

ALGORITHMIC MOTION PLANNING

ASEN 5254 SECTIONS 1 & 2

FALL 2024

LECTURE INFORMATION

Tuesday and Thursday 4:00-5:15pm

Room: AERO 111

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

INSTRUCTOR

Morteza Lahijanian

Office hour: Wednesday 1-2pm 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. 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 2-9: weekly homework assignments
- Week 10-11: final project proposal
- Week 11: mid-term exam (mini project)
- Week 16: final project report

CLASSROOM BEHAVIOR

Students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote, or online. Failure 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, marital 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](#).

ACCOMMODATION FOR DISABILITIES, TEMPORARY MEDICAL CONDITIONS, AND MEDICAL ISOLATION

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.

If you have a temporary illness, injury or required medical isolation for which you require adjustment, notify your faculty member in a timely manner so that your needs can be addressed.

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 (including use of paper writing services or technology [such as essay bots]), 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. Understanding the course's syllabus is a vital part in adhering to the Honor Code.

All incidents of academic misconduct will be reported to Student Conduct & Conflict Resolution: StudentConduct@colorado.edu. 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. Visit [Honor Code](#) for more information on the academic integrity policy.

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 [protected-class](#) discrimination and harassment, sexual misconduct (harassment, exploitation, and assault), intimate partner abuse (dating or domestic violence), stalking, and related retaliation by or against members of our community on- and off-campus. The Office of Institutional Equity and Compliance (OIEC) addresses these concerns, and individuals who 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](#) including confidential services can be found on the [OIEC website](#).

Please know that faculty and graduate instructors must inform OIEC when they are made aware of incidents related to these policies regardless of when or where something occurred. This is to ensure that individuals impacted receive outreach from OIEC about resolution options and support resources. To learn more about reporting and support for a variety of concerns, visit the [Don't Ignore It page](#).

RELIGIOUS HOLIDAYS

Campus policy requires faculty to provide reasonable accommodations for students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. Please communicate the need for a religious accommodation in a timely manner. In this class, inform the instructors of such conflicts at least three weeks in advance.

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

MENTAL HEALTH AND WELLNESS

The University of Colorado Boulder is committed to the well-being of all students. If you are struggling with personal stressors, mental health or substance use concerns that are impacting academic or daily life, please contact [Counseling and Psychiatric Services \(CAPS\)](#) located in C4C or call (303) 492-2277, 24/7.

Free and unlimited telehealth is also available through [Academic Live Care](#). The Academic Live Care site also provides information about additional wellness services on campus that are available to students.

CU COMMUNITY OF CARE

CU Boulder is committed to a community of care in which students are supported by faculty and staff throughout their college journey. You don't have to face academic challenges alone – CU and the college are here to help you learn and succeed in your coursework and campus life. Part of this community of care is your connection to faculty and staff across campus. Our college promotes and hopes you will connect with faculty or staff who may reach out during your educational journey at CU.