P2 Cyan Team Winter 2020 Brainstorming Document

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Arm Design

We wanted a simple arm design so it would be easier to code. We also wanted to reduce the number of joints so we would have an easier time deciding which joints needed to be moved to get in the correct position. The more joints we had, the more possible options we would need to consider for every movement.

We used the human arm as our inspiration for this project and saw what movements were needed for us to physically draw on a piece of paper using our thumb as a pen. When we rotated our arm so our thumb was facing towards the ground, we could rotate our arm using our shoulder joint and then move the hand up and down using our elbow joint. Our wrist added additional freedom that allowed us to make our thumb perpendicular to the paper.

The initial configuration that came in myarmsim.py allowed movement similar to our human arm. In Figure 1, below, we thought of joint 1 as the human shoulder, joint 2 as the elbow, and joint 3 as the wrist.

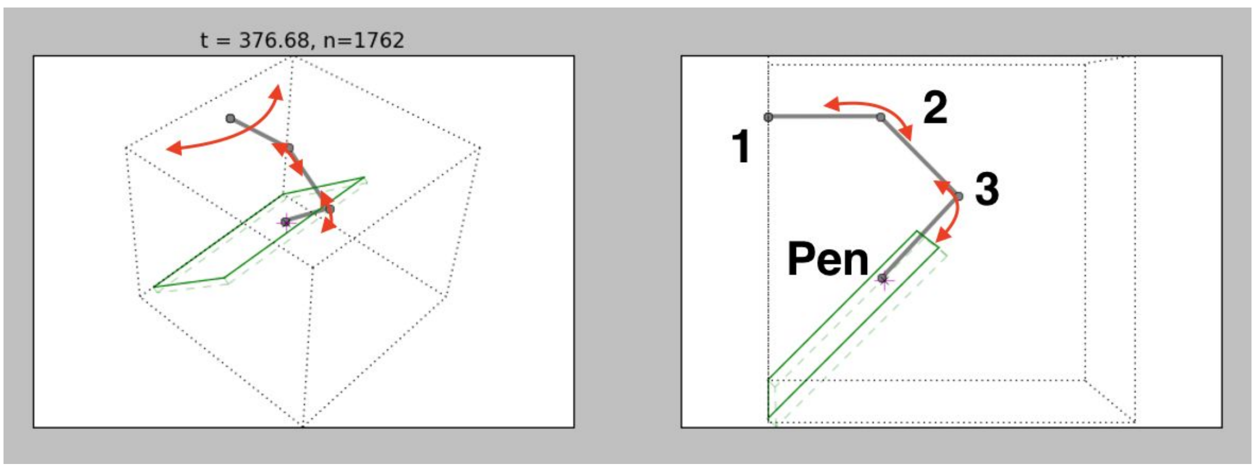

Figure 1: The initial robot arm configuration given for Project 2 defined in myarmsim.py.

With the movement of our arm limited to the configuration in Figure 1, we could only draw a square that had all its sides parallel to the sides of the paper. In order to allow drawing a square diagonally, we needed an additional joint (depicted in Figure 2 as joint 2) to allow roll.

Arm Segment Lengths and Axes of Rotation

We will set the arm lengths to be some scaled factor of L so that the end effector (pen) on our robot arm can be extended long enough to reach within 0 to 10 mm of the paper, which can be set anywhere in the workspace.

Joints one and three (depicted in Figure 2) control yaw and pitch, respectively, and are used to set the position of the pen. Joint 2 is used if the square needs to be drawn diagonally and can roll the arm so that movement from the first and third joints will move the arm diagonally. The fourth joint is responsible for ensuring the pen stays perpendicular to the paper.

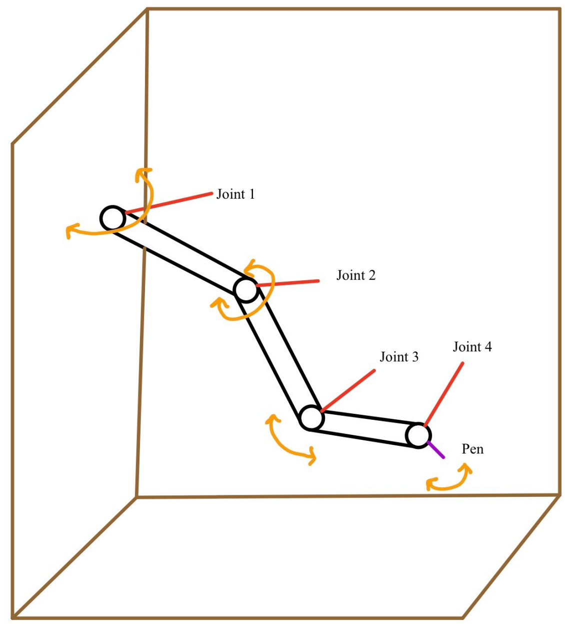

Figure 2: A schematic of our robot design. We added an additional joint (joint 2) to enable roll.

Control Scheme

We will use the second joint to angle the arm correctly for drawing the square depending on the angle of the square relative to the workspace. We will use the first and third joints to move the pen into place for drawing on the paper. The fourth joint will align the pen perpendicularly to the paper and then joints 1 and 3 will move the pen to draw the square.

1. We will define the position of the arm relative to the workspace using rigid body transformation defined in the matrix **Tws2s**. We will use the following resources for reference:
    a. Modern Robotics Youtube Playlist
    b. Robot Control: Forward Transformation Matrices

2. We will orient our arm so that we're within the proper distance from the paper (0 - 10 mm) and make our pen perpendicular to the paper. We will use all four joints to reach the proper position. We will save this configuration, so we can return to it automatically.

3. When we are given the four corner points for the square, we will move to our saved configuration. We will then use the second joint to rotate the arm so that the unit vectors constraining the 2D motion of the pen match the coordinate frame of the square. We will then draw the square by moving the first and third joints.