cs.ucla.edu) Tuesdays & Thursdays 11:00-12:00 am @Zoom
- Discussion 1C by Junheng Hao:
  - Time: 12-1:50 pm, Fridays.
  - Slides are posted on: https://www.haojunheng.com/teaching/cs146-winter21/
  - Recordings are posted on CCLE.
- Junheng's Zoom Link:
  - https://ucla.zoom.us/j/96240702917?pwd=QzFyWDZlYWpjNy9BSHl5OFMyNU1jdz09

Note: You can attend any discussion session (honestly they are at the same time).

Course Grading

- **Problem Sets: 50%**
  - Total 4 problem sets: Math/conceptual questions + programming tasks
  - No late submissions
- **Weekly Quizzes: 30%**
  - Math quiz on Week 1, weekly quizzes on Week 2-9
  - Lowest quiz score dropped
  - One-hour time for completion once the quiz starts
- **Final Exam: 20%**
  - Scheduled on **March 15**
  - All material covered, open book
  - Email to inform and confirm with both Prof. Sankararaman and your TA, for any accommodation approved by CAE

Reminder: Daylight saving time 2021 in California will begin at 2:00 AM on ***Sunday, March 14****!*

- **Default grade cutoff**

> 96	93	90	86	83	80	76	73	70	< 70
A +	A	A-	B+	B	B-	C+	C	C-	D

Yes, all online!

- As required by UCLA chancellor office, CS M146 is entirely online this quarter.
- All teaching activities (lectures, discussion sessions, office hours) will be held virtually through Zoom.
- Please **DO NOT** share the zoom links outside!
- Please **DO NOT** enter the meeting room outside the regular lectures, office hours and discussion time!

Other Questions?

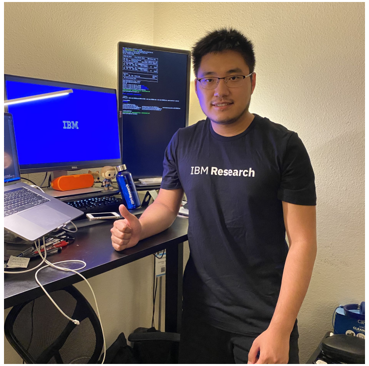
- Enrollment problems on myUCLA
- PTE
- Grading option
- CS145 and/or CS146

Need some help? Check here!

https://www.studentincrisis.ucla.edu/Portals/36/Documents/redfolder.pdf

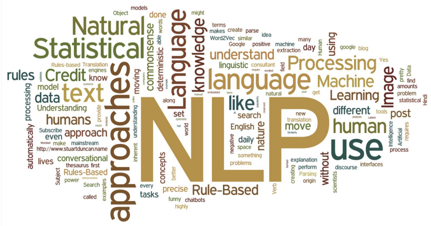
About TA (Myself)

- Fourth-year CS Ph.D. candidate
- UCLA Advisors: Yizhou Sun, Wei Wang (UCLA ScAi Institute, UCLA Data Mining Group)
- Past work experiences: @NEC Labs, @Amazon, @IBM Research AI
- Research interests: Knowledge Graphs, Graph mining, NLP, Bioinformatics, etc.
- Hobbies: Languages (beginner for Spanish and German), tennis, ...
- More about myself: https://www.haojunheng.com/



About My Research

- Foundational to knowledge-driven AI systems
- Enable many downstream applications (NLP tasks, Recommender, Bioinformatics, etc)



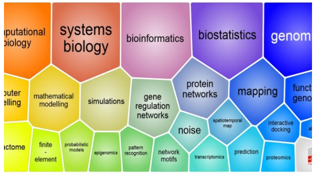
Natural Language Processing

Knowledge Graphs

QA & Dialogue systems

ebay
amazon
NETFLIX

Recommender Systems



Computational Biology

Announcements

- 12:00am, Jan. 9: Math quiz released on Gradescope.
- **11:59pm, Jan. 10 (Sunday):** Math quiz closed on Gradescope!
- Jan. 15 (expected): Problem set 1 released on campuswire/CCLE, submission on Gradescope.

Other deadline reminders (Problem sets, Quizzes, etc) will be announced in class and Campuswire, as well as my discussion webpage.

"Machine learning is part of both ***statistics*** *and* ***computer science****."*

-- I don't know who said that.

Math Review: Probability

- **Checklist:**
  - Properties of probability
  - Probability spaces (discrete/continuous)
  - Probability distributions (discrete/continuous)
  - Random variables
  - Multivariate probability distributions
  - Marginal probability and conditional probability
  - Expectation, variance, covariance
  - Rules of probability
  - Independence and Bayes rule

Math Review: Linear Algebra

- Checklist:
  - Basic calculus $y = x^2, \dfrac{\delta y}{\delta x} = ?$
  - Gradient calculation in matrix format

Math Review: Linear Algebra

- **Checklist:**
  - Vector, matrix
  - Norm
  - Multiplication
  - Useful (special) matrices
  - Rank of a matrix
  - Matrix inverse
  - Eigenvalues and eigenvectors

Math Review: Optimization

- Checklist:
  - Convex set and convex functions
  - Gradients
  - Gradient descent
  - *(For SVM)* Quadratic problem and dual problem, duality, KKT condition.

Math Review: Reading List

From the website: http://web.cs.ucla.edu/~sriram/courses/cm146.winter-2019/html/index.html (Details in the links below)

- Review of probability
  - Link 1: http://cs229.stanford.edu/section/cs229-prob.pdf
  - Link 2: https://www.cs.princeton.edu/courses/archive/spring07/cos424/scribe_notes/0208.pdf
- Linear Algebra
  - Link 2: http://cs229.stanford.edu/section/cs229-linalg.pdf
- Optimization
  - Link 1: http://cs229.stanford.edu/section/cs229-cvxopt.pdf
  - Link 2: http://cs229.stanford.edu/section/cs229-cvxopt2.pdf
- Machine Learning Math Essentials by Jeff Howbert from Washington U.
  - Link: http://courses.washington.edu/css490/2012.Winter/lecture_slides/02_math_essentials.pdf

About Math Quiz (Week 1)

- Notification: Campuswire Post#12.
- You will have up to **60 minutes** to take this exam.
- You can find the exam entry named "Week 1 Math Quiz" on GradeScope.
- There are in total **10 questions** with types of true/false and multiple choices. Note that for multiple-choice questions, it is possible to have one single correct answer and multiple correct answers (select all that apply).
- Quiz release date and time: **Jan 08, 2021 (Friday) 05:00 PM PST**
- Quiz due/close date and time: **Jan 10, 2021 (Sunday) 11:59 PM PST**

Practice Exercise 1

- Bayes Theorem
    - A patient goes to see a doctor. The doctor performs a test with 99 percent reliability, that is, 99 percent of people who are sick test positive and 99 percent of the healthy people test negative.
    - The doctor knows that only 1 percent of the people in the country are sick (well, obviously this is not COVID-19 in US)
    - If the patient tests positive, what are the chances the patient is sick? Is it 99%?

Practice Exercise 1 (Answer)

- Bayes Theorem
  - 99 percent of people who are sick test positive and 99 percent of the healthy people test negative. Only 1 percent of the people in the country are sick.
  - If the patient tests positive, what are the chances the patient is sick?
  - Further question: What is the chance of a false positive result?

	Diseased	Not Diseased	
Test +	99	99	198
Test -	1	9,801	9,802
	100	9,900	10,000

Practice Exercise 2

- Matrix Rank
- What is the rank of following matrix? Are they non-singular?

$$A = \begin{bmatrix} 1 & 0 & 1 \\ 2 & 1 & 2 \\ 1 & 0 & -1 \end{bmatrix}$$

$$B = \begin{bmatrix} 2 & 1 & 2 \\ 1 & 0 & 1 \\ 4 & 1 & 4 \end{bmatrix}$$

Practice Exercise 2: Answer

- Matrix Rank
- What is the rank of following matrix? Are they non-singular?

$$A = \begin{bmatrix} 1 & 0 & 1 \\ 2 & 1 & 2 \\ 1 & 0 & -1 \end{bmatrix} \qquad B = \begin{bmatrix} 2 & 1 & 2 \\ 1 & 0 & 1 \\ 4 & 1 & 4 \end{bmatrix}$$

- rank(A)=3, rank(B)=2
- What about the rank of the matrix B+mI (I is identity matrix)?

Practice Exercise 3

- Hessian matrix

$$
\mathbf{H}f = \begin{bmatrix} \dfrac{\partial^2 f}{\partial x^2} & \dfrac{\partial^2 f}{\partial x \partial y} & \dfrac{\partial^2 f}{\partial x \partial z} & \cdots \\ \dfrac{\partial^2 f}{\partial y \partial x} & \dfrac{\partial^2 f}{\partial y^2} & \dfrac{\partial^2 f}{\partial y \partial z} & \cdots \\ \dfrac{\partial^2 f}{\partial z \partial x} & \dfrac{\partial^2 f}{\partial z \partial y} & \dfrac{\partial^2 f}{\partial z^2} & \cdots \\ \vdots & \vdots & \vdots & \ddots \end{bmatrix}
$$

$$
f(x, y) = x^3 - 2xy - y^6
$$

Practice Exercise 3: Answer

- Hessian matrix

$$\mathbf{H}f = \begin{bmatrix} \frac{\partial^2 f}{\partial x^2} & \frac{\partial^2 f}{\partial x \partial y} & \frac{\partial^2 f}{\partial x \partial z} & \cdots \\ \frac{\partial^2 f}{\partial y \partial x} & \frac{\partial^2 f}{\partial y^2} & \frac{\partial^2 f}{\partial y \partial z} & \cdots \\ \frac{\partial^2 f}{\partial z \partial x} & \frac{\partial^2 f}{\partial z \partial y} & \frac{\partial^2 f}{\partial z^2} & \cdots \\ \vdots & \vdots & \vdots & \ddots \end{bmatrix}$$

$$f(x, y) = x^3 - 2xy - y^6$$

$$\mathbf{H}f(x, y) = \begin{bmatrix} f_{xx}(x, y) & f_{yx}(x, y) \\ f_{xy}(x, y) & f_{yy}(x, y) \end{bmatrix} = \begin{bmatrix} 6x & -2 \\ -2 & -30y^4 \end{bmatrix}$$

*Note: The Hessian matrix is a **symmetric** matrix, since the hypothesis of continuity of the second derivatives implies that the order of differentiation does not matter (Schwarz's theorem).*

Practice Exercise 4 (Link)

- Calculus: Chain rule → Later used in Neural Networks!

$f(x) = \cos^3(x)$

$f'(x) = ?$

Choose 1 answer:

(A) $3\cos^2(x)$

(B) $-\sin^3(x)$

(C) $[1-\sin^2(x)]\cos(x)$

(D) $-3\sin(x)\cos^2(x)$

What's next?

- In next week's discussion, we will discuss:
  - Materials in the first 2 weeks: Decision tree, kNN and linear classification
  - Programming prep: Python, Google Colab, some useful packages (numpy, scikit-learn, matplotlib, etc)
- Useful resources for programming resources
  - Python/Numpy/Matplotlib tutorial: https://cs231n.github.io/python-numpy-tutorial/
  - Scikit-learn: https://scikit-learn.org/stable/tutorial/index.html

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Thank you!

Q & A