ELEE 4280/6280 – Introduction to Robot Engineering
Spring 2023

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Text: Probabilistic Robotics, Thrun Sebastian, Wolfram Burgard, and Dieter Fox, MIT press.
State Estimation for Robotics, Timothy Barfoot, Cambridge University Press

Course Objectives

This class teaches related concepts of robot vision with a focus on autonomous lo- calization, and mapping and odometry concepts, which are essential to robotics. The typical applications include autonomous driving, augmented reality, mobile phone imaging, etc. Re- lated knowledge can be applied to air (unmanned aerial vehicles; UAV), ground (autonomous cars), and underwater robotics. This project-based course will enable students to learn related concepts and realize them to understand the essential components of the topics, such as cam- era calibration, feature extraction and tracking, outlier exclusion, and camera pose estimation. Students are expected to read the recent papers and develop ideas to realize or potentially improve current algorithms. Upon the completion of the course, students should be able to comprehend application scenarios of each major localization/mapping algorithm and obtain the basic skills to apply these algorithms in real-life.

Course Prerequisites or Co- Requisites:

Students in Engineering backgrounds such as computer science, electrical or mechanical engineering, or permission of the instructor. Basic linear algebra, geometry and programming skills are needed.

Topical Outline

The major topics are: (1) Basic knowledge and objectives regarding vision-based localization, mapping, and odometry methods. (2) Most commonly applied visual odometry methods.
(3) Typical SLAM methods (PTAM, etc) (4) Registration and localization methods (2D-to-3D, 3D-to-2D, 3D-to-3D) (5) Outlier filtering methods (multiple RANSAC, Back-projection) (6) Deep learning applications (7) Different tracking algorithms, including different features' performance, KLT, etc.

Grading

Regular homework assignments will be given and collected. Approximately 3 codings assignment and 2 projects will be assigned to explore algorithms and applications in greater depth. The assignments will focus on applications of techniques applied to robotics motion and localization. There will be two paper presentations.

Turn in code and one page report.

Coding in Matlab, Python, C/C++. For those using C/C++ get extra 5% bonus

Late policy: first 24 hours – 10% penalty, between 24 - 48 hours- 30% penalty, more than 48 hours will not be accepted (deadline: 11:59 pm on the due date).

No plagiarism allowed

Homework 20% (3 programming assignment)
Midterm exam 10%
Final exam 15%
Paper presentation 20% (2 papers)
Projects 35% (2 projects)

General Course Policies

- **Attendance.** Classroom attendance is mandatory. In preparation for a professional position in the real world, absences are only allowed in case of illness, emergencies, or special circumstances. Part of the class participation grade will be based on attendance patterns. If you know in advance that you must be gone from class, a notice or explanation (preferable written) is required in order to be considered for allowance to make up any work. Lectures will serve as an overall summary of the topic. There will be no opportunity to make up missed assignments, quizzes or classroom exercises unless approved in advance. In case of serious or protracted illness or emergency, your grades may be prorated if necessary. A student may be withdrawn from this course by the instructor without notification to the student for excessive absences or for failure to complete necessary prerequisites. For this course, "excessive absences" is defined as absences from all of the first three class
meetings or five (5) or more absences from any contiguous fifteen (15) scheduled class meetings.
- **Participation.** You are expected to actively participate in the classroom sessions and ask questions during the lecture regarding any aspects of the readings, homework, projects or lectures that are unclear to you. This will keep the class interesting for all and aid in learning by all. Due to COVID-19, face masks are strongly encouraged.
- **Assignments outside of class.** Much of what you will learn in this class will be in doing the several assignments and activities. To get closer to becoming a practicing professional (engineer), you must practice it. Please submit all homework on ELC.
- **Labs.** It is important for students to read/understand the lab contents before they come to the labs. A lab report is needed to submit onto ELC after each lab.
- **Exam.** Exams are comprehensive and will reinforce material covered in class. They will be focused on the understanding of the basic concepts/methods, and also apply the concepts/methods to solve circuit problems. ***You can look up your final exam date and time on the UGA website.***
- **Communication Quality.** The general policy of the College is having at least 30% of the grade on written materials reflects the quality of written communication will be applied. For a professional development course such as this, that % will be actually higher. **This includes the overall neatness of your work and the ability for me to understand what you put down.** Important to note: In industry and the workplace if you cannot effectively communicate your results to your supervisor, clients, or co-workers, then you have not completed the task and in essence it never happened.

- **Ethical Conduct.** Students are expected to maintain the high ethics of the engineering profession during the course; unethical behavior such as plagiarism on an assignment will be dealt with severely according to the policies and procedures on academic honesty of the University of Georgia.
- **General.**
  Studies done at the U.S. Military Academy at West Point have shown that student academic performance is hurt when mobile devices are allowed in class (see "Allowing devices in the classroom hurts academic performance.pdf"). I reserve the right to restrict their usage and/or publically call out those who violate this policy. This is good practice to learn; as you would not want to be constantly thumbing your device while in the middle of an important business meeting with your boss present, so don't do that in this class. In keeping with general professional practice in industry, hats should not be worn in class.

- **Written Assignment Format:**
  All assignments or project reports turned in must be organized and done in a manner acceptable for an engineering professional.
  Do not turn something in you would not hand it in to you supervisor at a professional job (who has hire / fire control or determines your raise for next year.)

- **Computing Tools:** The programming language can be in Matlab, Python, C and C++. While it is not the purpose of the course to teach programming, programs using C/C++ will give extra credits due to the real application requirement. The approach will be one of learning by example and application. The class will have a lecture/demonstration/discussion format.

- **University and Departmental Policies**
  ACADEMIC HONESTY
  The University of Georgia seeks to promote and ensure academic honesty and personal integrity among students and other members of the University Community. A policy on academic honesty has been developed to serve these goals. All members of the academic community are responsible for knowing the policy and procedures on academic honesty. The document for academic honesty may be found at the web site for The University of Georgia Office of Senior Vice President for Academic Affairs and Provost.
  All cases of suspected violation of the UGA Academic Honesty Policy will be reported and dealt with as appropriate.

  ENGINEERING PROFESSIONALISM POLICY
  Engineers make great contributions to society. Engineering is a very satisfying profession that provides many rewards but is demanding and requires hard work. The engineering profession is governed by a code of ethics. Engineering faculty at UGA expect students to act in a professional manner at all times and develop the work ethics required for a successful engineering career.

  Engineering students at UGA are responsible for maintaining the highest standards of professionalism and professional practice.

Coronavirus Information for Students

What do I do if I have COVID-19 symptoms?

Students showing COVID-19 symptoms should self-isolate and schedule an appointment with the University Health Center by calling 706-542-1162 (Monday-Friday, 8 a.m.-5p.m.). Please DO NOT walk-in. For emergencies and after-hours care, see https://www.uhs.uga.edu/info/emergencies.

What do I do if I test positive for COVID-19?

If you test positive for COVID-19 at any time, you arerequired to report it through the DawgCheck Test Reporting Survey. We encourage you to stay at home if you become ill or until you have excluded COVID-19 as the cause of your symptoms. UGA adheres to currentGeorgia Department of Public Health (DPH) quarantine and isolation guidanceand requires that it be followed. Follow the instructions provided to you when you report your positive test result in DawgCheck.

Guidelines for COVID-19 Quarantine Period (As of 1/1/23; follow DawgCheck or see DPH website for most up-to-date recommendations)

Students who are fully vaccinated do not need to quarantine upon exposure unless they have symptoms of COVID-19 themselves. All others should follow the Georgia Department of Public Health (DPH) recommendations:

Students who are not fully vaccinated and have been directly exposed to COVID-19 but are not showing symptoms should self-quarantine for 10 days. Those quarantining for 10 days must have been symptom-free throughout the monitoring period and continue self-monitoring for COVID-19 symptoms for a total of 14 days. You should report the need to quarantine on DawgCheck (https://dawgcheck.uga.edu/), and communicate directly with your faculty to coordinate your coursework while in quarantine. If you need additional help, reach out to Student Care and Outreach (sco@uga.edu) for assistance.

Students, faculty and staff who have been in close contact with someone who has COVID-19 are no longer required to quarantine if they have been fully vaccinated against the disease and show no symptoms.

Well-being, Mental Health, and Student Support

If you or someone you know needs assistance, you are encouraged to contact Student Care & Outreach in the Division of Student Affairs at 706-542-7774 or visit https://sco.uga.edu/. They will help you navigate any difficult circumstances you may be facing by connecting you with the appropriate resources or services.

UGA has several resources to support your well-being and mental health: https://well-being.uga.edu/

Counseling and Psychiatric Services (CAPS) is your go-to, on-campus resource for emotional, social and behavioral-health support: https://caps.uga.edu/, TAO Online Support(https://caps.uga.edu/tao/), 24/7 support at 706-542-2273. For crisis support: https://healthcenter.uga.edu/emergencies/.

The University Health Center offers FREE workshops, classes, mentoring and health coaching led by licensed clinicians or health educators: https://healthcenter.uga.edu/bewelluga/

Monitoring conditions:

Note that the guidance referenced in this syllabus is subject to change based on recommendations from the Georgia Department of Public Health, the University System of

Georgia, or the Governor's Office or. For the latest on UGA policy, you can visit coronavirus.uga.edu

Course Schedule
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	Topic
Week 1-3	Theory for motion estimation, transformation matric, Epipolar geometry
Week 4-5	Feature tracking, Tracking algorithms
Week 6-7	Visual odometry, Stereo odometry,
Week 8-9	Mid-term paper presentation, exam and project presentation
Week 10-15	SLAM, PTAM, Localization, ICP
Week 16	Final exam, project and Presentation

Final Examination: see UGA arrangement