CS 3630 Introduction to Robotics and Perception

Fall 2020

Instructor: Prof. Sonia Chernova, chernova@gatech.edu

TAs: List of TAs with contact info: https://bit.ly/2CwCPdY

Modality: Hybrid (touchpoints)

Designated Live Sessions: TuTh 3:30-4:45pm

Websites: All course content can be accessed through Canvas. This includes access to a Piazza portal for discussion.

Office Hours: to be posted on Canvas and Piazza

Course Description

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

The only formal prerequisite is CS1332 Data Structures & Algorithms. Prior knowledge of fundamentals of linear algebra and probability is helpful, but not required. Background in AI and Machine Learning is not assumed.

The course requires access to a laptop and a mobile device (cell phone or tablet) running Android or iOS. If you don't have access to these, please contact the instructor ASAP. All programming assignments will be completed in Python.

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
- Develop 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.

Course Modality Information

This course is designated as a Hybrid-Touchpoints course. All course content – lectures, assignments, assessments, and office hours – will be available online. In-person touchpoints will consist of picking up and/or dropping off equipment (see Robots section later in the document).

Attendance will not be taken in the class.

The course will include the following content delivery modes:

- **Lectures** - pre-recorded and made available for asynchronous viewing.
- **Discussions** – these will be public discussion sessions held during our normally scheduled class time (TuTh 3:30-4:45pm). The session will be structured as an interaction between the instructor and/or course TAs and attending students. The session will be recorded for later viewing. This is not a time to get one-on-one help on an assignment, but rather to get answers to more broad questions relating to course content. This is also a great opportunity for quiz prep.
- **Office Hours** – one-on-one office hours designed for private assistance regarding a personal issue or an assignment.

The course will include the following graded assessments (see Assignments and Grading section below for full details):

- **Lab assignments** – performed remotely and submitted online.
- **Quizzes** – completed online.
- **Research Topics** – completed remotely and submitted online.

When using remote teleconferencing software, we ask that you keep your camera on when possible. This is especially true for one-on-one and small group discussions.

References

There is no assigned textbook for this course. Relevant excerpts from various texts will also be provided on Canvas.

Assignments and Grading

All graded content will be made available on Canvas and turned in through Canvas.

Labs (10% each, 60% total): There will be 6 lab assignments throughout the semester, each worth 10% of the final grade. Lab 1 must be completed individually. Labs 2-6 may be completed either individually or in pairs. Lab grades will be determined using the grading rubric provided with each lab assignment. **Late Policy:** All lab assignments are due at the time and date indicated on the assignment document. Due to challenges introduced by remote learning, we are also adding a 72-hour grace period for lab assignments: submissions made up to 72 hours past the deadline will not be penalized. Assignments submitted more than 72 hours past the deadline will not be graded unless you've received special permission from course staff ahead of time.

Quizzes (5% each, 25% total): There will be 6 quizzes throughout the semester. For each student, the quiz with the lowest grade will be dropped, and the remaining 5 quizzes will each be worth 5% of the final course grade. Quizzes will be conducted online through Canvas/Gadescope.

Research Topics (3% each, 15% total): Robotics is a broad field, and we will cover only a small part of it in this course. To provide better perspective for the field as a whole, we will be using video lectures of leading researchers across the world. ~~We will provide a list of potential videos to watch, and you will pick 5 to view and submit a short writeup on.~~ A specific video will be assigned for each research topic assignment.

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 course staff if you have any questions. Multiple extra credit submissions may be made.

Grading Scale

Your final grade will be assigned as a letter grade according to the following scale:

A	90-100%
B	80-89%
C	70-79%
D	60-69%
F	0-59%

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.

Robots

You will use one of two robots: Cozmo or Vector.

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.

I'm in Atlanta, how do I get a robot? We will distribute robots during the third week of class. You will be able to schedule a time to pick up your robot on campus. Robots must be returned (in person or by post) at the end of the semester. More information regarding these logistics will be provided early in the term.

I'm not in Atlanta, how do I get a robot? You will need to provide us with a shipping label and we will ship the robot to you. You will need to ship the robot back at the end of the semester. More information regarding these logistics will be provided early in the term. Please reach out to Prof. Chernova if the shipping costs present a hardship and we will seek out other arrangements. For some students (e.g., international), obtaining a robot locally may be more cost effective.

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.

Communication with Course Staff and Peers

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

For the best and fastest response, we ask that you post your questions on Piazza instead of sending email. 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.

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 make an appointment or stop by to speak with Prof. Chernova within the first week of classes.

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.

Health-Related Considerations: The following health guidelines apply for all in-person touchpoints (primarily picking up and/or dropping off robot equipment).

Effective July 15, 2020, University System of Georgia (USG) institutions require all faculty, staff, students, and visitors to wear an appropriate face covering while inside campus facilities/buildings where six feet social distancing may not always be possible. All members of the campus community will be provided reusable cloth face coverings.

Face covering use will be in addition to and is not a substitute for social distancing. Anyone not using a face covering when required will be asked to wear one or must leave the area. Refusal to comply with the requirement may result in discipline through the applicable conduct code for faculty, staff or students.

There are a few exemptions. Reasonable accommodations may also be made for those who are unable to wear a face covering for documented health reasons.

For more information about face masks and coverings, review the guidelines from Human Resources.

Tentative Schedule

DATE	TOPIC	Due Dates
Week 1	Course Introduction	
Aug 18-20	Introduction to Robotic Systems	
Week 2	Computer Vision Fundamentals	
Aug 25-27	Image Processing: Segmentation, ~~ICP~~, RANSAC Foundations of Supervised Learning	
Week 3	Deep Learning for Vision	Sept 1: Lab 1 due
Sept 1-3		Sept 3: Quiz 1
Week 4	Representing Robot Pose	Sept 10: Research Topic 1 due
Sept 8-10	Differential Drive Robots	
Week 5	Representing Uncertainty	Sept 15: Lab 2 due
Sept 15-17	Foundations of Localization	Sept 17: Quiz 2
Week 6	Particle Filter Localization	Sept 24: Research Topic 2 due
Sept 21-23		
Week 7	Kalman Filter Localization	Oct 1: Quiz 3
Sept 29 - Oct 1		
Week 8	Kinematics in the Plane	Oct 6: Lab 3 due
Oct 6-8		
Week 9	Forward Kinematics	Oct 13: Research Topic 3 due
Oct 13-15	Inverse Kinematics	Oct 15: Quiz 4
Week 10	Path Planning: Representations and Fundamentals	
Oct 20-22	Path Planning: Search	Oct 20: Lab 4 due
Week 11	Path Planning: Probabilistic Methods	Oct 27: Research Topic 4 due
Oct 27-29		Oct 29: Quiz 5
Week 12		*Election day, Tue Nov 4th*
Nov 3-5	Robot Behavior Programming	Nov 4: Lab 5 due
Week 13	Autonomous Driving	Nov 10: Research Topic 5 due
Thu Nov 10-12	Potential fields, tentacles and exploration	
Week 14	Reinforcement Learning	Nov 17: Quiz 6
Nov 17-19	Deep Reinforcement Learning	Nov 19: Lab 6 due
Week 15 Nov 24	*Final instructional week, no new material*	return robots