MAE 242: Robot Motion Planning. Spring '22

Course web address: `canvas.ucsd.edu`

Instructor: Prof. Sonia Martínez, EBU-I 1807, 858-822-4243, `soniamd at ucsd dot edu`

Teaching Assistant: Parth Paritosh (`pparitos at ucsd dot edu`)

Lecture Time and Place: Tues/Th 9:30am - 10:50am, PCYNH 121

Type of lectures and ettiquette: This course will be taught in person at the location indicated above. Attendance is required, and for those who can not make it on occassion podcasts will be made available about 2 hours after the class takes place. It is requested that no mobile phones be used during the lecture.

Office Hours: Sonia, Wednesdays, 4:00 to 5:00pm via zoom

Parth, Thursdays, 5:00 to 6:00pm, via zoom

Texts: The following will provide the main background for the course (will be complemented with slides and notes):

- S. M. LaValle. *Planning algorithms*. 2006. This text is available at *Amazon.com*, and also freely available at the website `http://planning.cs.uiuc.edu/`.
- D. P. Bertsekas and J. Tsitsiklis. *Neuro-Dynamic Programming*. Athena Scientific, 1996
- R. S. Sutton and A. G. Barto. *Reinforcement Learning: An Introduction*. 2008, second edition available at the website `http://incompleteideas.net/book/RLbook2018.pdf`

Course Scope and Audience: Motion planning algorithms find application in a number of technologies and disciplines such as manufacturing, computer-aided design, computer graphics, artificial intelligence, and virtual environments, and general mechanical and aerospace robotic applications. The course is of interest for engineers and computer scientists who have an interest in robotics, control theory, and artificial intelligence alike.

The topics will mainly focus on advanced planning algorithms for robots. There will be roughly two main parts in this course: Part (I) on discrete, dynamic programming, and learning, part (II) on configuration spaces, and locomotion (vehicle / robot dynamics and control).

Prerequisites: This course is *math intensive*. Background knowledge in probability theory, linear algebra, mathematical analysis and convexity (optimization) are required to understand and enjoy this course. Background in nonlinear systems and controls is a plus. *Programming knowledge:* assignments will be given in PYTHON, and familiarity with this language is required. Assignments will mostly require functional-oriented programming, so if you are fluent in other programming languages (such as matlab), you could pick it up along the course (though a nontrivial effort to adapt may be required). In any case, you have to be used to programming, be familiar with functional programming and used to translating pseudo-code into code.

Syllabus: Tentatively, we will cover topics among the following (time permitting):

- Review of searches over graphs: BFS, DFS, BF, A*, Dijkstra's algorithm. Dynamic programming (backward value iteration and foward value iteration.)
- Markov decision processes and exact solution methods: value iteration, policy iteration, linear programming.
- Reinforcement-based Q-learning.
- Configuration spaces.
- Kinematic and dynamic motion models for robots.
- Motion control primitives for robots.

Assignments: Homework will be assigned throughout the course so that you can better grasp the course material. The exercises will include a combination of theoretical analysis exercises and programming (in python) plus a midterm and a final. They will be posted in the canvas course website and should be submitted through canvas via gradescope.

While all solutions will be made available, the correction of all homework problems is unfortunately not possible. Only one problem per analytical assignment will be corrected as well as the programming problems. Autograder in gradescope will occassionally be used to the automatic correction of some programming problems.

Late homework policy: Only one late homework is allowed with no penalty if turned within 24 hours after the deadline. All other hw can be submitted with one day delay and will be penalized with a 20% discount.

Collaboration policy: You are encouraged to work with other students on your assignments, and to help other students complete their assignments, provided that you comply with the following conditions:

1. Honest representation: The material you turn in for course credit must be a fair representation of your work. You are responsible for understanding and being able to explain and duplicate the work you submit.
2. Active involvement: You must ensure that you are an active participant in all collaborations, and are not merely dividing up the work or following along while another student does the work. For example, copying another student's work without actively being involved in deriving the solution is strictly prohibited. Each student should submit their own individually written answers to the homework problems and they should not be an exact copy of each other's.
3. Work individually or in small groups: Working in groups of more than **three** people is discouraged because it limits the amount of participation by each member of the group. In your homework solutions please indicate the names of the people you collaborated with.
4. Give help appropriately: When helping someone, it is important not to simply give them a solution, because then they may not understand it fully and will not be able to solve a similar problem next time. It's always important to take the time to help someone think through the problem and develop the solution. Often, this can be accomplished by asking them a series of leading questions.
5. If in doubt, ask your instructor: Be sure to ask in advance if you have any doubts about whether a certain type of collaboration is acceptable

Important Dates: The following are tentative dates for homework

Title	Issued	Due
Homework 1	April 1	April 8
Homework 2	April 8	April 15
Homework 3	April 15	April 22
Homework 4	April 22	April 29
Homework 5	May 6	May 13
Homework 6	May 13	June 3
Midterm	May 5	
Final	June 7	

Grading: It will depend on how many homework assignments are eventually set. Tentatively homework assignments (30%) and midterm / final assignment (70%). Extra credit problems will make up to 8% of the grade. Contributing to answering questions in Piazza (with 4 endorsed questions by instructor) or class will contribute to up to 2.5% of the grade.

Course websites:

`canvas.ucsd.edu`