INTRODUCTION TO COMPUTER VISION

The aim of Computer Vision (aka Machine Vision, Computational Vision) is to make computers "see" by processing images and/or video. Originally seen as a sub-area of artificial intelligence, computer vision has been an active area of research for almost 40 years.

By knowing such things as how images are formed, information about the sensors (cameras), and information about the physical world, it is possible to infer information about the world from an image or set of images. For example, one may wish to know the color of an apple, the width of a printed circuit trace, the size of an obstacle in front of a robot on Mars, the identity of a person's face in a surveillance system, the motion of an object, the vegetation type of the ground below, or the location of tumor in an MRI scan - automatically, from images.

Computer vision studies how such tasks can be done, and how they can be done robustly and efficiently.

Changelog:

- Sep 18: Announce TAs, clarify homework schedule and lateness policy
- Sep 10: Initial commit

1 COURSE INFORMATION

Lectures: Tue/Thu 2-3.15pm (GIRV 1004)
Discussion sections: Wed 9-9.50am (ARTS 1349), 10-10.50am (ARTS 1353), 11-11.50am (ARTS 1353)

Instructor:	Michael Beyeler (mbeyeler@ucsb.edu)
TAs:	Esha Singh (esingh@ucsb.edu)
	Galen Pogoncheff (galenpogoncheff@ucsb.edu)
	Kimia Afshari (kimia_afshari@ucsb.edu)
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Course website:	https://gauchospace.ucsb.edu/courses/course/view.php?id=32011
Piazza (forum):	https://piazza.com/ucsb/fall2022/csece181
Textbook:	None

2 COURSE FORMAT

The course will be taught in-person in GIRV 1004. I will be wearing a mask, but you do you. Lectures will be recorded for those who cannot attend, but you will have to ask for GauchoCast access for every lecture you missed. Discussions sections will be led by our TAs, and focus on in-depth discussion of lecture materials, help with homework assignments, tutorials, and more.

All materials, assignments, and resources can be found on our GauchoSpace course website.

3 COURSE PREREQUISITES

This course requires prior programming experience. While no prerequisites are specifically listed, ALL CS/ECE students have at least two programming courses, one using MATLAB/Python and one with C/C++. There will be one or more programming assignments, and one can work on these using either MATLAB or Python.

In addition, students are expected to have basic knowledge of calculus, linear algebra, probability, and statistics. These are typically covered in the undergrad-required Math courses. If you are unsure about the background details, please consult with the instructor.

4 EXPECTED LEARNING OUTCOMES

By the end of the course, you should be able to:

- explain & apply the fundamentals of image formation, alignment, and warping
- explain & apply the fundamentals of projective and epipolar geometry
- process image features using traditional & modern approaches
- summarize current approaches to object recognition, detection, and segmentation
- demonstrate expertise towards the implementation and programming practices of effective computer vision applications

5 TEXTBOOKS

Given that computer vision (CV) is fast-changing, there are no good textbooks at the undergraduate level that would cover all the topics of 181. However, students may find the following useful:

- Richard Szeliski (2020): Computer Vision – Algorithms and Applications, 2nd Edition. This free book covers basics of image formation, edge and feature detection, basic image processing, and optic flow. The 2nd edition has been extended to include deep learning.
- Hartley & Zisserman (2004): Multiple View Geometry in Computer Vision, 2nd Edition. This book is an excellent resource on the first few topics on homogeneous coordinates, camera models, and multi-view geometry. Some chapters are posted for free online.

6 STUDENT DROP-IN HOURS

Instructor and TAs will offer on-demand drop-in hours via Zoom:

Who?	**When?**	**Where?**
Prof. Beyeler	Thu 3.30–5pm	https://shoreline.ucsb.edu/meetings/1335298/f22-cs181-beyeler
Esha	TBA	TBA
Galen	TBA	TBA
Kimia	TBA	TBA
Yuchen	TBA	TBA

By clicking on the links above, you can sign up for one of the available slots for a particular week. The Shoreline app will automatically schedule a 15-min Zoom meeting and send you an invite.

Please give $\geq$ 1 hour notice.

7 COURSE MATERIAL

This is a rough outline of the course material and is subject to (slight) change as the quarter progresses.

Week	Date	Lecture	Discussion	HW out	HW due
Wk 0	Sep 19 – Sep 23	Welcome & course logistics Sep 22: Virtual lecture			
Wk 1	Sep 26 – Sep 30	Image formation • Image formation by the camera / by the eye • Geometric primitives and transformations	Logistics	HW1: Math1	
Wk 2	Oct 3 – Oct 7	Image warping & projection • Warping • Projection & distortion		HW2: Prog1	HW1: Math1
Wk 3	Oct 10 – Oct 14	Image warping & projection • Camera extrinsics • Homography		HW3: Math2	HW2: Prog1
Wk 4	Oct 17 – Oct 21	Image alignment & panoramas • Alignment & stitching • Blending Oct 20: Guest lecture		HW4: Prog2	HW3: Math2
Wk 5	Oct 24 – Oct 28	Stereo vision • Epipolar geometry • Two-view geometry Image features • Feature detection & extraction	Midterm review (Wk1 – Wk5)		HW4: Prog2
Wk 6	Oct 31 – Nov 4	Image features • Feature matching & tracking Midterm exam			Midterm
Wk 7	Nov 7 – Nov 11	Intro to deep learning • Deep net architectures • Supervised learning; training & optimization	Intro to TensorFlow, PyTorch, Keras TF Sandbox	HW5: Prog3	
Wk 8	Nov 14 – Nov 18	Deep learning-based CV: • Convolutional neural networks • Object detection & recognition		HW6: Prog4	HW5: Prog3
Wk 9	Nov 21 – Nov 25	Deep learning-based CV: • Instance & semantic segmentation Thanksgiving Day: NO CLASS			HW6: Prog4
Wk 10	Nov 28 – Dec 2	Advanced topics in CV	Quarter review		
Wk 11	Dec 5 – Dec 9	Finals Week Dec 6 (tentative): Final exam (in-person)			Final

8 COURSE REQUIREMENTS & GRADING

This class will be graded on a curve, with mean (50th percentile) of B/B-. Your grade will be determined as follows:

25% Weekly Assignments (drop the lowest)

Most weeks, you are expected to complete a short assignment. These are usually due by Sunday 11:59pm Pacific (timestamp of the online submission system).

At the end of the quarter, the lowest-scoring assignment will be dropped.

2x Pen & Paper Assignments

These are "paper & pen" problem sets where you have to apply the math presented in lecture or answer short conceptual questions.

4x Programming Assignments

These are Python-based programming assignments, for which you must turn in a working, commented Jupyter Notebook (preferred, via Google Colab) or Python script.

25% Midterm Exam

We will have a midterm exam during Week 6. It will happen either asynchronous via GauchoSpace/GradeScope (currently my top choice, pending some logistic issues) or in-class on Nov 3.

50% Final Exam

We will have an in-person final exam during Finals Week, most likely on December 6 in GIRV 1004 (pending approval from the university).

Attendance of classes and discussion sections is *strongly encouraged* but won't directly factor into your grade.

9 LATENESS POLICY

The following **lateness policy** applies to the weekly assignments:

- **Everybody gets 3 late days.** To make the deadlines more manageable, each student will be allowed 3 "late days" over the course of the quarter for which lateness will not be penalized. Late days cannot be applied to the midterm or final exam (should they be held online/asynchronously).
- **You can apply at most 2 late days per assignment.** This is because they're due Sunday night and we want to discuss solutions during the following Wednesday section. GauchoSpace will be configured so that the cut-off date for assignments is Tuesdays 11:59pm.
- **Being 1 minute late is the same as being 1 day late.** Since assignments are typically due on Sunday at 11:59pm Pacific, anything turned in between 12:00am and 11:59pm PST the next day is one day late; every day thereafter that an assignment is late, including weekends and holidays, counts as an additional late day.
- **Absolutely no late work will be accepted after the deadline if you have used up all your late days.** If you're not done on time you must turn in what you have in order to receive partial credit.

Please make sure you understand this policy.

Note: You should have ample time to complete the assignments. However, if you find yourself under exceptional circumstances (e.g., open-heart surgery, your dog ate your laptop) that prevent you from turning in an assignment on time, please email me.

10 DEPARTMENT POLICIES AND INFORMATION

10.1 Academic Misconduct Policy

Computer Science Instructors who have reasonable evidence of academic misconduct both report misconduct to the UCSB Office of Judicial Affairs and forward such reports to the OJA Conduct Committee. This allows the OJA to conduct an evidentiary hearing that may clear the student or may compellingly establish misconduct. If academic misconduct is established, the OJA, not the Instructor, decides the consequences other than the course grade, which is conferred by the Instructor.

Any work (written or otherwise) submitted to fulfill an academic requirement must represent a student's original work. Any act of academic dishonesty, such as cheating or plagiarism, will subject a person to Department and University disciplinary action. Cheating includes, but is not limited to, looking at another student's examination, referring to unauthorized notes or other sources of information during an exam, providing or receiving test or exam or paper answers, and having another person take an exam or write a paper for you. Representing the words, ideas, or concepts of another person without appropriate attribution is plagiarism. Whenever another person's written work is used, whether it is a single phrase or longer, quotation marks must be used and sources cited. Paraphrasing another's work, i.e., borrowing the ideas or concepts and putting them into one's "own" words, must also be acknowledged. http://www.sa.ucsb.edu/regulations/student_conduct.aspx

10.2 Reproduction of Course Materials

All course materials (class lectures and discussions, video lectures, examinations, Web materials) and the intellectual content of the course itself are protected by United States Federal Copyright Law, and the California Civil Code. UC Policy 102.23 expressly prohibits students (and all other persons) from recording lectures or discussions and from distributing or selling lectures notes and all other course materials without the prior written permission of the Instructor (see http://policy.ucop.edu/doc/2710530/PACAOS-100).

Students are permitted to take notes solely for their own private educational use. Exceptions to accommodate students with disabilities may be granted with appropriate documentation. To be clear, in this class students are forbidden from completing study guides and selling them to any person or organization. This text has been approved by UC General Counsel.

10.3 CS/ECE Offer Supportive Learning Environments

10.3.1 Wellness Statement

Personal concerns such as stress, anxiety, relationships, depression, cultural differences, - can interfere with a student's ability to succeed and thrive. For helpful resources, please visit Counseling & Psychological Services at http://caps.sa.ucsb.edu/ or contact us at 805-893-4411 (24/7). If you are concerned about a friend, referrals to Student Mental Health Coordination Services can be submitted 24/7 by using the Gaucho Support & Outreach Referral Form at www.sa.ucsb.edu/REFERaGAUCHO

10.3.2 Academic Support

You may wish to seek expert help on note-taking and test-taking techniques, or to cope with test anxiety. Campus Learning Assistant Services (CLAS) offers individual and group study skills and course-specific workshops. If you are interested, please contact CLAS at 893-4248 or visit http://www.clas.ucsb.edu.

10.3.3 Disabled Student Support

The Disabled Student Program (DSP), http://dsp.sa.ucsb.edu, is available for all students who experience permanent or temporary medical issues while enrolled at UCSB. DSP is available to help students find reasonable accommodations when their condition may impact their success in a course. Students must enroll in DSP to receive any accommodations for coursework or exams. Registration can be completed online and should be done as soon as the student is aware there is a medical issue.

10.3.4 Gender/Sex Discrimination Policy and Student Support

Under Title IX, university students are protected from harassment and discrimination based on gender and sex. If you, or another student, feels uncomfortable or in need of support at any time related to their gender, sex, and/or sexual orientation, please contact UCSB's Resource Center for Sexual and Gender Diversity http://wgse.sa.ucsb.edu/RCSGD/home