Engineering Applications of Computer Vision and Deep Learning for Biological Systems

ABE 6933
Class Periods: Tuesdays and Thursdays 12:50-2:05 pm.
Location: Frazier Rogers Hall, Room 282.
Academic Term: Fall 2023
Credits: 3 credits

Instructor: Changying "Charlie" Li, Ph.D., Email: cli2@ufl.edu; Phone: 352- 294-6727.

Office Hours: by appointment.

Pre-requisites: Fundamental machine/statistical learning courses or equivalent approved by the instructor. Prior programming experiences in Python, Matlab, and Linux operating systems.

Course description and general topics:
Topics in modern computer vision and deep learning techniques are explored with an emphasis on their engineering applications in agricultural and food systems. Students will learn the basic principles of:
- Camera models and stereo vision
- Motion and tracking: optical flow, Kalman filter, Bayes filter, particle filter
- Image classification, segmentation, and object detection
- Neural networks and backpropagation
- Convolutional neural networks (CNN)
- Generative models, transformers
- Deep reinforcement learning

Students are expected to apply the knowledge and skills learned from this course to the research problems of their interests. Course assignments will assess student learning of key topics in the course. An individual class project is required, which can be based on a research project or a self-motivated study initiated from the course. The delivery of the project includes a pre-proposal, a technical paper, and an oral presentation.

Course learning objectives:
Upon the completion of this course, the students should be able to:
- Understand fundamental concepts and principles of computer vision and deep learning.
- Explain various modern deep learning architectures.
- Choose and compose proper architectures for specific engineering applications.
- Build, train and test models using commonly used machine learning frameworks.
- Interpret the results in specific engineering settings.

Suggested textbooks and references:
The following textbooks and references are suggested for the course. Most of the materials can be accessed online for free.

1. Richard Szeliski. Computer Vision: Algorithms and Applications. Springer.
2. Hartley, Richard, and Andrew Zisserman. Multiple view geometry in computer vision. Cambridge university press, 2003.
3. Deep Learning by Ian Goodfellow, Yoshua Bengio, and Aaron Courville (https://www.deeplearningbook.org/)
4. Richard Sutton and Andrew Barto. Reinforcement Learning: An Introduction. MIT Press.

5. Russell, S. J. (2010). Artificial intelligence a modern approach. Pearson Education, Inc.
6. The Principles of Deep Learning Theory (https://arxiv.org/abs/2106.10165)
7. Matrix math for deep learning: https://explained.ai/matrix-calculus/index.html
8. Anaconda: https://www.anaconda.com/
9. Python: https://www.python.org/
10. Jupyter Notebook: https://jupyter.org/
11. PyTorch: https://pytorch.org/
12. Several classical and state-of-the-art research papers on computer vision and deep learning will be covered.

Course Schedule: The following is a tentative schedule of the lectures. The schedule is a general plan for the course; any deviations, if necessary, will be announced by the instructor.

Week No.	Topic	Homework Assignment
1	Introduction to computer vision	
2	Camera models and epipolar geometry	Assignment 1
3	Essential matrix and fundamental matrix	
4	Image projections and homography	
5	Motion and tracking	Assignment 2
6	Machine learning	
7	Neural networks and training: backpropagation	
8	Convolutional neural networks (CNN)	Assignment 3
9	Image classification and object detection	
10	Image segmentation	Project Proposal Due
11	Generative adversarial networks (GAN)	Assignment 4
12	Attention mechanisms & transformer, vision transformer	
13	Deep reinforcement learning I	
14	Deep reinforcement learning II	
15	Project presentation and report	*Project Presentation and Final Paper Due*

Grading Policy: Course grades will be calculated in accordance with the following:

Percent	Grade	Grade Points
93.5 - 100	A	4.00
89.5 - 93.4	A-	3.67
86.5 - 89.4	B+	3.33
83.5 - 86.4	B	3.00
79.5 - 83.4	B-	2.67
76.5 - 79.4	C+	2.33
73.5 - 76.4	C	2.00
69.5 - 73.4	C-	1.67
66.5 - 69.4	D+	1.33
63.5 - 66.4	D	1.00
59.5 - 63.4	D-	0.67
0 - 59.4	E	0.00

More information on UF grading policy may be found at:

UF Graduate Catalog
Grades and Grading Policies

Evaluation of Grades: The grading system includes four assignments and a class project (a paper and an oral presentation).

Assignment1	10%
Assignment2	10%
Assignment3	10%
Assignment4	10%
Journal paper presentation	10%
Project proposal	10%
Project paper	30%
Project presentation	10%
Total	**100%**

More information on UF grading policy may be found at:
https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

Assignments: Assignments will be assigned via CANVAS. Assignments must be turned in to the instructor by the designated date and time (typically in one week after the posting of the assignment). **Late assignments will not be accepted unless they follow the University's Excused absence.**

Journal paper presentation: Students are expected to make at least one presentation of a selected classical and state-of-the-art research paper on computer vision and deep learning.

Final Comprehensive Project: Students must choose a project topic that utilizes the tools and concepts explored in the course. This topic can be related to their ongoing research or approved by the instructor.

The deliverables of the project will include: a proposal (a selected topic with a detailed outline of the project paper with at least three initial references), an oral presentation (about 20 minutes) to the class, and a technical paper/report that will follow the format of a professional journal.

Attendance Policy, Class Expectations, and Make-Up Policy: Students are expected to attend classes and participate in course discussions. Excused absences must be consistent with university policies in the Graduate Catalog (https://catalog.ufl.edu/graduate/regulations) and require appropriate documentation. Additional information can be found here: https://gradcatalog.ufl.edu/graduate/regulations/

Students Requiring Accommodations
Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting https://disability.ufl.edu/students/get-started/. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation
Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

In-Class Recording
Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

University Honesty Policy
UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (https://sccr.dso.ufl.edu/process/student-conduct-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment
The Herbert Wertheim College of Engineering values varied perspectives and lived experiences within our community and is committed to supporting the University's core values, including the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of race, creed, color, religion, age, disability, sex, sexual orientation, gender identity and expression, marital status, national origin, political opinions or affiliations, genetic information, and veteran status.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:
• Your academic advisor or Graduate Program Coordinator
• HWCOE Human Resources, 352-392-0904, student-support-hr@eng.ufl.edu
• Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
• Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use
All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy
There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: https://registrar.ufl.edu/ferpa.html

Campus Resources:
Health and Wellness

U Matter, We Care:
Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: https://counseling.ufl.edu, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence
If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)
Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/.

Academic Resources

E-learning technical suppor*t*, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Connections Center, Reitz Union, 392-1601. Career assistance and counseling; https://career.ufl.edu.

Library Support, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. https://teachingcenter.ufl.edu/.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers. https://writing.ufl.edu/writing-studio/.

Student Complaints Campus*:* https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/;https://care.dso.ufl.edu.

On-Line Students Complaints*: https://distance.ufl.edu/getting-help/; https://distance.ufl.edu/state-authorization-status/#student-complaint*