KOÇ UNIVERSITY

College of Engineering

DEPARTMENT OF MECHANICAL ENGINEERING

FALL 2020

MECH 444/544 PROJECT #1

Altay Atalay - aatalay17@ku.edu.tr

Berke Ataseven - bataseven15@ku.edu.tr

Instructor: Çağatay Başdoğan

Contents

Introduction and Abstract

Simulations are crucial for robotics applications. Simulations serve as a platform to test the system in software so that testing the system in real life becomes safer and easier. Simulation allows for a significant reduction in cost, time, and effort. Building simulations for robotics applications requires several components such as trajectory planning, and a controller to control the actuators, which determine the response of the robot.

The aim of this project is to develop a dynamical model of the PHANToM Premium 1.5 haptic, robotic arm, which can be seen in figures 1 and 2, and design a controller using MATLAB's Simulink, which will account for and compensate for position and velocity errors while the robotic arms end-effector point moves on a straight path.

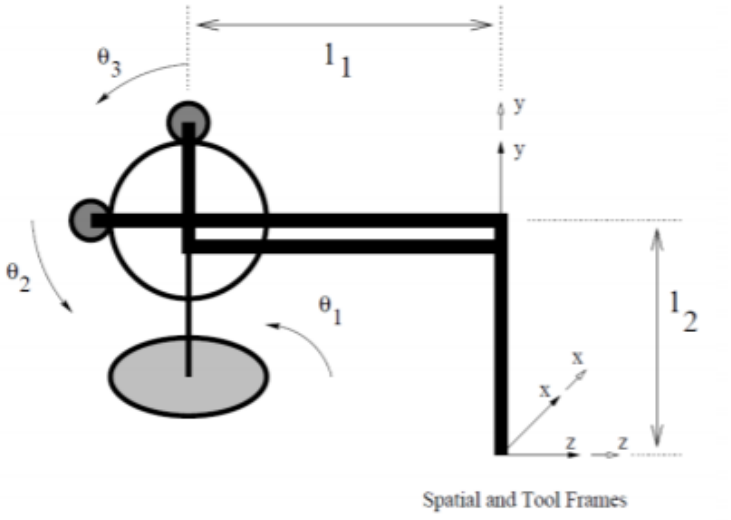

Figure 1 Zero configuration on the manipulator

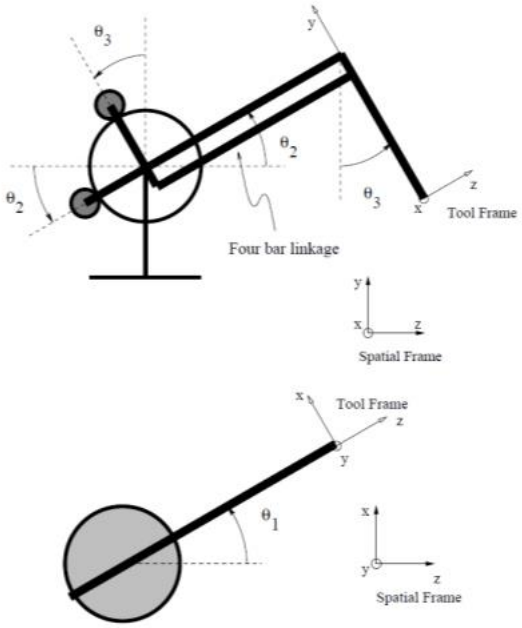

Figure 2 Side and top views

Discussion & Results

To control the position of the end-effector's position, a force is applied by the PID controllers. The proportional, integral and derivative components of the PID work together to calculate the force which is required to bring the error (desired-actual) to zero, achieving this goal fast and efficiently.

We were able to form a very robust controller. As visible from the plots, the desired x,y,z trajectories and the actual trajectories are almost identical, to the point that they are almost indifferentiable. This also means that the forces applied were of correct magnitude and direction, and the joint angle response was approximately what it ideally should be.

The plots representing the force outputs of the controller can be seen in figures 3, 4 and 5.

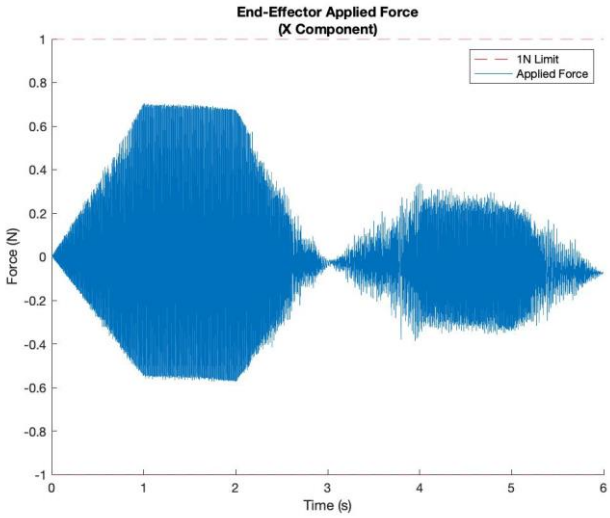

Figure 3 End-effector Applied Force X Component

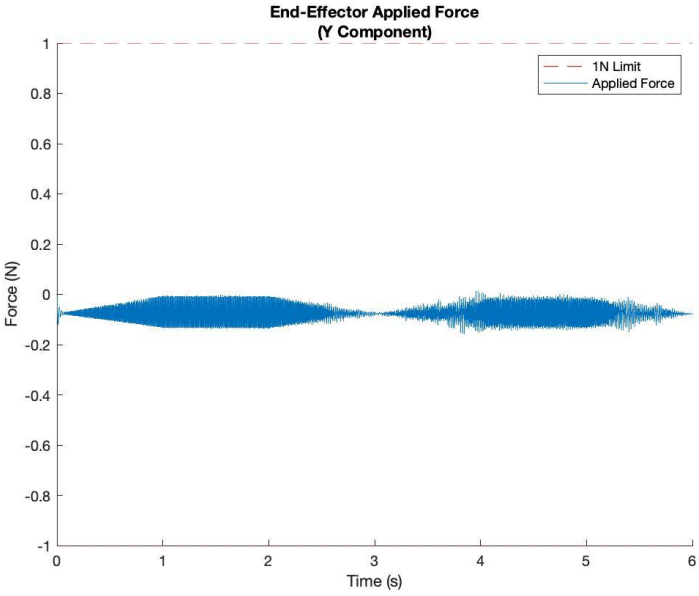

Figure 4 End-effector Applied Force Y

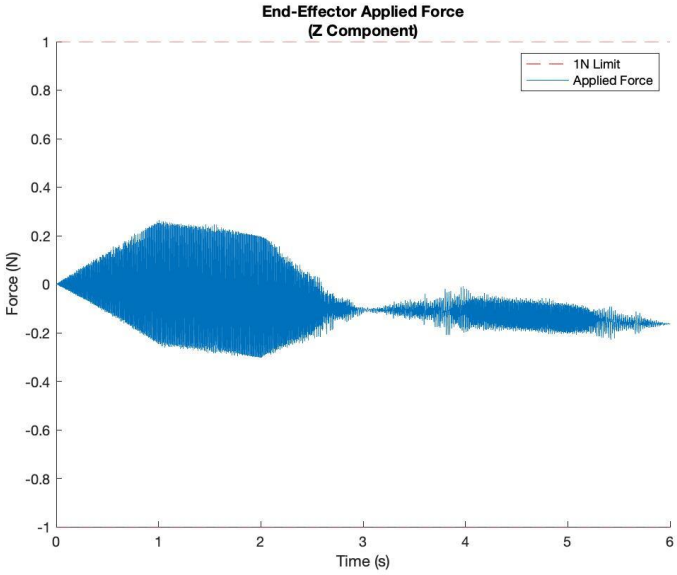

Figure 5 End -effector Applied Force Z Component

The plots representing the desired and simulated trajectories (joint angles and end-effector position) as a function of time

The program can take any number of points within 3D workspace either as start point or target point.

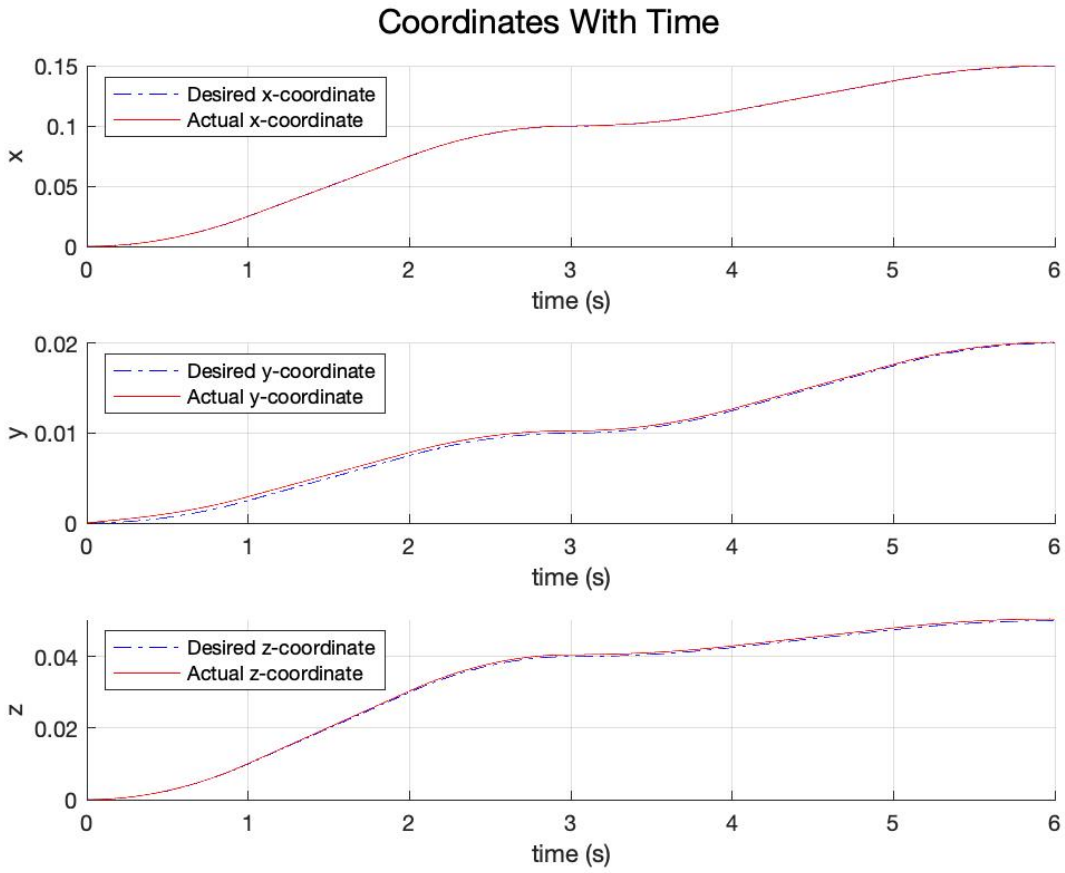

Figure 6 End-effector Position

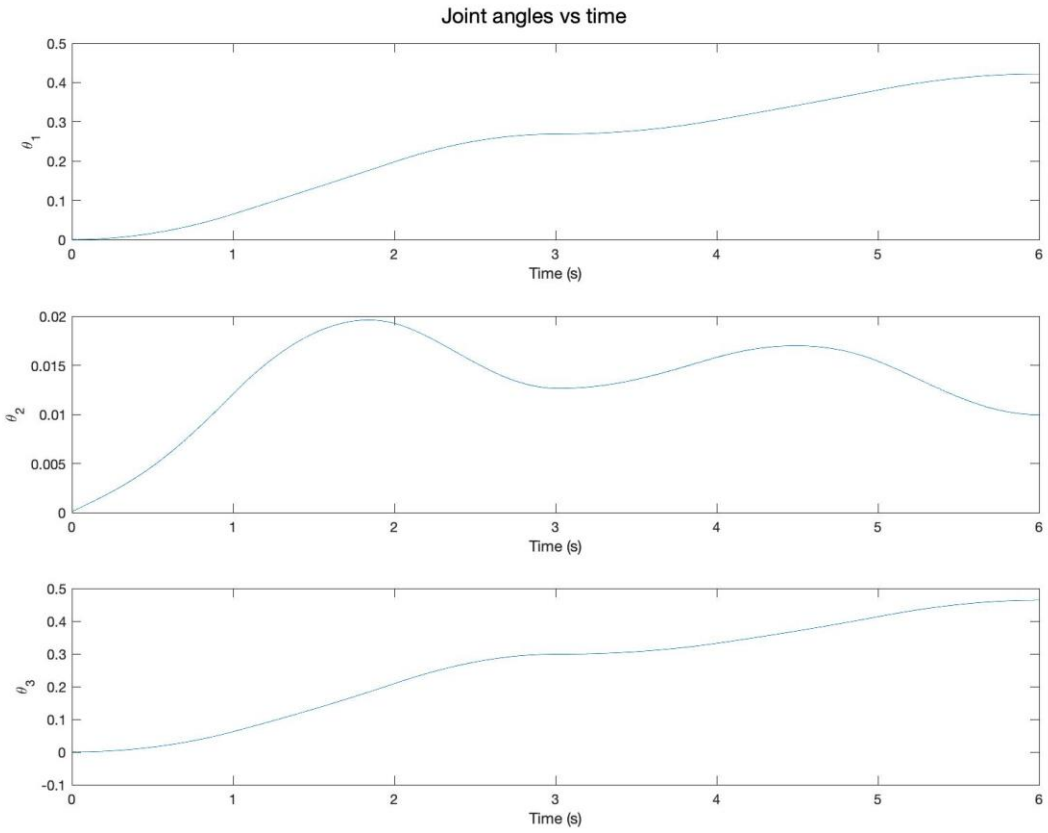

Figure 7 Joint Angles

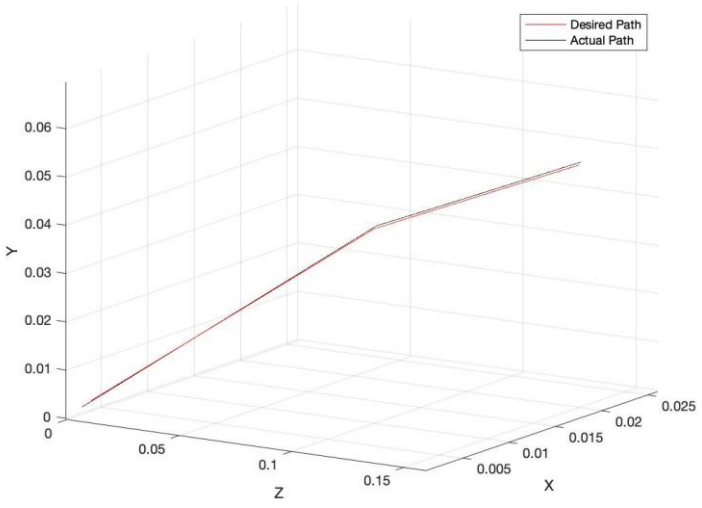

Figure 8 End-effector Position in 3d space

The plots representing the tracking error as a function of time for the end-effector can be seen in Figure 9.

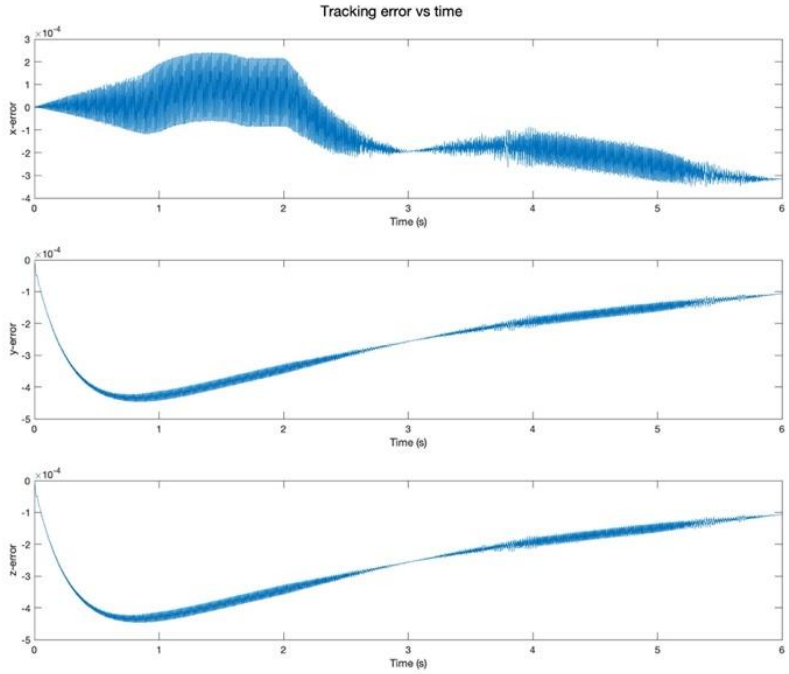

Figure 9 Tracking errors

The average tracking error, and the task completion time for the linear path can be seen in Figure 10.

```
Average Tracking Error: (m)
x:-0.0000395  y:-0.0003086 z:-0.0002873

Task Completion Time: 6.00
```

Figure 10 Calculated errors and Completion time

The final configuration of the Simulink model can be found in Figure 11.

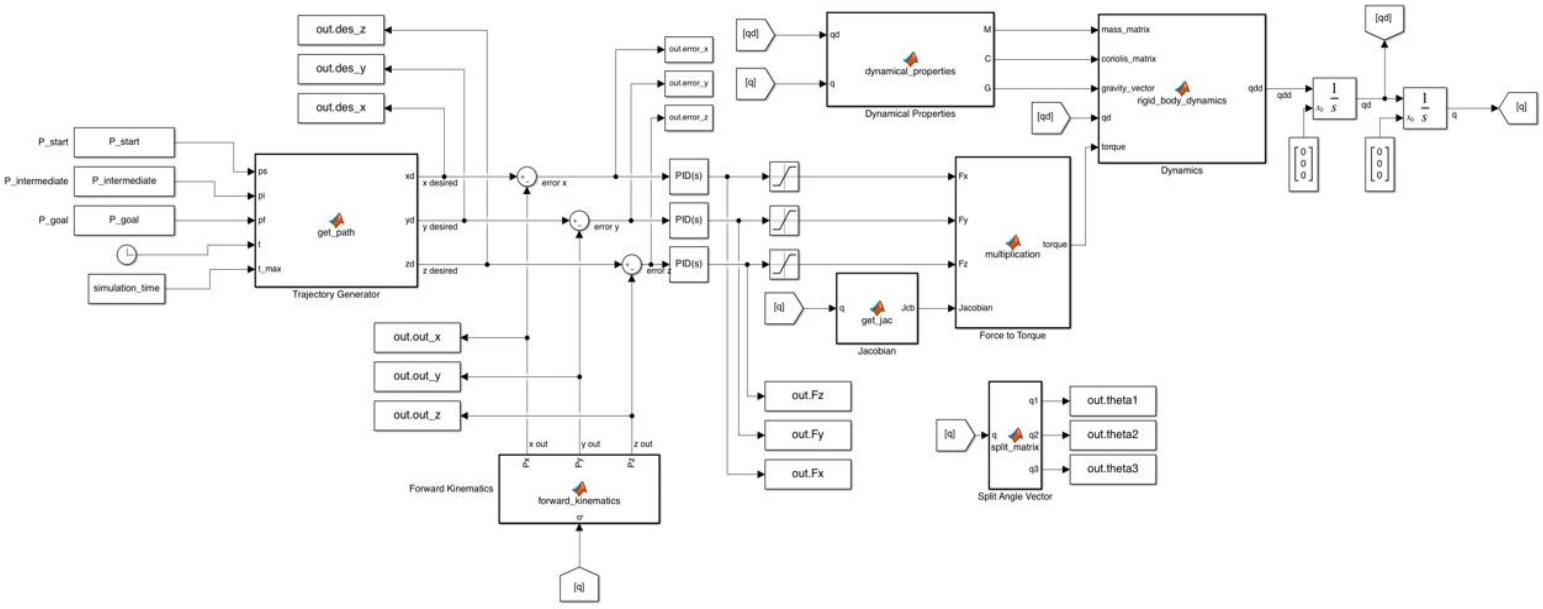

Figure 11 Schematic of Design

Conclusion

In conclusion, we have simulated the movement of the PHANToM Premium 1.5 haptic robotic arm when the arm's position is controlled by an PID controller. Simulation showed that the robot works as desired.