282.772

Industrial Systems Design and Integration

Gripper Project

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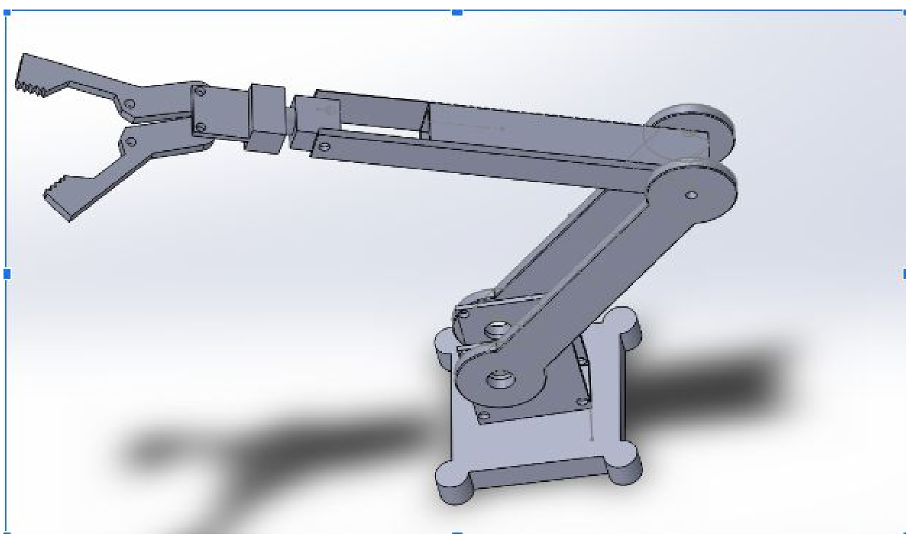
Introduction

Mechanical robots are widely used in industries and manufacturing. It is important to understand the dynamic components that are integrated together to deliver the functions of a robot. Robots are important for industries due to their unique advantages that they offer in production. They are capable of automating repetitive tasks at a high volume while increasing efficiency and lowering margins of error. They also provide speed, accuracy and stamina whereas a human worker would not be able to.

This report will be looking into the design of a robotic arm with two degrees of freedom. The primary focus of the movement is at the end-effector, which is at the end of the robotic arm and is sometimes known as a gripper. It is used to pick up objects or tools that can be fixed onto the end-effector. It is crucial for the end-effector to have flexibility and freedom to diligently perform its respective tasks.

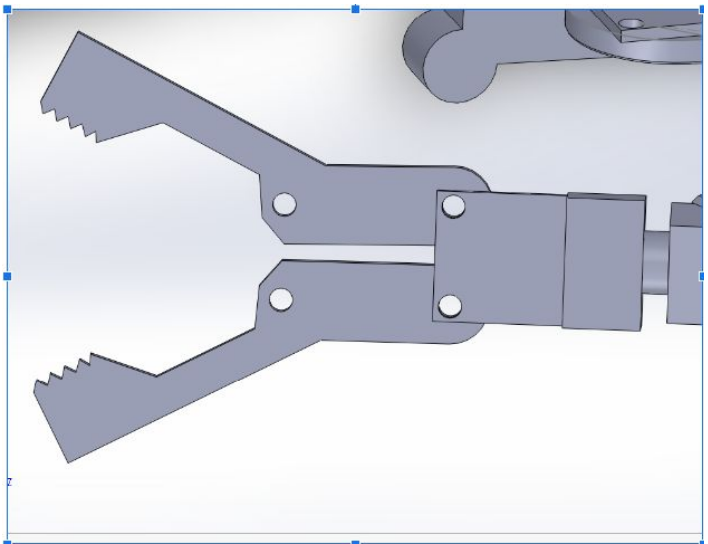
Methodology

CAD Design



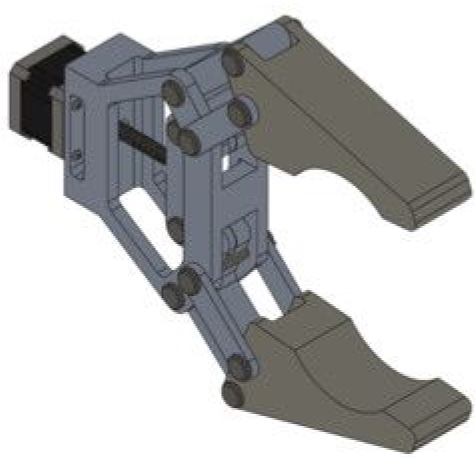
This is the original robot arm CAD design which was constructed on Solidworks for a previous assignment. This system has 4 degrees of freedom.The arm of the robot consists of a base that is capable of rotating 360 to move the arm around. There are two long joints and a short joint at the end before the arm connects with the grappler.

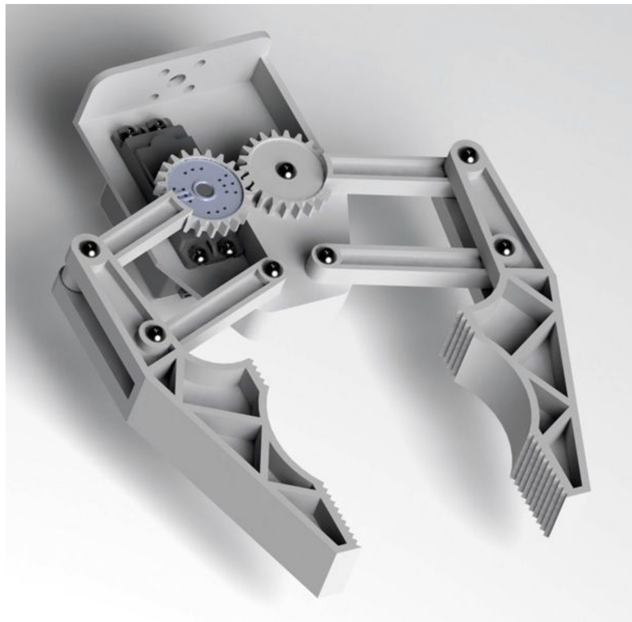
The two long joints are for extended reach and support. The short joint is so the grappler can move at an angle, increasing it's grappling ability. There is an open hollow gap in the first joint so that the second joint can retract into it, increasing the flexibility of the robotic arm.

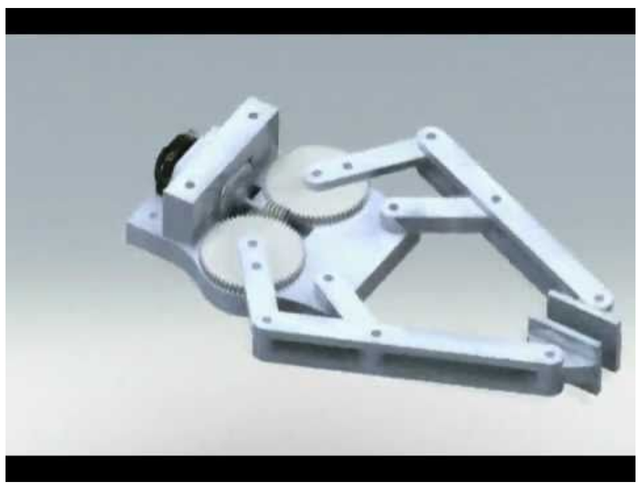


This is a poorly designed grappler. I had difficulty getting the orientations and mates to co-exist with each other in SolidWorks assembly. A proper, planned design with premeditated dimensions would be more robust and have other connectors, joints, gears and motors to further demonstrate

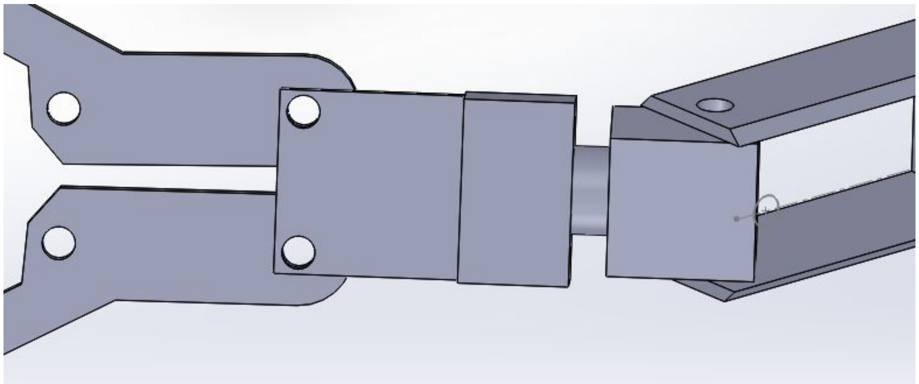
Due to the ill thought design, it would be incapable of picking up most objects due to it's awkward positioning, angles and design. Because of this, I will be looking at other end-effectors from others.







These are various end-effector designs I found on Google. The end-effector would be connected to a servo motor. A servo motor would be used for the movement of the grapplers because the encoder will provide higher accuracy and precision for the orientation of the grappler. Server motors have high power output and efficiency. They are also compact in size thus making it easier to integrate inside the grappler.



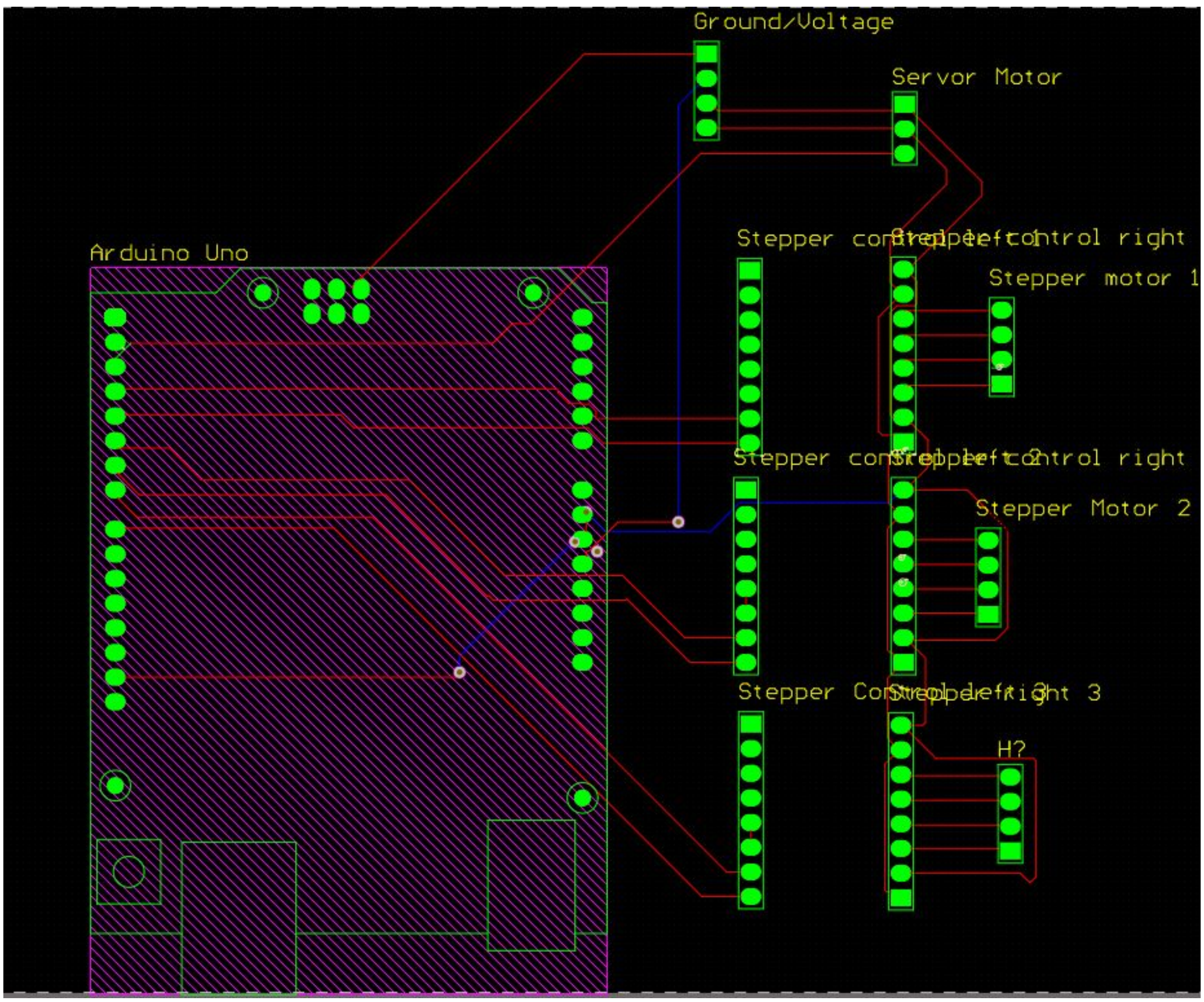
This is the wrist of the robotic arm which connects the grappler to the main arm. It has a joint that is capable of free rotation to increase the movement and access of flexibility of the grappler. This wrist compartment will have a stepper motor integrated to control the dextretious rotations and movements of the grappler.

The stepper motor also provides precise positioning and repeatability of movement. It also needs to be strong and have high accuracy so the wrist doesn't do extra rotations or step out of the required angle which will cause issues for the grappler's positioning and ability to perform. As the rotational angle is correlated to the input pulses and has effective response time to starting, stopping and reverse, the stepper motor ticks off all the required specifications for the robotic arm to maximise its performance output.

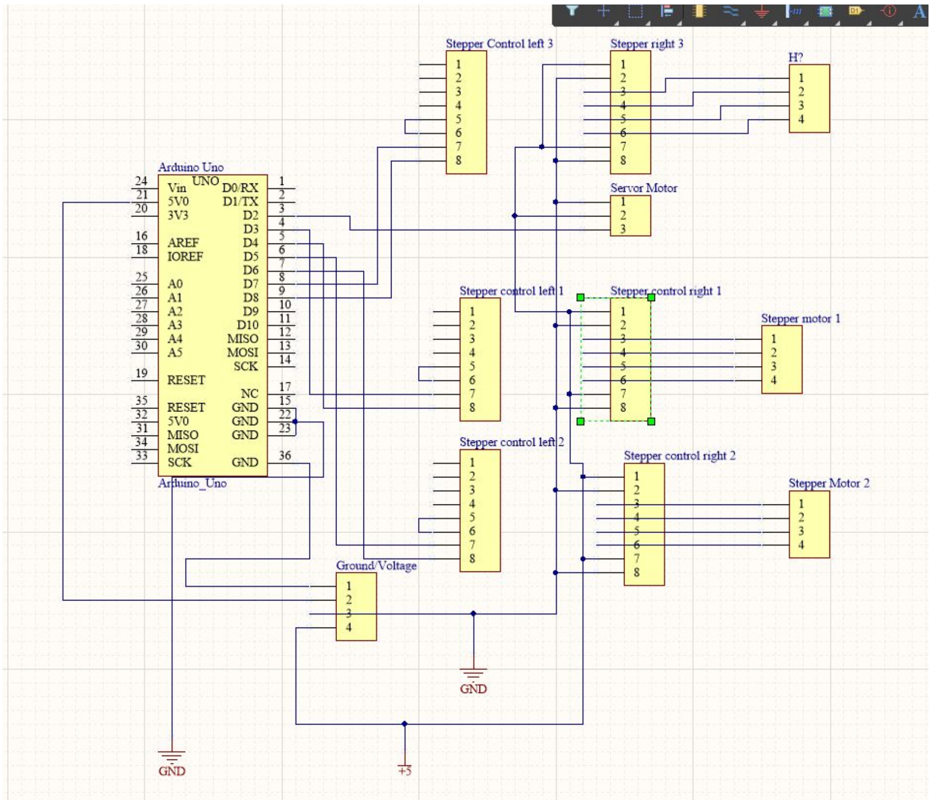
The other joints of the robotic arm which consists of the elbow, shoulder and base will also have motors to aid the movement. The elbow and shoulder can use either a servo or stepper motor. Both motors can effectively perform the movements required for the elbow and shoulder joint. The base will have a stepper motor for the exact reasons that were stated for the wrist.

The materials for the design of the robotic arm will need to be structurally sound and strong so steel or aluminium would be required. But as this is just a small project to lift a tiny object, plastic is also strong enough for the test run and it is much cheaper than steel or aluminium. These parts can be 3d printed out from a bigger 3D printer. Acrylic and MDF wood can also be used as this is available in the Massey university workshop. The parts can be laser cut using the laser cutting machine. Brackets to hold motors and to keep the arm's joints together are also 3D printed.

PCB Design



Ground/Voltage
Servor Motor
Arduino Uno
Stepper motor 1
Stepper Motor 2
H?



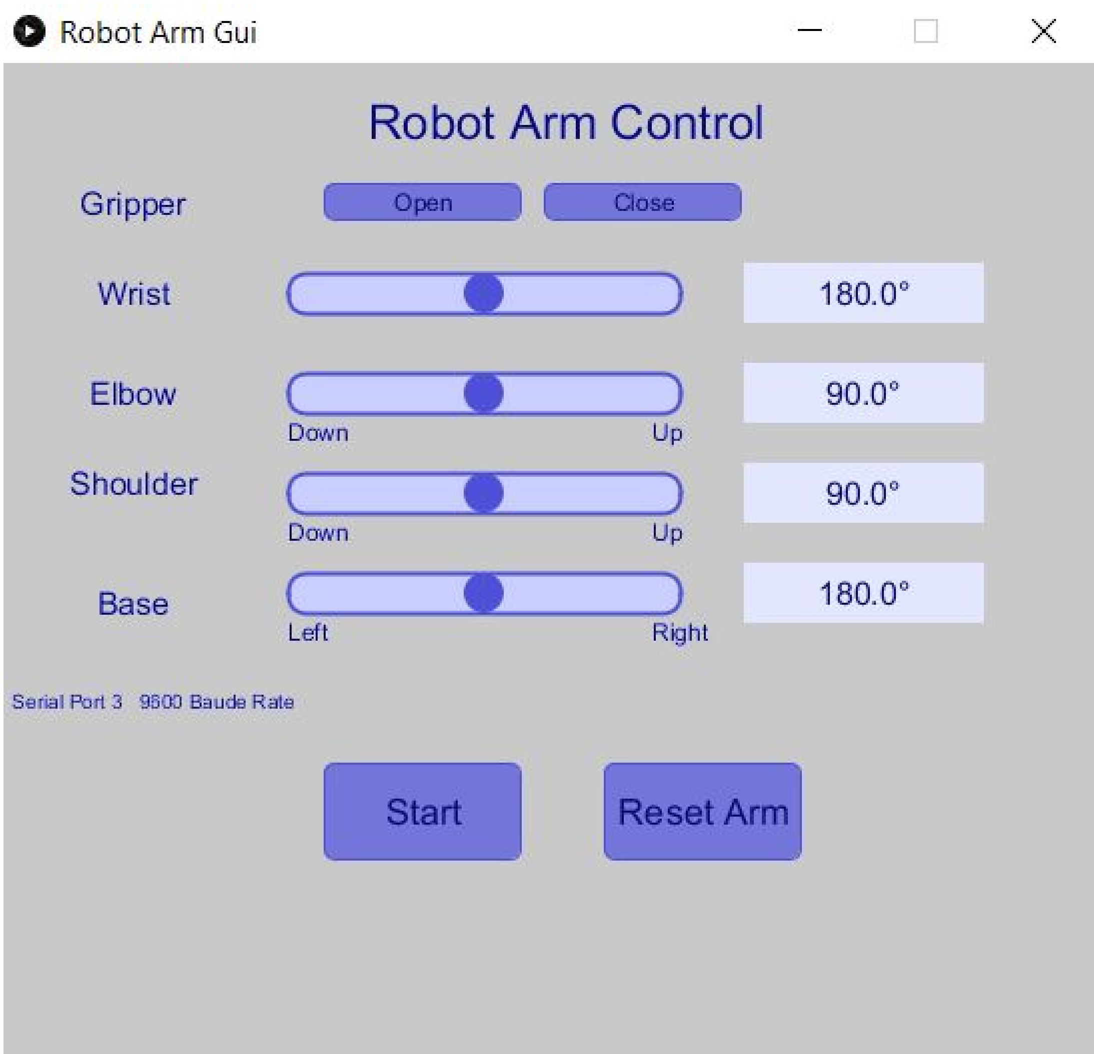
This is the respective PCB that was specifically designed for my robotic arm. This was designed on Altium. An Arduino microcontroller is used for this design as I am familiar with Arduino and it has sufficient resources to run this system efficiently.

An external ground and voltage in headers were installed as the Arduino uno would not be capable of powering multiple motors with it's input voltage source. This would lead to the system malfunctioning and the motors not working or working on low efficiency due to the low power source so it is vital to have an external ground and voltage source. I choose a 4 header component just including the extra two connections into the Arduino's input voltage and ground source.

Six 8 headers were used for the 3 stepper motor control boards. This is because the stepper motor board has 16 pins. All the pins were wired respectively as I found on the data sheets. The digital pins D2-D9 from the Arduino uno were used to connect all the motor connections. The input voltage and ground of the motors were connected to the external voltage and ground header. 3 four headers were used to connect the stepper motors to the motor control boards. A 3 header was used for the servor motor as it has 3 pins.

The PCB was traced using one layer for most of the wires but the extra ground and voltage connection to the board required a second layer due to overlap. These connections are not needed for the system to function however. These overlaps could also be avoided if the arduino was flipped around to close the distance between the digital pins and motors control boards. The control boards were placed parallelly so they can be placed neatly on top after the PCB is manufactured and the motor wire connections are placed right beside the motor control. This PCB will be manufactured in the Massey University electronics lab by Kay.

GUI Design



This GUI was designed on the processing development environment. I chose this specific development tool because I already had experience using it for other Arudino based projects and there are a lot of tools and libraries that can be utilized to create various types of graphical user interfaces.

This GUI is straight forward and easy for an user to interact with. The gripper has a simple open and close function where the gripper will open or close based on the buttons pressed. It is important to program the gripper in a so that the gripper doesn't continuously and forcefully keep clamping when it has an object in its grasp as this excess force on an solid object will damage the robotic arm. These open/close buttons can be changed into a slider if this proves to be a problem.

The wrist and base have 360 degrees of freedom as they are capable of rotating freely due to the design. The movements on the elbow and shoulder are limited as if it was capable of too much free fall rotation, the robotic arm will have excess movement where it will hit the ground and perform too many unnecessary movements which will damage the arm. Tests will be conducted with the elbow and shoulder joints to measure the ideal angle limitations and movements that are required for efficient performance.

The start button turns the robotic arm on and performs a serial connection to the microcontroller. The reset button resets all the components to its original angles which are defined on the picture above.

Results

Due to the current global situation, a physical design was not constructed unfortunately. This also means that I am unable to test out and integrate my PCB, GUI and CAD parts together to test out a working robotic arm. An animation was made on Solidworks with my CAD design. The animation consists of the robotic arm CAD picking up a work piece. It is impossible to gauge out if my design would have been able to carry out this task due to dynamics and complexities that would be present in a real time scenario so the animation is not a good indicator of a functioning design. Furthermore the animation is not utilizing the software and electronic components. It is definitely guaranteed that there would be multiple setbacks and design flaws in a real time setting.

Conclusion

A robotic arm is a complex and dynamic piece of equipment which requires different systems working together simultaneously to function effectively. The aims of this assignment were successfully achieved which required the development of electronic, control, software and mechanical aspects to be integrated together for a robotic arm to pick up a designated work piece. CAD was designed for the mechanical design of the arms, PCB for the electrical components of the motors and a software GUI to control the entire system.