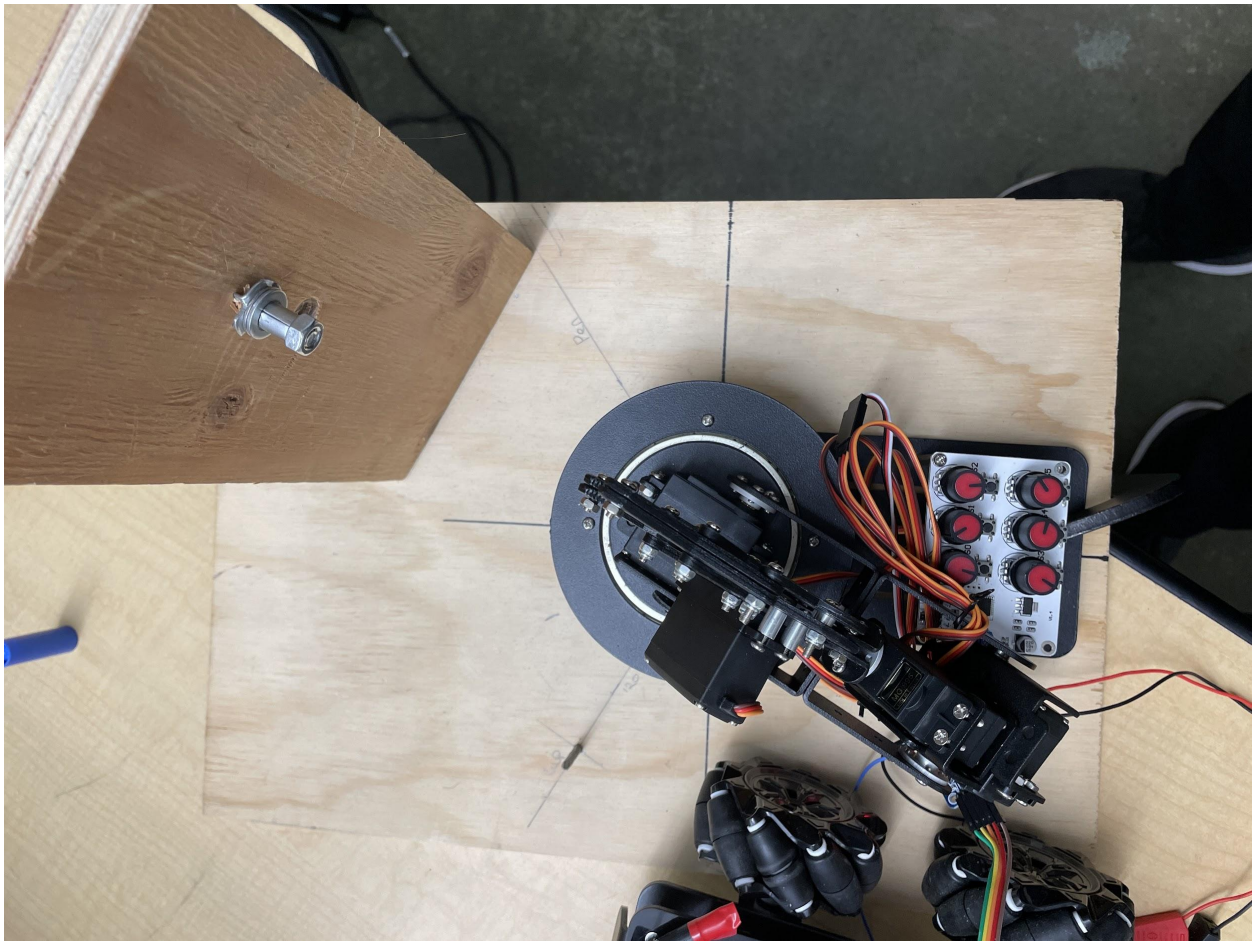
ATCS: Robotics Kinematics Software

Robot Arm Final Project

By Ethan Cao

Objective

Our objective is to remove the nut from the bolt and place it onto the nail using our five degree of freedom robot arm. The nut is screwed on until flush at L1 and the nail is located at L2. A picture of the setup is below:



I worked with gloria on this project and she focused on the math of the arm while I focused on mechanical changes and implementing code.

Arm description

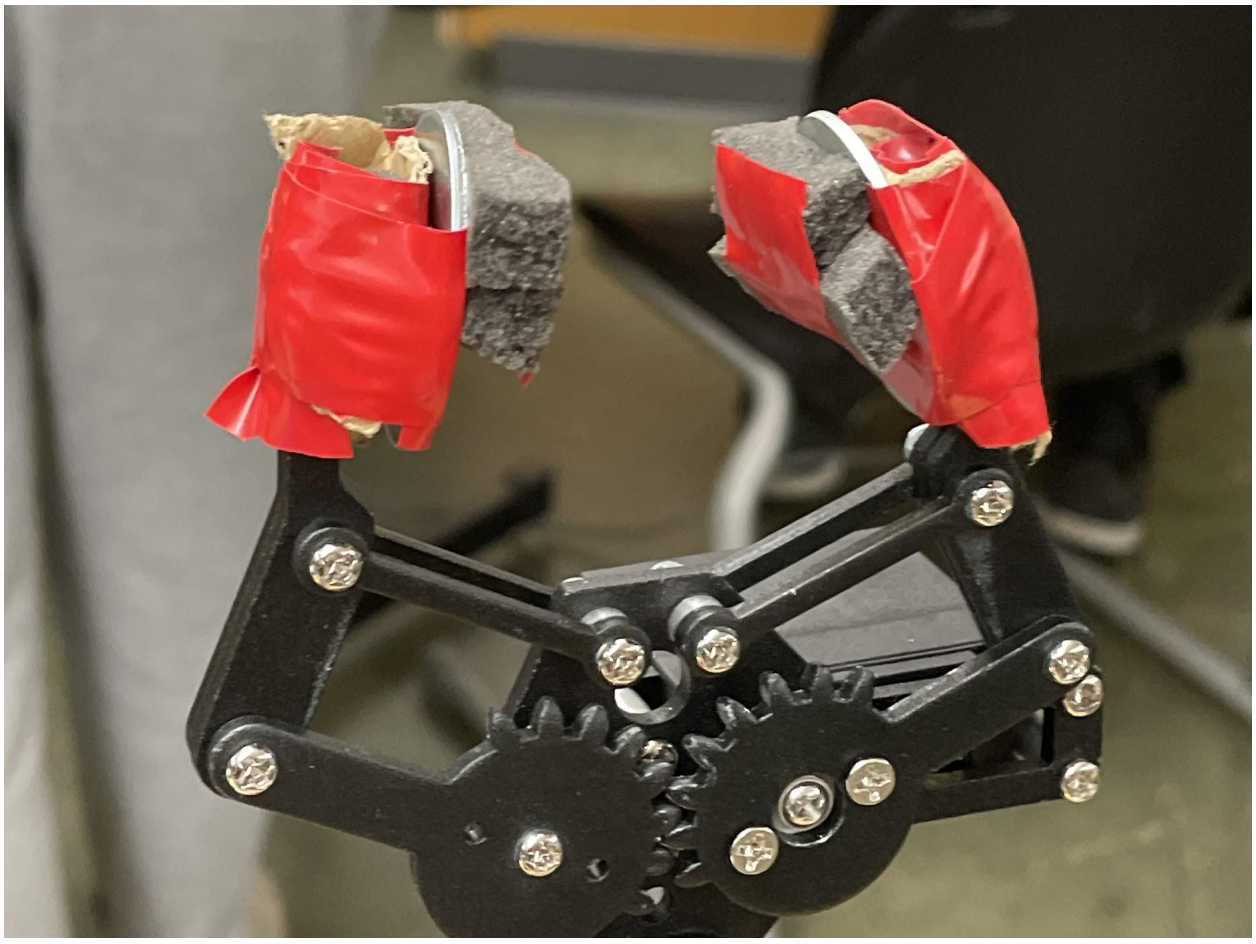
Our robot arm achieves 5 degrees of freedom by using 5 rotational servos driven through the PWM ports of an Adafruit PCA9685. The Adafruit PCA9685 is powered and controlled through the I2C bus of a Raspberry Pi 4B. The arm has one servo to rotate the base, two servos to move the arm vertically and horizontally, one servo to rotate the claw, and one servo to open and close the claw. Each of the servos has a range of 180 degrees

Mechanical changes

We had to make two minor mechanical changes to the robot arm in order to accomplish our objective.

First, we had to mechanically offset the upper horizontal/vertical movement servo by ninety degrees. This would allow our robot arm to retract its horizontal reach to values less than the length of the upper joint, as the upper joint could form an angle which is less than ninety degrees.

Second, it was difficult to have the claw perfectly line up with the nut every single time due to the backlash in the robot arm. To solve this, we added washers and foam tape to the ends of the claw to give us more wiggle room when grabbing the nut. A picture of our claw modifications is below



Finally, we tightened the bolts as far as possible to reduce backlash.

Slow motion

While it was possible to complete the objective moving the arm to each point as fast as possible, we found the original speed to be extremely violent. Therefore, we added a system that would calculate the time a move should take given a fixed max speed (in degrees per second) and moved the arm in small increments spread out across that time to reach the final position. We also added a boolean parameter to define if we wanted the rotations to be instant (send servos to the final angle immediately) for motions that are not sensitive to rapid motion.

Tuning and testing

We originally used measure points to tell the arm where to move and these points got us close to where we wanted but weren't exactly correct due to imperfect servo alignment. We modified our points until the arm could reliably reach the nut location and screw location before moving on to unscrewing the nut. We discovered that the surface area of the claw was too small and that increasing the contact area of the claw would give us more wiggle room. Additionally, we reduced the claw power to allow the nut to slip if we grabbed the pointy edge of its hexagonal shape. This allowed us to remove the nut every time with six turns. At the very end, we struggled to consistently release the nut from the claw, as it would always stick to one side momentarily, giving the nut a horizontal speed. We could solve this in the future by either reducing the speed the claw opens, getting the tip of the screw into the nut before releasing, or changing the material of our gripper.