Advanced Robot Perception
EEL 6935
Class Periods:
Location: Classroom location
Academic Term: Spring 2021

Instructor:
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Office Hours:

Teaching Assistant/Peer Mentor/Supervised Teaching Student:
Please contact through the Canvas website

Course Description
(3 credits) Fundamentals of applying deep learning to real cameras and sensors on robotic platforms.

Course Pre-Requisites / Co-Requisites
EEL 4403/5406.

Course Objectives
Effective wielding of a subset of deep learning approaches that are practically useful for building perception algorithms for robotic systems. Unlike most deep learning approaches which rely on available conventional (i.e. color) imagery from online databases, the focus here is on data from real sensors in robotic and autonomous scenarios, such as thermal cameras (both MWIR and LWIR), event cameras, stereo cameras, high-speed cameras, LIDAR sensors and optical processors. Students will be in a position to apply deep learning techniques to any new platform they encounter, with any novel suite of visual and non-visual sensing modalities. Knowledge will be disseminated regarding both the physics and optics of sensing system families, as well as the practical programming projects to use novel sensors that do not have online databases available. In this sense, the projects and the material will cover the intersection between computing and advanced sensors for robotic applications.

Materials and Supply Fees
None

Professional Component (ABET):
This course consists of 1.5 credits of Engineering Design and 1.5 credits of Engineering Science

Relation to Program Outcomes (ABET):

Outcome	Coverage*
1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	High
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	High
3. An ability to communicate effectively with a range of audiences	
4. An ability to recognize ethical and professional responsibilities in engineering situations and make	Medium

informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts		
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	Medium	
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	High	
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies	High	

Required Textbooks and Software
- Matlab with image processing / computer vision toolbox
- Python / Pytorch on the student's HiperGator account

Recommended Materials
NA

Course Schedule

Week 1:
Lec 1: Basics of Neural Networks
Lec 2: Intro to Computational Sensors
Lec 3: Project 1: Converting between two different streams with GANs

Week 2: GANs
Lec 4: Intro to GANs
Lec 5: GANs and Robot Perception
Lec 6: Project 1 Presentations

Week 3:
Lec 7: Passive 3D Sensors in robot perception
Lec 8: Monocular + X
Lec 9: Project 2: Color Upsampling

Week 4:
Lec 10: Augmentation
Lec 11: Guided Upsampling
Lect 12: Project 2 Presentations

Week 5:
Lec 13: Active 3D Sensors in robot perception
Lec 14: MEMS mirror-based computational sensors 1 (Episcan, EpiTof and others)
Lec 15: Project 3: Monocular + depth upsampling (Project 2 Assessment due)

Week 6:
Lec 16: Thermal imagery in robot perception
Lec 17: Fine tuning neural networks for robotic platforms
Lec 18: Project 3: Fine tuning completion for thermal imagery

Week 7:
Lec 19: Compressive sensing in robotic platforms
Lec 20: Adding physical constraints into learning frameworks
Lec 21: Project 4: Adding binary masks in a neural network

Week 8:
Lec 22: MEMS mirror-based computational sensors 2 (Programmable Apertures and others)
Lec 23: MEMS mirror-based computational sensors 3 (Phase arrays and others)
Lec 24: Project 3 and 4 Presentations

Week 9:
Lec 25: Event cameras in robot perception
Lec 26: Event cameras in neural networks
Lec 27: Project 5: Upsampling event cameras + grayscale imagery (Projects 3 and 4 Assessment due)

Week 10:
Lec 28: Optical processing in cameras 1 (Classical processing, Optical templates for robotics and others)
Lec 29: Optical processing in cameras 2 (FlatCam and others)
Lec 30: Project 6: Learning optical templates under fabrication constraints

Week 11:
Lec 31: Differentiable renderers in learning frameworks
Lec 32: Rendering for descattering
Lec 33: Project 5 and 6: Presentations

Week 12:
Lec 34: LSTM and its impact on robot perception
Lec 36: Reinforcement learning in robot perception
Lec 37: Project 7: Robots and high-speed video processing (Projects 5 and 6 Assessment due)

Week 13:
Lec 38: Time-of-flight revolution 1 (Looking around corners)
Lec 39: Time-of-flight revolution 2 (Single photon sensors)
Lec 38: Project 7: Presentations

Week 14:
Lec 39: Learning from simulated worlds to real-worlds
Lec 40: Reinforcement learning in simulated worlds
Lec 41: Project 8: Robot control in Pytorch 3D (Project 7 Assessment due)

Week 15:
Lec 45: Project 8 presentations
Lec 46: Fusion with non-visual sensors (Project 8 Assessment due)
Lec 47: Sensor fusion project presentations (Graduate students' report due)

Online Course Recording
Our class sessions may be audio visually recorded for students in the class to refer back and for enrolled students who are unable to attend live. Students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to consent to have your profile or video image recorded, be sure to keep your camera off and do not use a profile image. Likewise, students who un-mute during class and participate orally are agreeing to have their voices recorded. If you are not willing to consent to have your voice recorded during class, you will need to keep your mute button activated and communicate exclusively using the "chat" feature, which allows students to type questions and comments live. The chat will not be recorded or shared. As in all courses, unauthorized recording and unauthorized sharing of recorded materials is prohibited.

Attendance Policy, Class Expectations, and Make-Up Policy

This class will be presented online using Zoom and requires access to a working webcam and stable internet connection. I prefer that students keep their camera on during the class so that I can see you as I would during normal face-to-face classes. Studies show that if we can see each other's faces then we will have more engagement, more student success, and more faculty success. However, this is not a requirement. I understand if on certain days you can't have your camera on due to internet bandwidth limitations, other family members, health issues, or any other reasons.

Excused absences must be consistent with university policies in the undergraduate catalog (https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx) and require appropriate documentation.

Evaluation of Grades

Assignment	Total Points	Percentage of Final Grade
In class projects (~10)	100 each	35%
Participation in class and Assigned paper discussion	100 each	30%
Presentations and Paper Reviews (Graduate student's report is part of the presentation)	100	15%
Final	100	20%
		100%

Participation in class will be mandatory through a round-robin student select, as done in Computational Photography, the pre-requisite for this class. Since I assign papers to read every semester, participation will require knowledge of the paper. Finally, the assessments are individual projects, that each person will code and test themselves. Each project will have an "ideal result" and the closer to that the student gets, the better the grade that will be received.

This course is co-listed with the graduate class. Grading for projects are different from the undergraduate course: the "ideal result" in both will be different. The graduate students will also have final report due that goes in depth for one of the class projects.

Grading Policy

Percent	Grade	Grade Points
90.0 - 100.0	A	4.00
87.0 - 89.9	A-	3.67
84.0 - 86.9	B+	3.33
81.0 – 83.9	B	3.00
70.0 - 80.9	B-	2.67
65.0 - 70	C+	2.33
50.0 – 64.9	C	2.00
45.0 - 50	C-	1.67
40.0 - 44.9	D+	1.33
30.0 - 39.9	D	1.00
20.0 – 29.9	D-	0.67
0 - 19.9	E	0.00

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

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/.

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/policies/student-honor-code-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 broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

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
• Robin Bielling, Director of Human Resources, 352-392-0903, rbielling@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: http://www.counseling.ufl.edu/cwc, 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 Resource Center, Reitz Union, 392-1601. Career assistance and counseling. https://www.crc.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://care.dso.ufl.edu.

On-Line Students Complaints: http://www.distance.ufl.edu/student-complaint-process.