ME 221, Fall 2022
University of California, Riverside
Department of Mechanical Engineering

Project Description (v2 9/22)
Proposal Due: 10/27
Final Presentation: 12/1
Final Report Due: 12/3

1 Overview

The purpose of the course project is to apply the tools and concepts learned throughout the quarter. Ideally, the project should be chosen to correspond with your thesis/dissertation research. The goal of the project is to design or choose a commercial robot to complete a chosen task and to simulate the robot dynamics using a simulation environment or, if possible, using a real robot from your research project. If you're not currently working on research, or your research area is out of the scope of this course, you can make up your own scenario. To begin, formulate your project as a *research question* which you will try to answer. This will keep the project focused and in scope.

2 Requirements

Must include manipulation or locomotion with serial or parallel kinematic chains. You can also have a mobile *wheeled* robot component, but control and simulation of kinematic chains is required.

Should have sufficient degrees-of-freedom or complexity Do not choose an overly simple robot, e.g., planar or 2 degrees of freedom. The project should be challenging.

Implementation of some type of robot control. You cannot simple simulate a passive robot. Some exceptions will be granted, for example, design and simulation of a passive dynamic walker would be okay. You are encouraged to use motion control libraries.

Interaction with the environment. The robot must interact with an external environment is some way, either through intermittent contact or through physical coupling.

3 Deliverables

Proposal - 20% - Due 10/20. The proposal document is a concise overview of the proposed project. What research question does your project aim answer? You should include details of the chosen robot and summary of the task(s) to be completed. Include a short description of the chosen simulation environment and outline the challenges. The proposal document should be no more than 1 page, and must include a project title. You will receive feedback and approval of your proposed topic choice.

Final Report - 50% - Due 12/8. The final report should consist of a short paper no longer than 4 pages (not counting references) and written in the style of a conference paper. The manuscript must be prepared using the IEEE conference template, either using Microsoft Word or LaTeX, and should include the following sections:

a. **Abstract.** A single paragraph summarizing the paper's content, including a concise introduction of the topic, outline of the major results, and summary of the conclusions.
b. **Introduction.** This section should provide context for the project and include a summary of related work. Make sure to answer the following: Why is the problem interesting, what question does your project aim answer, how is it challenging and what related work has been done before?
c. **Methods.** Here you should provide a detailed description of all the techniques used to generate your results. Include a description of the robot, task, and simulator, and supporting figures. Provide details of the algorithms used to complete the task with visual aids (e.g., block diagram of the controller).

d. **Results and Discussion.** Present and discuss the results of your project. Include figures to support your results. Provide context and interpretation.

e. **Conclusion.** Restate your research question, the methods used, and your major findings. Contextualize your results in terms of what has been previously done.

Presentation - 30% - Due 12/1. The presentation will consist of a 10 minute summary of your project. Include figures, schematics, and animations to support your results.

4 Suggested Simulation Environments

- MATLAB Robotic Systems Toolbox
- pyBullet
- MuJoCo

5 Other Simulation Environments

- GAZEBO
- Webots

6 Sample Projects

Pick and place robot. Simulate a pick and place task where the object can be seeded arbitrarily in the workspace and the robot formulates a trajectory to grab and move the object to a target.

Interaction robot. Simulate a robot coupled to a dynamic object (e.g., mass-spring-damper) with the robot moving the object to a desired location or a desired dynamic relationship, e.g., impedance control.

Hand writing robot. Simulate a robot that can trace out arbitrary words on a surface. The challenge will be to generate path plans.

Industrial sanding robot. Simulate a robot that provides a constant force, e.g., application towards a sanding operation, to a curved (smooth) surface without prior of knowledge of the surface geometry.

Rehabilitation robot. Simulate a human with a wearable robot that provides prescribed motions to one of the human's limbs.