Final Project: Design and Implementation of Planning Algorithms

CS 6370 / ME EN 6225 Motion Planning
University of Utah **Spring 2023**

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1 Administrative

- **Deliverables:**
  - **Initial Proposal** of your group and problem to work on. You should choose a group of two (2) two four (4) members and describe the general problem and proposed solution (different group sizes may be granted with instructor approval). You should prepare a proposal description of approximately one page. The best topics will match your interests and/or build on your ongoing research. If you struggle to find a topic we can help suggest some. We will discuss these in class the day they are due and you will receive feedback from your classmates the following week. Make sure to include your names and email addresses on the proposal.
  - **Proposal Reviews and Feedback** you will be assigned three other groups proposals to review. You will have one week to write a short one-page review of the proposal. You will turn these in to the instructor and email them directly to the teams you are reviewing. Your group needs to schedule a meeting with the instructor to discuss this feedback from your peers and to finalize the project plan.
  - **Project Timeline** you will revise your project proposal following the feedback from other students, as well as your meeting with the instructor. The revised proposal will include a ***detailed*** timeline for your project, where you set goals with dates for your team.
  - **Literature Review** you must prepare and submit a review of the relevant research on your motion planning topic. The review should discuss related research on both the domain/application of your work (e.g. motion planning for sewing machines) and the methods you propose to use (e.g. random search methods with deformable object constraints). We do not expect you to find all possibly relevant papers, but do expect you to show sufficient effort to place your work in the context of existing methods. We can offer some starting points of papers to look at if you are unsure.
  - **12 Minute Presentation** of your work and your results. The presentation should include a description of the problem and the algorithms you used to solve it. Most importantly: have data plots, pictures, and movies of your results. **Practice your talk, and make sure your computer is ready to show your slides in the room (i.e. bring cables, adapters, and test the compute before the day you present)!**
  - **Final PDF Report** on your work in the **IEEE Conference Standard**. The report should be approximately six (and maximum of eight) pages and include the sections below.
  - **Final Project Video** in addition to your paper you should submit a final project video showing the system working. This is a common and expected component for most robotics research submissions these days. Your video should be a maximum of 2

minutes and use a standard codec for easy viewing. Submit either the file directly or a youtube link. This should be professional looking (not just an unedited and uncropped screen recording of your desktop, for instance).

  - **Team Analysis** In addition to the final paper and presentation, each group member is responsible for turning in a short description describing the contributions of each team member and your analysis of your team's efforts. These should be written independently by each member of the team. It should be approximately one paragraph in length.
  - **Presentation Reviews** you must provide written reviews of all group presentations (other than your own). You must submit these both online through canvas and send them to the groups, so that the presenters can improve their talks in the future.

- **Due Dates:** (subject to change)
  - **Initial Proposal Due:** February 13, before class.
  - **Proposal Reviews Due:** February 22, before class.
  - **Timeline Due:** March 6.
  - **Literature Reviews Due:** March 27.
  - **Presentation Times:** Last two weeks of classes (total number of groups dependent).
  - **Presentation Slides Due:** April 25.
  - **Final Report, Video, and Team Analysis Due Date:** May 3.
  - **Presentation Reviews:** May 3.

2 Project Goals

In class we are studying the means by which robots use models of the world in order to make decisions about their actions. We have seen how different representations of the world and different algorithms are better suited for various problem domains. The instructor believes that you are qualified to do research in planning! In this project you are to study the problem and devise the most effective planning strategy to solve it. You will apply your planner to a simulated robot. Finally, you will explain your choices, methods and evaluate the performance of your solution.The key notion that distinguishes planning from other forms of decision making is that planners reason about the effects or consequences of actions. Decisions should reflect a comparison of how actions or sequences of actions impact the robot's ability to achieve its goal. Your planner should select a reasonable course of action to achieve your goal. Since planning requires a model, some of your robots will need to acquire/learn a model prior to choosing actions. In that case, consider modeling to be part of your algorithm and your project. The most compelling examples of planning involve decisions by the robot that can only be understood in the context of a plan. A human observer tends to perceive intelligence when he or she cannot understand the immediate decisions of the robot until future actions reveal the nature of the plan and the value of previously accomplished states. Try to use this insight as you develop your algorithms and applications.

3 Final Report

Your report must follow the IEEE conference standard. LaTeXand Word template files can be found at the following url: `http://www.ieee.org/conferences_events/conferences/publishing/templates.html`. The instructor believes this is a great chance to practice writing conference-level papers. If you need additional help with this process do not hesitate to contact other class members, the TA, or the instructor. Please make use of the writing center as needed to help with improving your writing: `https://writingcenter.utah.edu/`. The report should include the following sections. Think of this as a prototype. You may add or remove sections as long as it helps the overall coherence of the report.

3.1 Abstract

A summary of your work. What is the key result of your work? What approach did you take. What important conclusion should the reader draw from reading your report?

3.2 Introduction

Describe the problem, explain what makes it an interesting challenge for planning and introduce your solution.

3.3 Related Work

Look into the background material on both the problem and the methods that you are using to solve it. Cite these as references and use them to show both the challenges of the problem and the merits of the particular solution you selected. The instructor will ask: "Did you make the best choice?"

3.4 Methods

Describe the details of your algorithms and any supporting tools such as the software/hardware architecture, vision, etc. that were used in your experiments. Give an explanation for each choice that you made. Pictures and pseudo-code often help with explanation. Often times, in our domain, this is the most interesting section.

3.5 Experiments

Summarize the experiments you conducted. Under what conditions did you test your approach? What criteria did you use to evaluate your algorithm? Give plots, graphs, and pictures that show how well your algorithm performed.

3.6 Analysis

Analyze your algorithms from a theoretical and/or experimental point of view. How do they relate to the criteria described in class? For instance: optimality, completeness and efficiency. How well did the algorithms perform in actual experiments. If you tried different algorithms or parameters use this section to compare their performance.

3.7 Discussion

What did you learn in the process of doing this project? What lessons should a reader take away from your work? If you were to extend this work, what directions would you consider exploring?