Assignment

COMP 766 / ECSE 683

Deadline: Feb 23, 2025

1 Objective

The goal of the assignment is to demonstrate that you can solve a robotics task through imitation learning or optimal control. You can either (1) learn a model that reproduces similar motion from a motion dataset or (2) use optimal control to solve a particular problem.

Robot and Simulator

You are free to choose any robot and simulator for this assignment. You can choose the standard ones, (RoboSuite, Issac Lab, Pybullet, Drake, ROS) or other simulators that you like. You can use any robot (arms, legged robots, etc) from your simulator or create one of your own. If you have any doubts, please consult the instructor.

Methods

You are allowed to choose from one of the following topics introduced in the class:

- optimal control
  - trajectory optimization
  - iLQR/DDP based methods
- imitation
  - behaviour cloning
  - inverse reinforcement learning

What is not allowed: reinforcement learning, interpolations, or any methods that simply engineer a solution

Option 1: Imitation Learning

Learn a model that can reproduce some motion data. Example dataset can be found in RoboMimic and Open X-Embodiment You can find whatever motion you would like to learn. There is no restriction on how you use the dataset. You can (1) learn a mapping between positions and velocity or (2) learn a mapping between position/velocity and torques. There is no restriction on the imitation learning algorithm. You can follow the examples discussed in the class (simple deep learning, learning dynamical systems, etc) or choose any other imitation learning algorithms.

Option 2: Optimal Control

If you choose to solve it with optimal control, you do not need to find a motion data. Instead, define a cost function that can solve your problem. You can specify the joint/velocity/torque limits in the optimization framework.

Controller

Most simulators already have a simple controller available. You can control either kinematics or dynamics control. The output of your model should be within the physical limits of the robot. The kinematics and dynamics limit might be specified in the factory white paper or the URDF model.

You might find a line similar to the following:

```
<limit effort="306" lower="-1.57079632679" upper="1.57079632679" velocity="1.91986217719"/>
```

This line specifies that the joint has the following limits:

- torque limit = $[-306, 306]$
- joint limit = $[-1.57079632679, 1.57079632679]$
- velocity limit = $[-1.91986217719, -1.91986217719]$

2 How to submit your assignment

Create a repository under your github or CS gitlab account and share it with the instructor (github name: hsiuchin-lin, gitlab name: linhz). This will be the same repository for your course projects, so you only need to do it once. Your submission should include the following items:

- source code
- a *README.md* file that provides the instructions for running your code
- a pdf documentation that describes your solution
- **(optional)** a recorded video of your simulation

2.1 README.md

The README.md should provide instructions to reproduce your experiment and should be at the top of your main directory. Your README.md should include, at least, the following information:

- Your name
- List the system requirements if any. If there's no requirement, please specify the environment where the source code is tested, including your
  - Operating system
  - Software required and their version number
  - Extra software packages needed
- How to run your source code (which file to run, etc)

2.2 Documentation

The documentation should describe your examples and experiments. You can include the following components

- Describe your examples
  - What is the configuration space, task space, and its degree of freedom
  - Describe your state and action
- Describe your method
  - What is your approach? (e.g., optimization, imitation learning)
  - How do you ensure the motion is within the physical limits?
- Discuss any limitations. Does it work 100% of the time? Why?
- You can use any *public* resources you can find online. However, please provide the references in your documentation. Your assignment will be reported for plagiarism if you take resources online and claim it as your work.

3 Evaluation

The assignment is worth 20 points toward your final grade.