CPE 521-A Autonomous Mobile Robotic Systems

School of Engineering and Science

Fall 2021

Instructor: Yi Guo
Canvas Course Address: https://sit.instructure.com/courses/49794
Course Schedule: Tuesday 12:30pm-3:00pm
Contact Info: (201) 216 5658. Please use Canvas email.
Office Hours: Tuesday 3-5pm, and by appointment
Office Location: Burchard 202
Zoom Link for Office Hours: https://stevens.zoom.us/j/7860071815
Prerequisite(s): This course does not assume any prior knowledge of robotics. However, the course does assume a working knowledge of calculus, discrete math, matrix algebra, probability, and the ability to program in Matlab, C++, or Python.

COURSE DESCRIPTION

This course will offer the students an overview of the technology of autonomous mobile robotic systems and the mechanisms that allow a mobile robot to move through a real-world environment to perform its tasks. Since the design of any successful mobile robot involves the integration of many different disciplines -- among them kinematics, signal analysis, information theory, artificial intelligence, and probability theory -- the course will discuss all facets of mobile robotic system, including hardware design, wheel design, kinematics analysis, sensors and perception, localization, mapping, motion planning, navigation, and robot control architectures. Multi-robot systems will also be introduced due to their broader applications, such as search and rescue tasks, and exploring tasks. Credit: 3.

STUDENT LEARNING OUTCOMES

After successful completion of this course,

- Student will be able to express the kinematic model of a differential drive mobile robot;
- Student will be able to express the relationship between the global reference frame of the plane and the local reference frame of the robot;
- Student will be able to identify common sensors on robots and describe the functionality;
- Student will be able to understand robot localization methods and apply them in indoor environments.

COURSE FORMAT AND STRUCTURE

To access the course, please visit stevens.edu/canvas .

Lecture Time and Location

Lecture: Tuesday 12:30pm-3:00pm
Location: McLean 119

Course Logistics

- Attendance of lectures is mandatory.
- New course materials will be posted before the lecture time every week. It is your responsibility to check the posted materials (lecture slides, reading assignments, and homework assignments, etc.) in the weekly Module promptly.
- When assignments are due, they are due by 9:00 p.m. EST on the due date listed in the course schedule.
- Deadlines are an unavoidable part of being a professional and this course is no exception. Course requirements must be completed and posted or submitted on or before specified due date and delivery time deadline. Due dates and delivery time deadlines are defined as Eastern Standard Time (as used in Hoboken, NJ). Please note, students living in distance time zones or overseas must comply with this course time and time and due date deadline policy.
- All homework and report submissions are through Canvas. The server will not accept late submissions. For example, if the deadline of assignment is 9:00 p.m., the server will not accept any upload after 9:00 p.m. server time. You'll have enough time for each assignment, so please submit early. Don't scan and upload at the last minute. Scanners or computers are not responsible for late submission but you are.
- An assignment file should be appended by your last name, such as "assignment1_[YourLastName].pdf". This may make it easier for me to manage assignment files.

Virtual Office Hours

Virtual Office Hours are a synchronous session (through Zoom) to discuss questions related to weekly readings and/or assignments. Office hours will be held Tuesday 3-5pm EST. To connect to the weekly session, go to https://stevens.zoom.us/j/7860071815.

Instructor's Online Hours

I will be available via email and will respond as soon as I am available (generally within 24-48 hours). For the online discussions, I will check in at least 3 times per week. Keep in mind that it is not possible for me to respond to every single posting every week (nor is it pedagogically appropriate), but I will be sure to respond to a variety of postings and students each week and attempt to assure equality in terms of responses to students. Furthermore, there is a specific discussion forum that you can use to ensure that you have my attention – to ask questions or to call my attention to a particular discussion you are engaged in that you would like me to take a look at. If you feel you are being neglected in any way, please contact me use Canvas email. Also please check your Canvas email. I use the Canvas email for group announcements and individual emails.

TENTATIVE COURSE SCHEDULE

Tentative Course Schedule

Week	Date	Topics	Readings	Assignment
1	8/31	Introduction to Autonomous Mobile Robotic Systems	Textbook Chapter 1	
2	9/7	Locomotion: Legged Robots	Textbook Chapter 2: 2.1, 2.2	Multimedia Watching
3	9/14	Locomotion: Wheeled Robots	Textbook Chapter 2: 2.3, 2.4	Quiz #1 in Class
4	9/21	Mobile Robot Kinematics	Textbook Chapter 3	HW#1 Due 9/28
5	9/28	Lab 1: Matlab Simulation for Kinematic Position Control	Lab 1 Instruction	Lab 1 Report Due 10/5
6	10/5	Sensors for Mobile Robots, Vision	Textbook Chapter 4: 4.1, 4.2-4.7	HW#2 Due 10/12
7	10/12	No Class, Monday Class Schedule		
8	10/19	**Midterm Exam**		
9	10/26	Mobile Robot Localization 1	Textbook Chapter 5: 5.1-5.4	Quiz #2 in Class
10	11/2	Mobile Robot Localization 2	Textbook Chapter 5: 5.5-5.7	Quiz #3 in Class
11	11/9	Simultaneous Localization and Mapping (SLAM)	Textbook Chapter 5: 5.8	HW #3 due 11/16
12	11/16	Lab 2: Robotics Simulation, ROS	Lab 2 Instruction	Lab 2 Report Due 11/23
13	11/23	Final Project Assignment	Final Project Guidelines	**Final Project Report Due 12/14 (Tuesday)**
14	11/30	Final Project Consultation		
15	12/7	Final Project Presentation		

COURSE MATERIALS

Textbook:
R. Siegwart, I. Nourbakhsh, and D. Scaramuzza, Introduction to Autonomous Mobile Robots, Second Edition, The MIT Press, 2011. ISBN 0-262-01535-8.

COURSE REQUIREMENTS

Attendance: Attendance of lectures is mandatory. Attendance verification is reported to university during the semester following university policy.

Homework: The homework assignment is due the next **Tuesday** by 9:00 p.m. EST after the assignment. Please scan your homework in a single pdf file, and submit it online through Canvas following the homework submission link. Solutions will be posted after the due date on Canvas, and grades will also be posted in Canvas. Please mark your calendar for homework due dates. Late assignment will not be accepted. Possible revision of grades may be discussed immediately following the announcement of grades (no later than one week from it).

Quizzes: Quizzes will be offered a few times throughout the semester, and will be automatically graded in Canvas. They are designed to help inform the instructor whether students understand course content. Quizzes are administrated during the lecture time.

Labs: There will be two labs, one on Matlab programing and one on Robot Operating System (ROS) installation. Lab reports are due one week after the assignment on Tuesday by 9:00 p.m. EST.

Midterm Exam: The midterm exam will be held on Oct. 19 (Tuesday) during the class time from 12:30 p.m. to 3:00 p.m.

Final Project: The final project will be a programing task in Robot Operating System (ROS). Detailed final project assignment and guidance will be distributed in class. A final report is due three weeks after the assignment.

TECHNOLOGY REQUIREMENTS

Baseline technical skills necessary for online courses

- Basic computer and web-browsing skills
- Navigating Canvas

Technology skills necessary for this specific course

- Live web conferencing using Zoom for Online Lectures and Virtual Office Hours

Required Equipment

- Computer: PC with Linux, or PC with Windows 7+, or Mac (OS X) with high-speed internet connection
- Webcam: built-in or external webcam, fully installed
- Microphone: built-in laptop or tablet mic or external microphone

Required Software

- Microsoft Word for lab reports and final project report
- Matlab
- Robot Operating System (ROS): instruction will be given on installation and resources

GRADING PROCEDURES

Grades will be based on:

Homework	20%
Quizzes	15%
Lab Reports	15%
Midterm Exam	25%
Final Project	25%

Late Policy

Late assignment will not be accepted.

Academic Integrity

Graduate students in 500-level courses are bound by the Graduate Student Code of Academic Integrity, while undergraduate students in those courses have special provisions that have been agreed upon by the Dean of Graduate Academics and the Honor Board.

Undergraduate Honor System

Enrollment into the undergraduate class of Stevens Institute of Technology signifies a student's commitment to the Honor System. Accordingly, the provisions of the Stevens Honor System apply to all undergraduate students in coursework and Honor Board proceedings. It is the responsibility of each student to become acquainted with and to uphold the ideals set forth in the Honor System Constitution. More information about the Honor System including the constitution, bylaws, investigative procedures, and the penalty matrix can be found online at http://web.stevens.edu/honor/

The following pledge shall be written in full and signed by every student on all submitted work (including, but not limited to, homework, projects, lab reports, code, quizzes and exams) that is assigned by the course instructor. No work shall be graded unless the pledge is written in full and signed.

"I pledge my honor that I have abided by the Stevens Honor System."

Reporting Honor System Violations

Students who believe a violation of the Honor System has been committed should report it within ten business days of the suspected violation. Students have the option to remain anonymous and can report violations online at www.stevens.edu/honor.

Graduate Student Code of Academic Integrity

All Stevens graduate students promise to be fully truthful and avoid dishonesty, fraud, misrepresentation, and deceit of any type in relation to their academic work. A student's submission of work for academic credit indicates that the work is the student's own. All outside assistance must be acknowledged. Any student who violates this code or who knowingly assists another student in violating this code shall be subject to discipline.

All graduate students are bound to the Graduate Student Code of Academic Integrity by enrollment in graduate coursework at Stevens. It is the responsibility of each graduate student to understand and adhere to the Graduate Student Code of Academic Integrity. More information including types of violations, the process for handling perceived violations, and types of sanctions can be found at www.stevens.edu/provost/graduate-academics.

Special Provisions for Undergraduate Students in 500-level Courses

The general provisions of the Stevens Honor System do not apply fully to graduate courses, 500 level or otherwise. Any student who wishes to report an undergraduate for a violation in a 500-level course shall submit the report to the Honor Board following the protocol for undergraduate courses, and an investigation will be conducted following the same process for an appeal on false accusation described in Section 8.04 of the Bylaws of the Honor System. Any student who wishes to report a graduate student may submit the report to the Dean of Graduate Academics or to the Honor Board, who will refer the report to the Dean. The Honor Board Chairman will give the Dean of Graduate Academics weekly updates on the progress of any casework relating to 500-level courses. For more information about the scope, penalties, and procedures pertaining to undergraduate students in 500-level courses, see Section 9 of the Bylaws of the Honor System document, located on the Honor Board website.

EXAM CONDITIONS

The following procedures apply to quizzes and the midterm exam for this course.

1. Students may use the following materials during quizzes and/or exams. Any materials that are not mentioned in the list below are not permitted.

Material	Permitted?	
	Yes	No
Handwritten Notes	X	
Typed Notes	X	
Textbooks	X	
Readings	X	
Calculator	X	

2. Students are not allowed to work with or talk to other students during quizzes and the midterm exam.
3. For the final project, you may work with other students on programming in ROS, but each student should write the final report independently.

LEARNING ACCOMODATIONS

Stevens Institute of Technology is dedicated to providing appropriate accommodations to students with documented disabilities. The Office of Disability Services (ODS) works with undergraduate and graduate students with learning disabilities, attention deficit-hyperactivity disorders, physical disabilities, sensory impairments, psychiatric disorders, and other such disabilities in order to help students achieve their academic and personal potential. They facilitate equal access to the educational programs and opportunities offered at Stevens and coordinate reasonable accommodations for eligible students. These services are designed to

encourage independence and self-advocacy with support from the ODS staff. The ODS staff will facilitate the provision of accommodations on a case-by-case basis.

For more information about Disability Services and the process to receive accommodations, visit https://www.stevens.edu/office-disability-services. If you have any questions please contact: Phillip Gehman, the Director of Disability Services Coordinator at Stevens Institute of Technology at pgehman@stevens.edu or by phone 201-216-3748.

Disability Services Confidentiality Policy

Student Disability Files are kept separate from academic files and are stored in a secure location within the Office of Disability Services. The Family Educational Rights Privacy Act (FERPA, 20 U.S.C. 1232g; 34CFR, Part 99) regulates disclosure of disability documentation and records maintained by Stevens Disability Services. According to this act, prior written consent by the student is required before our Disability Services office may release disability documentation or records to anyone. An exception is made in unusual circumstances, such as the case of health and safety emergencies.

INCLUSIVITY

Name and Pronoun Usage

As this course includes group work and class discussion, it is vitally important for us to create an educational environment of inclusion and mutual respect. This includes the ability for all students to have their chosen gender pronoun(s) and chosen name affirmed. If the class roster does not align with your name and/or pronouns, please inform the instructor of the necessary changes.

Inclusion Statement

Stevens Institute of Technology believes that diversity and inclusiveness are essential to excellence in academic discourse and innovation. In this class, the perspective of people of all races, ethnicities, gender expressions and gender identities, religions, sexual orientations, disabilities, socioeconomic backgrounds, and nationalities will be respected and viewed as a resource and benefit throughout the semester. Suggestions to further diversify class materials and assignments are encouraged. If any course meetings conflict with your religious events, please do not hesitate to reach out to your instructor to make alternative arrangements.

You are expected to treat your instructor and all other participants in the course with courtesy and respect. Disrespectful conduct and harassing statements will not be tolerated and may result in disciplinary actions.

MENTAL HEALTH RESOURCES

Part of being successful in the classroom involves a focus on your whole self, including your mental health. While you are at Stevens, there are many resources to promote and support mental health. The Office of Counseling and Psychological Services (CAPS) offers free and confidential services to all enrolled students who are struggling to cope with personal issues (e.g., difficulty adjusting to college or trouble managing stress) or psychological difficulties (e.g., anxiety and depression). CAPS is open daily from 9:00 am – 5:00 pm M-F. Evening hours are available by appointment in the Fall / Spring semesters and up-to-date information regarding the availability of evening appointments can be found by visiting www.stevens.edu/CAPS. To schedule an appointment, call 201-216-5177.

Due to the pandemic, in-person appointments may be limited until further notice. Up-to-date information about the availability of in-person services can be found at www.stevens.edu/CAPS. Teletherapy (therapy via secure video platform) is available to registered students physically located in the states of New York or New Jersey. Students located outside of NY / NJ are encouraged to pursue local treatment through their personal health insurance. To learn more about the process of finding a therapist please visit the CAPS webpage on Seeking Help Off-Campus.

EMERGENCY INFORMATION

In the event of an urgent or emergent concern about the safety of yourself or someone else in the Stevens community, please immediately call the Stevens Campus Police at 201-216-5105 or on their emergency line at 201-216-3911. These phone lines are staffed 24/7, year round. For students who do not reside near the campus and require emergency support, please contact your local emergency response providers at 911 or via your local police precinct. Other 24/7 national resources for students dealing with mental health crises include the National Suicide Prevention Lifeline (1-800-273-8255) and the Crisis Text Line (text “Home” to 741-741). If you are concerned about the wellbeing of another Stevens student, and the matter is *not* urgent or time sensitive, please email the CARE Team at care@stevens.edu. A member of the CARE Team will respond to your concern as soon as possible.