CSCI 4302/5302: Advanced Robotics

Learning goal: Design and implement algorithms and hardware that enable autonomy in uncertain, dynamic environments.

Instructor: Christoffer Heckman (`christoffer.heckman@colorado.edu`), ECES 130

Graduate Course Assistants: Jeff Venicx (`jeff.venicx@colorado.edu`), Mike Miles (`mike.miles@colorado.edu`), Carl Stahoviak (`carl.stahoviak@colorado.edu`).

Grader: Carl Stahoviak (`carl.stahoviak@colorado.edu`).

Meeting times: Monday, Wednesday and Friday, 9–10am.

Office hours: Monday and Wednesday, 10–11am in Chris's office, and by appointment.

Website: `https://moodle.cs.colorado.edu`.

Textbook: Springer Handbook of Robotics, ed. Siciliano & Khatib; e-book available through library.

Description: This class is the follow-up class to CSCI3302 "Introduction to Robotics." Robots perceive their environment with signal processing and computer vision techniques, reason about them using machine learning, artificial intelligence and discrete algorithms, and execute their actions based on constraints imposed by sensor uncertainty, their mechanism, and their dynamics. "Advanced Robotics" will teach the key concepts used by autonomous mobile platforms and provide hands-on experience with state-of-the-art software and systems.

Lecture materials are supported by exercises around the "Robot Operating System" ROS and will lead to the completion of a group project. After the Autonomous Vehicle Competition (AVC) at SparkFun, and the F$\frac{1}{10}^{\text{th}}$ Autonomous Racing Competition at CPS Week in Pittsburgh, this class will focus on robust autonomous driving. Exercises will be conducted in a virtual environment and will later be transferred to a autonomous vehicle platform.

Topics: Computer vision including sparse visual odometry, simultaneous localization and mapping (SLAM), sensor fusion and filtering; the Robot Operating System (ROS); planning algorithms, nonholonomic constraints in dynamics and controls; intrinsic and extrinsic sensor calibration; embedded systems; and experimental robotics.

Grading: Your grade will be determined by the following breakdown:

Attendance and participation: 10%.

Seminar speaker selfies/reports: 10%.

Midterm: 15%.

Semester project: 30%.

Assignments: 35%.

Attendance and Participation: Your attendance and participation in class is mandatory. Every course meeting will result in a participation grade:

2 points if you are present and contributing satisfactorily.

1 point if you are present but tardy, or not contributing.

0 points if you are absent.

With 43 class meetings and 2 points possible per class meeting, there are 90 participation points available. The attendance grade however will be out of 74 to permit the occasional absence for any or reason or lack thereof.

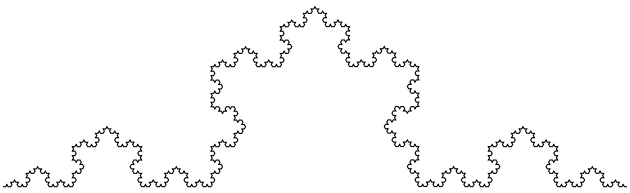
Seminar Speaker Reports: During the course of this semester, we will have at least three seminar speakers in the field of robotics visit CU Boulder's College of Engineering and Applied Science to give presentations on their research. The dates of these speakers are currently **to be determined**. You have two choices: attend the seminar and upload a selfie with the speaker (need not be right next to her/him), or read the speaker's research website along with one of her/his publications and write a 1-page report, to be submitted on Moodle by the due date announced.

Exams and Competition: Practical experience with programming and team-based code development is a standard skill required for work in robotics. The course final will consist of a competition tackled by small teams; more details on this will be released in the first half of the semester.

Student teams will participate in a midterm competition to demonstrate adequate progress toward the final exam competition **by the end of class on March 22**.

Student teams will participate in a competition during the final exam period for the course, **1:30–4p on May 8** (University link). All team members must be present for this final examination, or notify the instructor by four weeks before this date to arrange accommodation. There may be an alternate date arranged mid-semester in the event some team(s) wish to compete in advance.

Assignments: There will periodically be assignments offered during the course of the semester which are designed to give practical experience geared toward a successful semester project. Assignments must be completed individually unless otherwise noted on the prompt.



Disability Accommodations: If you qualify for accommodations because of a disability, please submit to your instructor a letter from Disability Services in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities. Contact Disability Services at 303-492-8671 or by e-mail at dsinfo@colorado.edu. If you have a temporary medical condition or injury, see the Temporary Injuries guidelines under the Quick Links at the Disability Services website.

Religious Observances: Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments, or required attendance. In this class, all students are permitted a set number absences without any affect on their attendance grade, for any reason including religious accommodation. See the campus policy regarding religious observances for full details.

Classroom Behavior: Students and faculty each have responsibility for maintaining an appropriate learning environment. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, color, culture, religion, creed, politics, veteran's status, sexual orientation, gender, gender identity and gender expression, age, disability, and nationalities. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. For more information, see the policies on classroom behavior and the student code.

Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation: The University of Colorado Boulder (CU Boulder) is committed to maintaining a positive learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct, discrimination, harassment or related retaliation against or by any employee or student. CU's Sexual Misconduct Policy prohibits sexual assault, sexual exploitation, sexual harassment, intimate partner abuse (dating or domestic violence), stalking or related retaliation. CU Boulder's Discrimination and Harassment Policy prohibits discrimination, harassment

or related retaliation based on race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. Individuals who believe they have been subject to misconduct under either policy should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127 or cureport@colorado.edu. Information about the OIEC, university policies, anonymous reporting, and the campus resources can be found on the OIEC website.

Please know that faculty and instructors have a responsibility to inform OIEC when made aware of incidents of sexual misconduct, discrimination, harassment and/or related retaliation, to ensure that individuals impacted receive information about options for reporting and support resources.

Honor Code: All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the academic integrity policy of the institution. Violations of the policy may include: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access, clicker fraud, resubmission, and aiding academic dishonesty. All incidents of academic misconduct will be reported to the Honor Code Council (honor@colorado.edu; 303-735-2273). Students who are found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code Council as well as academic sanctions from the faculty member. Additional information regarding the academic integrity policy can be found at honorcode.colorado.edu.