CS 3630 Introduction to Robotics and Perception

Fall 2021

Instructor: Prof. Harish Ravichandar, harish.ravichandar@cc.gatech.edu, Klaus 1310

TAs: List of TAs with contact info: https://shorturl.at/doO69

Lectures: TR 3:30 pm - 4:45 pm in Kendeda "The Living" Building – Room 152

Websites:

- **Canvas:** We will use Canvas for tracking grades and for lab submissions.
- **Piazza**: All announcements, assignments and discussions will be available through Piazza. Sign up at https://piazza.com/gatech/fall2021/cs3630

Office Hours (for both the instructor and the TAs): Calendar at https://shorturl.at/jszHL

Robotics Education Lab: CCB 030 (Directions at https://bit.ly/2Z635Gj)

Course Description

This course covers fundamental problems and leading solutions to autonomous robot behavior – how can a robot perceive the world, and how can it use that information to operate effectively.

The only formal prerequisite is CS1332 Data Structures & Algorithms. Prior knowledge of fundamentals of linear algebra and probability is very helpful, but not required. Background in AI and ML is not assumed. All programming assignments will be completed in Python.

The course requires access to a laptop and a mobile device (cell phone or tablet) running Android or iOS and a cable to connect your phone to your laptop. If you don't have access to these, please contact the instructor ASAP.

Course Objectives

Upon completion of this course, students will be able to:

- describe and explain what robots are and what they can do
- describe mathematically the position and orientation of objects and how they move
- design a control architecture for a mobile robotic system
- implement navigation and localization algorithms based on sensor fusion and environment representation
- write moderately involved programs in Python to control a robotic system
- construct, program, and test the operation of a robotic system to perform a specified task.

Reference Material

There is no assigned textbook for this course, but material covered in lectures has significant overlap with the following textbooks:

1. *Introduction to Autonomous Mobile Robots*, by R. Siegwart, I. Nourbakhsh, MIT Press, 2011.
2. *Robotics, Vision and Control*, by Peter Corke, Springer, 2011.
3. *Mobile Robots: Navigation, Control and Remote Sensing*, by G. Cook, Wiley-IEEE Press, 2011.

All three books are available in digital form through online access at the Georgia Tech library.

Lecture Streaming and Recording

All lectures will be delivered in Room 152 of the Kendeda Building. Each lecture will be streamed live on Bluejeans and recorded for later viewing. Please check the Bluejeans tab on Canvas for links to the live lectures and to access recordings of past lectures.

Assignments and Grading

Labs (10% each): There will be 6 lab assignments throughout the semester, each worth 10% of the final grade. Lab 1 will be completed individually, and labs 2-6 in pairs. Lab grades will be determined using the grading rubric provided with each lab assignment. **Late Policy:** Due to challenges introduced by the pandemic, we are also adding a *72-hour grace period* for lab assignments. Submissions (or demos) made up to 72 hours past the deadline will not be penalized. Submissions (or demos) made more than 72 hours past the deadline will not be graded unless you've received explicit special permission for an extenuating circumstance from course staff ahead of time.

Quizzes (6% each): There will be 7 quizzes throughout the semester at the end of class on the dates designated on the syllabus. For each student, the quiz with the lowest grade will be dropped, and the remaining 6 quizzes will each be worth 6% of the final course grade. Because the lowest quiz is being dropped, we will not be rescheduling quizzes missed due to unexcused absences (travel, job interviews, etc.). Make-up quizzes will only be scheduled for absences approved by the Dean of Students or by special permission by the instructor.

Participation (4%): The participation grade will be based on peer review by your partner(s) at the end of the semester.

Extra Credit: You may earn extra credit throughout the semester by making a helpful contribution to the class – basically any significant contribution that helps others excel. Extra credit will be assigned as 0.2-0.5% of total class grade (e.g. a final class grade of 89.7 could be bumped up to 90.2), depending on the type of contribution. Submissions should be posted publicly to Piazza. Example contributions include, but are not limited to:

- A tutorial about how to overcome a common robot issue – 0.2%
- Posting a link to an external library and including a short, general-purpose example of how it could be used in a given setting – 0.2%
- Releasing code for an improved visualization or debugging tool – 0.5%

Feel free to reach out to the course staff if you have any questions. Multiple extra credit submissions may be made.

Partners

You may partner with another student to complete Labs 2-6. All other assignments are to be completed individually. Labs 2-6 may also be completed individually if you prefer. You may also switch partners between assignments, or complete some assignments individually and some with a partner. Just make sure it's clear on the submission who the work should be attributed to.

Communication with Course Staff and Peers

We will be using Piazza and Canvas for course announcements, questions, and discussion.

For the best and fastest response, we ask that you post your questions on Piazza instead of sending emails. If others are likely to have a similar question or benefit from the answer, make a public Piazza post. Feel free to make private posts to the course staff if your question concerns a solution, your grade, or other private information.

We encourage everyone to actively contribute to discussion, answer each other's questions and generally use Piazza as broadly as possible to make the course run smoothly. We recommend configuring the email settings to send new post notifications in real time, not at the end of the day.

Robots

You (and your partner) will receive a robot to use for the semester that you will return, with all accessories, at the end of the course. **You will use one of two robots: Cozmo or Vector**. Each robot will be numbered, and we will keep track of who has which robot. At the end of the semester, you are responsible for returning the robot for which your name is listed. If you switch teams and start using a new robot, please email one of the TAs and they will update the spreadsheet.

Why are there two different robots? The class originally used the Cozmo robot made by Anki. Anki later released an updated version of the robot under the name Vector. Visually, the two robots look the same except for the color (Cozmo in white, Vector in dark gray). Georgia Tech owns a mix of Cozmo and Vector robots.

Anki vs Digital Dream Labs? To make matters extra confusing, Anki was bought by Digital Dream Labs, who are continuing to manufacture and support Vector. So when you search online, you'll see mentions of both companies.

What are key differences between Cozmo and Vector? The main difference between the two platforms is Internet connectivity. Cozmo creates its own network and requires you to connect your phone to that network in order to execute your code. Vector is instead configured to connect to an external WiFi. There are minor additional differences, such as camera resolution.

Which robot will I get? Either one, you won't be able to control which robot you receive.

How will the model of the robot impact my work? Robot version should have minimal impact on lab assignments. All labs were designed to be compatible with both robots. If needed, separate instructions will be provided.

Can I use my own robot? Yes, definitely. Let us know if you already have access to either Cozmo or Vector and we'll note that down in our records.

Note that the robots are the property of the College of Computing, and the College may charge a fee of up to $175 for the cost of the robot if it is not returned at the end of the semester.

Course Policies

The course schedule and policies mentioned in this syllabus may change at any time during the term, but all changes will be clearly documented and announced.

Student Disability Services: If you need course adaptations or accommodations because of a disability, or if you have medical information to share with the instructor, please contact the Office of Disability Services and register with them. In addition, please make an appointment or stop by to speak with the instructor within the first week of classes so that we can make necessary arrangements to support you.

Academic Honesty Policy: Review Georgia Tech's Academic Honor Code. Any work you present as your own should represent your own understanding of the material. When external sources were used as significant points of information (sample code, etc.), the source must be referenced in your submission. Following Georgia Tech's guidelines, all suspected cases of academic cheating will be forwarded for review by the Office of Student Integrity.

Acknowledgements

Assignments, lectures, and ideas on this syllabus are adapted from prior offerings of this course at Georgia Institute of Technology by Profs. Sonia Chernova, Frank Dellaert, and Seth Hutchison. I would like to thank Sonia, Frank, and Seth for the helpful discussions and access to their course materials.

Tentative Schedule

DATE	TOPIC	NOTES
Tue Aug 24	Course Introduction	
Module 1: Perception		
Thu Aug 26	Image Processing and Object Recognition – Episode I	
Tue Aug 31	Image Processing and Object Recognition – Episode II	
Thu Sep 02	***Pick up robots at Robotics Education Lab in CCB***	
Tue Sep 07	Image Processing and Object Recognition – Episode III	**Lab 1 due**
Thu Sep 09	Coordinate Transforms – Episode I	***Quiz 1: Aug 24 – Sep 07***
Tue Sep 14	Coordinate Transforms – Episode II	
Thu Sep 16	***Demo day***	**Lab 2 due**
Module 2: Estimation		
Tue Sep 21	Representing Uncertainty, Foundations of Localization	***Quiz 2: Sep 09 – Sep 16***
Thu Sep 23	Particle Filter – Episode I	
Tue Sep 28	Particle Filter – Episode II	
Thu Sep 30	Kalman Filter – Episode I	***Quiz 3: Sep 21 – Sep 24***
Tue Oct 05	Kalman Filter – Episode II	**Lab 3 due**
Thu Oct 07	Fundamentals of SLAM	
Tue Oct 12	Self-Driving Cars and Open Discussion	
Module 3: Planning		
Thu Oct 14	Representations and Fundamentals	***Quiz 4: Sep 26 – Oct 03***
Tue Oct 19	Search-based Methods	
Thu Oct 21	Probabilistic Methods – Episode I	
Tue Oct 26	***Demo day***	**Lab 4 due**
Thu Oct 28	Probabilistic Methods – Episode II	***Quiz 5: Oct 08 – Oct 22***
Module 4: Control		
Tue Nov 2	Robot Control – Episode I	
Thu Nov 4	Robot Control – Episode II	
Tue Nov 09	Potential fields, Tentacles, and Exploration	***Quiz 6: Oct 29 – Oct 31***
Thu Nov 11	***Demo day***	**Lab 5 due**
Guest Speakers		
Tue Nov 16	*Guest Speaker: Prof. Sehoon Ha*	
Thu Nov 18	*Guest Speaker: Prof. Karen Feigh*	
Tue Nov 23	Open Discussion	***Quiz 7: Nov 12 – Nov 19***
Thu Nov 25	***Thanksgiving Break***	
Module 5: Robot Learning		
Tue Nov 30	Robot Learning – Episode I	
Thu Dec 02	Robot Learning – Episode II	
Tue Dec 07	***Demo Day***	**Lab 6 due; return robots**