

ALGORITHMIC MOTION PLANNING

ASEN 5254 SECTIONS 1/1B

FALL 2022

LECTURE INFORMATION

Tuesday and Thursday 2:30-3:45pm

Room: AERO 114

Video recording will be made available after each lecture on the course canvas page

INSTRUCTOR

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Office hour: Wednesday noon-1pm and by appointment

COURSE DESCRIPTION

This class provides an overview of the “lessons” learned by the robot motion planning research community in the last 30 years. We will examine approaches based on potential functions, graphs (roadmaps and cell decompositions), and sampling methods. We will also examine task and motion planning techniques, as well as basic approaches in planning under uncertainty. More broadly, this class provides a set of *tools* that can be used in tackling new problems and enables the pursuit of complex research questions such as *planning for autonomous systems*.

PREREQUISITES

A significant part of the performance evaluations (homework, final project) will involve coding, implementing, and evaluating algorithms. This requires at least the knowledge of how to plot 2-D/3-D functions, manipulating arrays and other data structures in addition to standard constructs (loops, functions, etc.). C++ and Python are the preferred languages, but MATLAB is also acceptable. Basic knowledge of differential equations, linear algebra, and control systems is also required.

GRADING AND EVALUATION

Classwork consists of some homework exercises worth 30%, a mid-term exam (mini project) worth 30%, and a substantive project worth 40% of the grade.

COURSE TEXTBOOKS

Required:

- *Principles of Robot Motion: Theory, Algorithms, and Implementations*
H. Choset, K.M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L.E. Kavraki and S. Thrun
MIT Press
2005
e-book through CU library: <https://libraries.colorado.edu/record=b9646308~S3>
- *Planning Algorithms*
Steven LaValle
Cambridge University Press
2006
Free download: <http://lavalle.pl/planning/>

Additional Resources:

- *Probabilistic Robotics*
S. Thrun, W. Burgard, and D. Fox
MIT Press
2005
- *Robot Motion Planning*
Jean-Claude Latombe
Kluwer, 1991.
- *Handbook of Robotics*
B. Siciliano et al.
MIT Press, 2018

COURSE OUTLINE

- Planning to move
- Object representation, transformation, and kinematics
- Configuration space
- Gradient-based motion planning algorithms
- Discrete Search

- Sampling-based motion planning algorithms
- Motion planning with kinodynamic constraints
- Optimal motion planning algorithms
- Task and motion planning
- Motion planning under uncertainty

COURSE SCHEDULE

- Week 1-9: weekly homework assignments
- Week 10-11: final project proposal
- Week 11: mid-term exam (mini project)
- Week 16: final project report

CLASSROOM BEHAVIOR

Both students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote or online. 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 race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. For more information, see the [classroom behavior](#) policy, the [Student Code of Conduct](#), and the [Office of Institutional Equity and Compliance](#).

REQUIREMENTS FOR COVID-19

As a matter of public health and safety, all members of the CU Boulder community and all visitors to campus must follow university, department and building requirements and all public health orders in place to reduce the risk of spreading infectious disease. CU Boulder currently requires COVID-19 vaccination and boosters for all faculty, staff and students. Students, faculty and staff must upload proof of vaccination and boosters or file for an exemption based on medical, ethical or moral grounds through the MyCUHealth portal.

The CU Boulder campus is currently mask-optional. However, if public health conditions change and masks are again required in classrooms, students who fail to adhere to masking requirements will be asked to leave class, and students who do not leave class when asked or who refuse to comply with these requirements will be referred to Student Conduct and Conflict Resolution. For more information, see the policy on classroom behavior and the Student Code of Conduct. If you require accommodation because a disability prevents you from fulfilling these safety measures, please follow the steps in the “Accommodation for Disabilities” statement on this syllabus.

If you feel ill and think you might have COVID-19, if you have tested positive for COVID-19, or if you are unvaccinated or partially vaccinated and have been in close contact with someone who has COVID-19, you should stay home and follow the further guidance of the Public Health Office (contacttracing@colorado.edu). If you are fully vaccinated and have been in close contact with someone who has COVID-19, you do not need to stay home; rather, you should self-monitor for symptoms and follow the further guidance of the Public Health Office (contacttracing@colorado.edu).

ACCOMMODATION FOR DISABILITIES

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the [Disability Services website](#). Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance. If you have a temporary medical condition, see [Temporary Medical Conditions](#) on the Disability Services website.

PREFERRED STUDENT NAMES AND PRONOUNS

CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

HONOR CODE

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the [Honor Code](#). Violations of the Honor Code may include, but are not limited to: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. All incidents of academic misconduct will be reported to Student Conduct & Conflict Resolution (honor@colorado.edu); 303-492-5550). Students found responsible for violating the [Honor Code](#) will be assigned resolution outcomes from the Student Conduct & Conflict Resolution as well as be subject to academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found on the [Honor Code website](#).

SEXUAL MISCONDUCT, DISCRIMINATION, HARASSMENT AND/OR RELATED RETALIATION

CU Boulder is committed to fostering an inclusive and welcoming learning, working, and living environment. University policy prohibits sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, protected-class discrimination and harassment, and related retaliation by or against members of our community on- and off-campus. These behaviors harm individuals and our community. The Office of Institutional Equity and Compliance (OIEC) addresses these policies, and individuals who believe they have been subjected to misconduct can contact OIEC at 303-492-2127 or email cureport@colorado.edu. Information about university policies, [reporting options](#), and support resources can be found on the [OIEC website](#).

Please know that faculty and graduate instructors have a responsibility to inform OIEC when they are made aware of any issues related to these policies regardless of when or where they occurred to ensure that individuals impacted receive information about their rights, support resources, and resolution options. To learn more about reporting and support options for a variety of concerns, visit [Don't Ignore It](#).

RELIGIOUS HOLIDAYS

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, inform the instructor of such conflicts at least three weeks in advance.

See the [campus policy regarding religious observances](#) for full details.