ASEN 5519 Special Topics – Sections 2/2B
Algorithmic Motion Planning
Fall 2021

Lecture Information

Tuesday and Thursday 2:50-4:05pm
Room: AERO N240
Video recording will be made available after each lecture on the course canvas page

Instructor

Morteza Lahijanian
Office: AES 267
Email: Morteza.Lahijanian@colorado.edu
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 and linear algebra 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://planning.cs.uiuc.edu/

Additional Resources:

- *Probabilistic Robotics*
  S. Thrun, W. Burgaard, 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 policies on classroom behavior and the Student Conduct & Conflict Resolution policies.

Requirements for COVID-19

As a matter of public health and safety due to the pandemic, 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. Students who fail to adhere to these 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.

As of Aug. 13, 2021, CU Boulder has returned to requiring masks in classrooms and laboratories regardless of vaccination status. This requirement is a temporary precaution during the delta surge to supplement CU Boulder's COVID-19 vaccine requirement. Exemptions include individuals who cannot medically tolerate a face covering, as well as those who are hearing-impaired or otherwise disabled or who are communicating with someone who is hearing-impaired or otherwise disabled and where the ability to see the mouth is essential to communication. If you

qualify for a mask-related accommodation, please follow the steps in the "Accommodation for Disabilities" statement on this syllabus. In addition, vaccinated instructional faculty who are engaged in an indoor instructional activity and are separated by at least 6 feet from the nearest person are exempt from wearing masks if they so choose.

Students who have tested positive for COVID-19, have symptoms of COVID-19, or have had close contact with someone who has tested positive for or had symptoms of COVID-19 must stay home. In this class, if you are sick or quarantined, inform the instructor that you are not able to attend the lectures immediately; lecture recordings will be made available.

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 academic integrity policy. 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 the Honor Code (honor@colorado.edu); 303-492-5550). Students found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code as well as 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

The University of Colorado Boulder (CU Boulder) is committed to fostering an inclusive and welcoming learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, or protected-class discrimination or harassment by or against members of our community. Individuals who believe they have been subject to misconduct or retaliatory actions for reporting a concern should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127 or email cureport@colorado.edu. Information about OIEC, university policies, reporting options, and the campus resources can be found on the OIEC website.

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

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.