CS163 Deep Learning for Computer Vision
Fall 2024

Course Logistics

Instructor: Professor Bolei Zhou <bolei@cs.ucla.edu>

Teaching Assistants: Zhizheng Liu <zhizheng@cs.ucla.edu>, Sicheng Mo <smo3@cs.ucla.edu>

Learning Assistants: Joe Lin, Krystof Latka

Lecture Time: Monday/Wednesday 4:00 pm - 5:40 pm

Lecture Location: ENGR VI MLC (1st floor Mong Lecture hall)

***ZOOM link**: https://ucla.zoom.us/j/96372616646. (It is only for emergency use, the quality is BAD as we are in a huge lecture hall, and the video recording is not guaranteed).

Discussion and TA office hours

- DIS 1A F 8:00 am-9:50 am PUB AFF 1234
- DIS 1B F 10:00 am-11:50 am PUB AFF 1234
- Office Hour F 2:00 pm-3:30 pm HAINES A2

Prof. Zhou's Office Hours:

- **Monday 5:30 pm - 6:10 pm** at the lecture hall or Eng VI, 295D
- **Wednesday 5:30 pm - 6:10 pm** at the lecture hall or Eng VI, 295D

Piazza Link: https://piazza.com/ucla/fall2024/cs163

- all questions about the assignments, course projects, or other course-related things should be there
- The reply turnaround time from TAs is expected to be no more than 36 hours, so please be patient for a day

Bruinlearn course site: https://bruinlearn.ucla.edu/courses/191395

Prerequisites: Familiarity with **Python programming**, **Linear Algebra**, **Calculus**, and **Probability**. Students should have taken **at least one course relevant** to machine learning, image processing, computer vision, or data mining.

Grade Structure: Letter grades are assigned based on the following:

Assignments	40%
Final exam	50%
Course project	10%

Course Material: There is no required textbook, although the following two textbooks can be seen as helpful resources and practices. Both are freely available online.

- Dive into Deep Learning by Zhang, Lipton, Li, Smola (free PDF available)
- Deep Learning by Goodfellow, Bengio, and Courville
- Understanding Deep Learning by Simon J.D. Prince (free PDF available)

Details on Homework Assignments: Four assignments will be released on the following schedule. Each problem set is allotted 3 weeks for completion. You will be allotted 3 late days for assignments as you choose. Beyond this 3-day grace, late assignments will not be accepted without a valid explanation.
Assignments will be released at:
https://github.com/UCLAdeepvision/CS163-Assignments-2024Fall

Assignment 1	OUT: Monday, Sept 30	DUE: Sunday, Oct 20
Assignment 2	OUT: Monday, Oct 14	DUE: Sunday, Nov 3
Assignment 3	OUT: Monday, Nov 4	DUE: Sunday, Nov 23
Assignment 4	OUT: Monday, Nov 18	DUE: Sunday, Dec 8

Final Exam Details: 8:00 am - 11:00 am, Wednesday, December 11, 2024, Location TBD.
The final exam will cover all the lecture materials (including some assignment-related and conceptual questions regarding the guest lectures) and assignments. You are allowed to bring **one double-sided A4/US Letter-sized cheat sheet**, which can be printed or handwritten, and **NO OTHER textbooks or lecture slides**. You are also allowed to bring a basic calculator to the exam, though most of the computation problems should be easy to calculate by hand.
***** Note that the time and date of the exam are pre-set and not negotiable, and there is no make-up exam. If you cannot make it to the final exam, you may have to drop this course.

Course Description

Computer Vision has been a core field of Artificial Intelligence, facilitating a wide range of applications from image search to self-driving. The recent development of

deep learning has greatly advanced the performance of visual tasks like visual recognition and image generation. This course covers the details of deep learning approaches for computer vision. Through this course, students will learn to implement the deep neural networks used in various computer vision such as visual recognition and image generation. We will go through the learning algorithms, neural architecture design, and practical skills of training and debugging neural networks.

The course is directed primarily at senior undergraduates and fresh graduate students interested in deep learning applications, but it can also be taken by juniors who satisfy the prerequisites. Students should have taken linear algebra, programming, and data structure; taking at least one machine learning-relevant course will also be very helpful.

Learning Objectives

- Students should be able to understand the deep learning foundations such as back-propagation and convolutional neural networks.
- Students should be able to train and debug deep neural networks for various computer vision tasks, including but not limited to image recognition, semantic segmentation, object detection, and image generation.

Course Project

- Students will divide themselves into small groups (up to 4) with the goal of delving deeply into a chosen computer vision topic as their course project.
- Topics can either be chosen from a list provided by instructors, or proposed by students with instructor approval. A tentative list is available here
- The course project will have two equally weighted deliverables - an in-class presentation and a project report.
- Please sign-up by the end of Week 4 to register your group members and book a presentation timeslot here.
- Project presentation
    - During the discussion sections, the presentations will be held in person between Weeks 6 to 9, please upload your slides here.
    - Each presentation should last about 5-15 minutes, and each group member will be expected to present.
    - The presentation should focus mostly on introducing the topic (in contrast, the project report will place greater emphasis on discussing solutions). The rubric is as follows:
        - Appropriate choice of topic [0.5 pt]

        - Introduction and formalization of topic [1 pt]
        - Brief overview of one deep learning based solution [1 pt]
        - Plan for the final report [1 pt]
        - Clarity and Technical Accuracy of Presentation [1.5 pts]

    - There will also be a short Q&A at the end of the presentation for students/TAs to ask questions.
- Project Report
    - The final report will be due at the end of Week 10. The instructions for submitting the final report are in the course project repo.
    - It will be formatted as a technical blog article with Markdown hosted on the course website (see below for past-year references). Note that it will be made available to your fellow students and the general public to read and learn from. The rubric is as follows:
        - Format and writing - [1.5 pts]
        - Technical Accuracy - [1.5 pts]
        - A proper discussion of at least 3 existing literature - [2 pts]
        - Bonus: Running existing codebases [1 pt]
        - Bonus: Implementing your own ideas [1 pt]
    - **Extra Credit Opportunity:** While not mandatory, we highly encourage groups to run existing codebases or implement your own ideas toward the chosen topic. Extra credit will be offered to groups that successfully accomplish this.
    - Course project reports from the previous years:
        - https://ucladeepvision.github.io/CS188-Projects-2024Winter/
        - https://ucladeepvision.github.io/CS188-Projects-2023Winter/
        - https://ucladeepvision.github.io/CS188-Projects-2022Winter/
    - Selected outstanding examples:
        - https://ucladeepvision.github.io/CS188-Projects-2023Winter/2023/01/27/team13-text-guided-image-generation.html
        - https://ucladeepvision.github.io/CS188-Projects-2022Winter/2022/01/27/team07-medical-image-segmentation.html
    - Some good (external) technical blog articles
        - https://lilianweng.github.io/lil-log/2021/07/11/diffusion-models.html and https://lilianweng.github.io/lil-log/2018/12/27/object-detection-part-4.html (md source: https://github.com/lilianweng/lil-log/blob/master/_posts/2018-12-27-object-detection-part-4.md)) and many other blogs by Lilian.
        - https://yang-song.github.io/blog/2021/score/
        - http://karpathy.github.io/2016/05/31/rl/

    - https://gtsam.org/2020/08/30/Laplacian.html
- Google Cloud credit will also be provided to encourage students to implement and run code for the course project. Instructions on using them will be covered in the discussion.
- The tentative timeline for the course project is as follows:

End of Week 4	Form groups and book presentation slots
Weeks 6 to 9	In-class presentations
Dec. 13	Final Report Due

Schedule

Slide PDFs will be made available on the Bruinlearn course site and below

Week 1: Overview
Assignment 1 out
Lecture 1: Course introduction [slides]
Lecture 2: Image classification and machine learning basics
Discussion: TA Tutorial on Colab & PyTorch Basics

Week 2: Image classification and linear neural networks
Lecture 3: Linear classifier for image classification
Lecture 4: Regularization + Optimization
Discussion: TA Tutorial on PyTorch Advanced and Google Cloud

Week 3: Foundation on neural networks
Assignment 2 out
Lecture 5: Neural Networks
Lecture 6: Backpropagation
Discussion: TA Tutorial on Course Project and DL Hardware/Software
Assignment 1 due

Week 4: Convolutional neural networks
Lecture 7: Convolutional Neural Networks
Lecture 8: CNN architectures
Discussion**:** TA Presentation on CV Research

Week 5: Training and understanding neural networks
Lecture 9: Training NNs
Lecture 10: Visualizing and understanding neural networks
Discussion: Lecture 1-10 Recap

Assignment 2 due
Week 6: RNN, Attention, Transformer, ViT
Assignment 3 out
Lecture 11: RNN and Attention
Lecture 12: Transformer and ViT

Week 7: Object detection and dense prediction (Monday is Veterans Day)
Lecture 13: Object detection
Discussion: Midway Presentation

Week 8: Dense prediction, Generative models: intro
Assignment 4 out
Lecture 14: Dense prediction (semantic segmentation, pose estimation)
Lecture 16: Generative models: intro
Discussion: Midway Presentation
Assignment 3 due

Week 9: Generative models: Advances (Thanksgiving week)
Lecture 17: Generative models: advances
Lecture 18: A taste of CV research by various student researchers (will be pre-recorded as is too close to Thanksgiving break…)
Discussion: Midway Presentation

Week 10: CV research and course summary
Lecture 19: Recent progress and how to do CV research
Lecture 20: Course Recap
Discussion: Final Review
Assignment 4 due

Week 11: Final Week
Final Exam
Final Project due