Project 1 Report

1. Title:

Robot Juggling

1. Key Ideas:

The project, Robot Juggling, explores the use of a Proportional-Derivative controller to control a simulated robot in a variety of ways. Specifically, the project involved learning the implementing of PD control to adjust the robot’s position to get a desired state along with simulating different gain settings to observe under-damped, over-damped, and critically damped behaviors. By going through the processes of understanding the behaviors of the robot, the project then covers how the robot can begin juggling.

1. Data Needed:

The project provides Jupyter notebooks and requires the user to download several data components and pieces of software. As the project is older, it utilizes Python 2.7 and Miniconda 2 for the creation of environments. To create the environment there is the utilization of the following libraries: pyBox2D, NumPy, SciPy, MatPlotLab, Jupyter, and PyGame. The project also comes with Python scripts to run the demonstrations within the Jupyter notebooks.

1. Methods:

The project was constructed in Python 2.7 using the Miniconda 2 environment along with essential libraries for the simulation and data handling. Methods of tuning the Proportional-Derivative controller to observe the system behavior was used, heavily utilized during the simulation getting the robot to a desired position. Project covered methods of open-loop control, where force and torque is applied to the robot without feedback and feedback control, where adjustments are made during real time errors. To reach the desired goal, we use such methods along with the mirror control law to produce a robot that can juggle a ball.

1. Screenshots:

A diagram of a ball state

Description automatically generatedA white background with a red dot and black lines

Description automatically generatedResults:

1. A diagram of a robot state

   Description automatically generatedEvaluation:

The Proportional-Derivative controlled robot is successful in tracking and mirroring the ball’s vertical motions as it adjusts to match the ball’s movement. The controller uses an energy-based approach where it matches the ball’s energy state to create a smooth response to the change in height. It does this by also achieving accurate alignment with the specified peak and impact points. As the setup has been optimized for the movement to be vertical, incorporating some form of lateral adjustment could enhance the robot’s ability to handle a more complex ball trajectory.

1. Experience:

The project emphasized the practical aspects of tuning Proportional-Derivative controllers. I also learned about the impact of the proportional and derivative gains and how it corresponds to the stability and responsiveness of the system. Using open-loop and feedback controls also helped understand how each method influences the robot’s behavior.