ROBOTICS 4 DOF ARM

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Introduction

The main focus of this project was to design and develop the mechanism for robotic arm for lifting. The robotic arm was designed with four degrees of freedom and programmed to accomplish accurately simple light material lifting task to assist in the production line in any industry. Laser Cutting method is used in this project to fabricate the components of the robotic arm. Therefore, it provided more precise dimensions and huge time and cost-saving in fabrication. The robotic arm is equipped with 4 servo motors to link the parts and bring arm movement. Arduino, an open-source computer hardware and software is applied to control the robotic arm by driving servo motors to be capable to modify the position.

Introduction

- What is “4 DOF Arm”?
- 4 DOF Arm stands for 4 Degree of Freedom Arm, that means in order to specify any position of the arm we need 4 independent co-ordinates or variables to estimate a single possibility of the arm. 3 variables are given then there can be more than 1 possible position.

Why do we need to make robotic arm?

In manufacturing a robotic arm is widely used in the assembling or packing line by lifting the small objects with repetitive motion that human couldn’t bear to do in a long period of time. The light material lifting task can be done by the robotic arm efficiently and timesaving because it is not restricted by fatigue or health risks which man might experience

In medical technology, prosthetic arm can be aimed at improving dexterity of the disabled people. In near future, such robotic arms can further improve the emerging field of medical technology, by assisting surgeons for critical surgery.

What were the components used?

We used a myriad of components including the following in Electrical Area

- 5 Servo Motors-2 SG90 , 3 MG995
- Jumper wires
- Battery
- Battery Charger
- Arduino UNO as our micro-controller
- Breadboard

We used the following in Mechanical Area

- We made a 3D AutoDesk model and did laser cutting of acrylic sheet accordingly
- We then paired the links using different screws , bolts, washers for proper hinges
- We made a wooden base for our model

Design Work

The mechanical design of the robot arm is based on a robot manipulator with similar functions to a human arm. Robotic arm system often consists of links, joints, actuators, sensors and controllers. The links are connected by joints to form an open kinematic chain. One end of the chain is attached to the robot base, and another end is equipped with a tool (hand, gripper, or end-effectors) which is analogous to human hand in order to perform assembly and other tasks and to interact with the environment. There are two types of joint which are prismatic and rotary joints and it connect neighbouring link. Symbolic representation of joints-

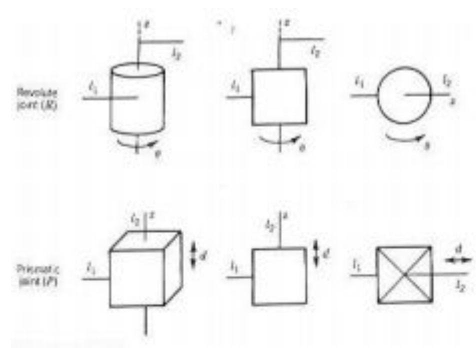


Fig 1. shows two types of joint in robot

The links of the manipulator are connected by joints allowing rotational motion and the links of the manipulator is considered to form a kinematic chain. Figure 2 shows the Free Body Diagram for mechanical design of the robotic arm. A robotic arm with only four degrees of freedom is designed because it is adequate for most of the necessary movement. At the same time, it is competitive by its complexity and cost-saving as number of actuators in the robotic arm increases with degrees of freedom.

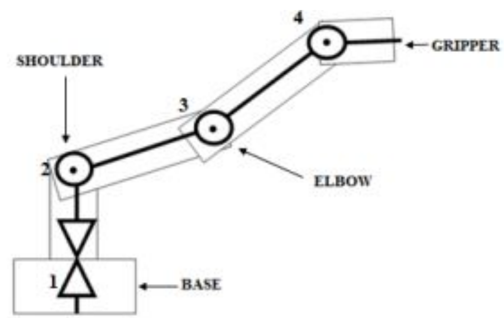


Fig. 2 Free body diagram of the robotic arm.

Actuators are devices that cause rotary joints to rotate about their motion axes, or drive prismatic joints to slide along their motion axes. In our design, we are using electrical actuating systems. DC motors and stepper motors are used to actuate the movement of the robotic arm. This is because this system can be controlled easily and the servo motor is able to give a fast response, high accuracy, included encoders which automatically provide feedback to the motors and adjustability of position accordingly. This type of actuator is suitable for small robots. However, the disadvantages of the servo motor is that rotation range is less than 180 degree span, thus the region reached by the arm and possible positions are greatly decrease. Selecting suitable motor for the application is crucial in the design stage which decision is made based on torque and the speed of the motor. Force calculation of joint ensures that the motor chosen can support the weight of the robotic arm and also the load which need to be carried. Servo motors is recommended when high torque and precise speed desired by the user. For only positioning without requiring a high torque, stepper motors are used in the application. Torque is the tendency of force to rotate an object about an axis.

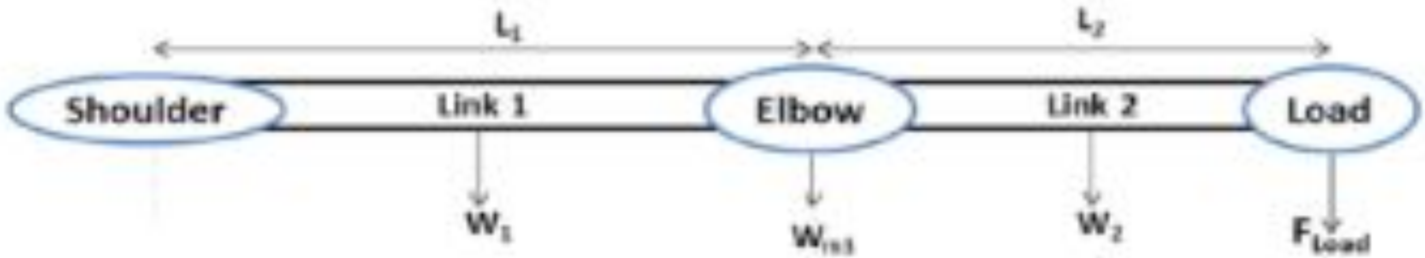


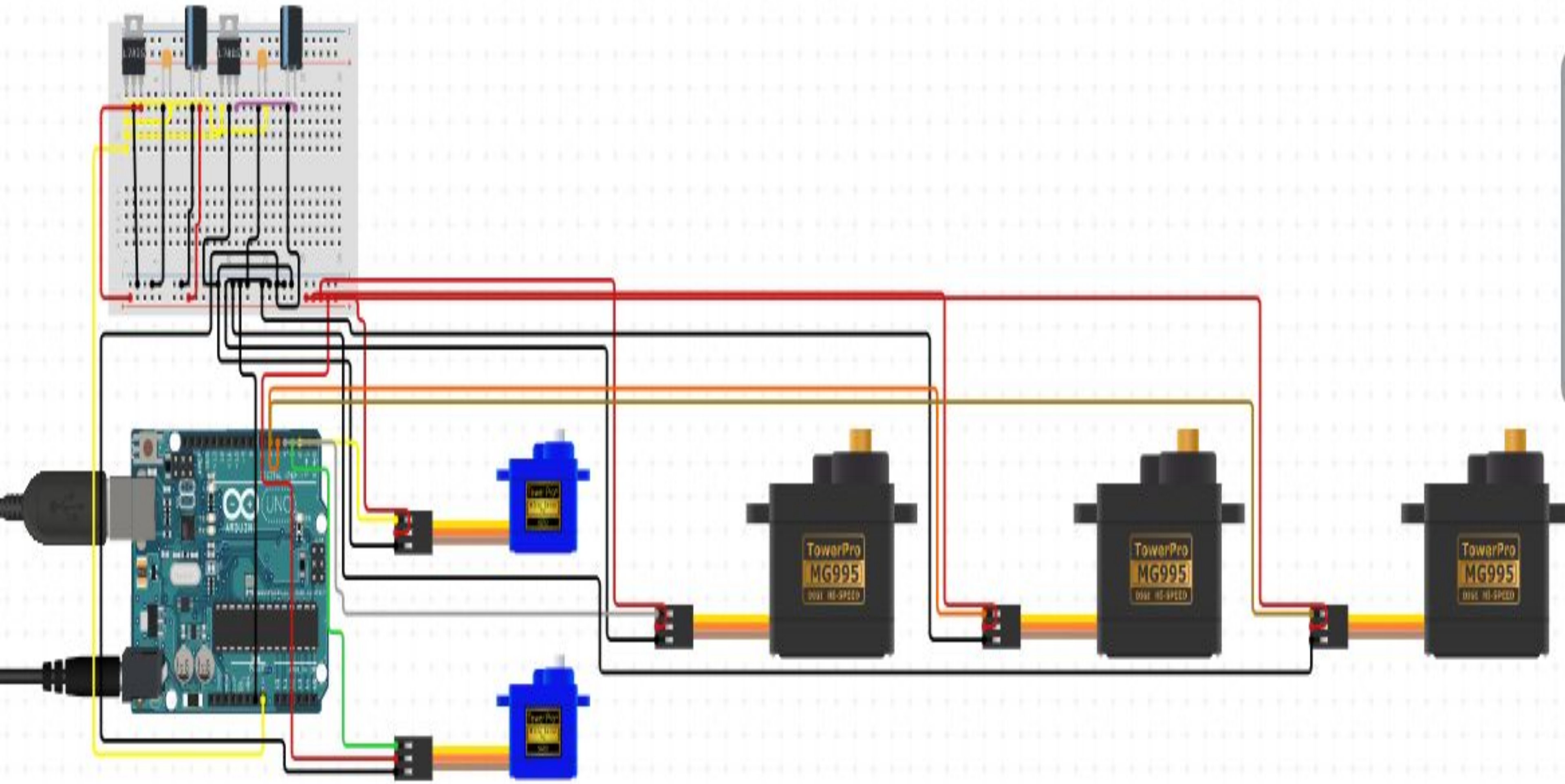
Figure 4: Free body diagram of the robotic arm in the fully stretched out configuration

$$T_{elbow} = [F_{load} \times L_2] + \left[w_2 \times \left(\frac{L_2}{2}\right)\right] \quad (2)$$

$$T_{shoulder} = [F_{load} \times (L_1 + L_2)] + \left[W_2 \times \left(\frac{L_2}{2} + L_1\right)\right] + (W_{m3} \times L_1) + \left(W_1 \times \frac{L_1}{2}\right) \quad (3)$$

Where W_1 and W_2 represent the weight of the Links (1) and (2), respectively. W_{m3} accounts for the weight of elbow motor. F_{load} represents the combined weight of the payload and the gripper.

Electrical connections



Dynamics

Servo elbow angle : α

Servo shoulder angle:β

Length AB = l_1

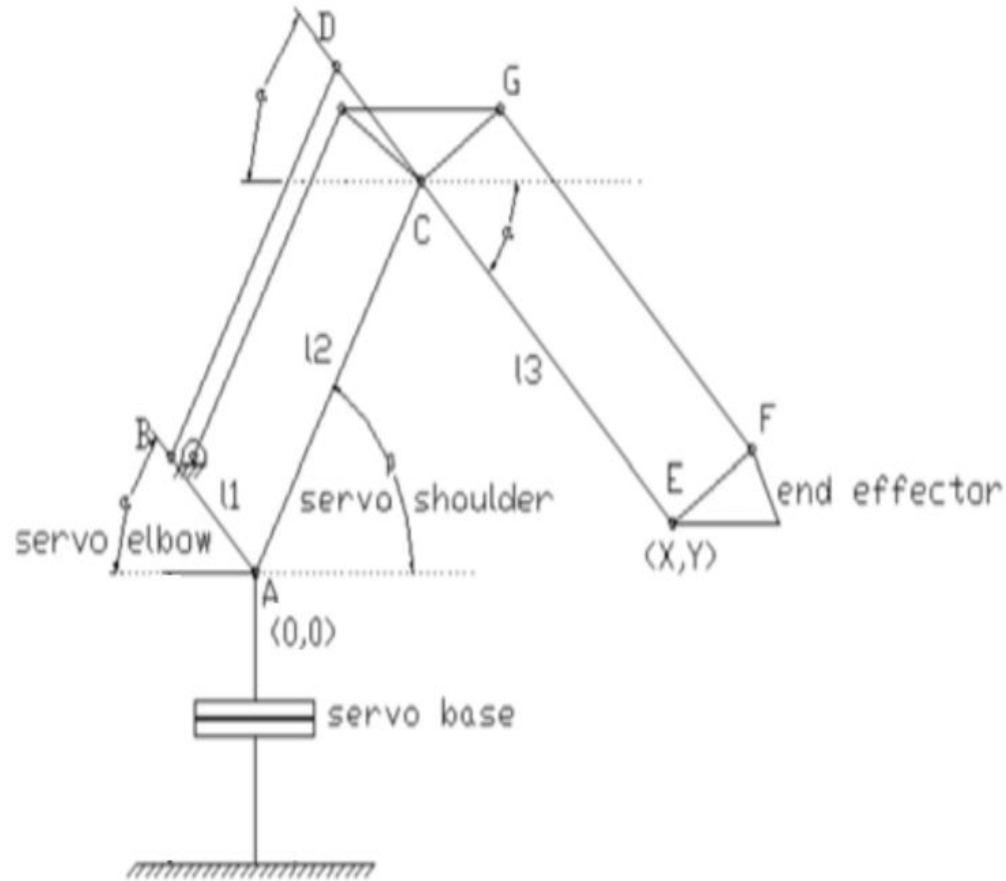
Length AC = l_2

Length CE = l_3

Coordinates of End Effector: (X,Y)

$X = l_2\cos(\beta) + l_3\cos(\alpha)$

$Y = l_2\sin(\beta) - l_3\sin(\alpha)$



Development

The servo motor is controlled via an Arduino Uno through coding.

The robotic arm parts are joined together by fastener: screws and nuts. For it’s light material lifting application, we designed the end-effector(gripper) and coded accordingly. We used MatLAB to find solutions of equations(in terms of given coordinates of final position) which gave us angles and thus the bot could reach the final coordinates and come back. We also manually confirmed. solutions using coordinate geometry. We also run the loop which moves the motors in a continuous cycle according to write theta function and all the links complete their motion. We tested the performance of the robotic arm by varying the load to be lifted; the lifting mechanism of a robotic arm is validated.

Accuracy

Due to variation in weight, the final position of arm varies. This imprecision are caused by two factors. The first factor was the size of the weight which is not compatible and not suitable for the gripper due to its smooth surface. Secondly, the linkage bends a lot when gripping the 100g weight. This shows the lack of strength of the galvanized wire which causes imprecision for the robotic arm. The robotic arm was able to reach a good precision on its timing is because the usage of servo motor. Servo motors moves according to the input receive. The programming was set to perform the task within the given time For example: delay (500) which indicate the delay for 500 milliseconds. This shows that the robotic arm will perform the task within 500 milliseconds.

Future Scope

In the further development, the robotic arm can be situated on a mobile platform with 4 wheels to allow portability and navigation. Design of a universal gripper is interesting because it can lift different shapes of objects. Robotic arm can have sensors to detect the position of the objects and the whole process is automated and it can also communicate with user through networking.

References

1. https://www.researchgate.net/publication/289893486_Design_and_Development_of_a_Mechanism_of_Robotic_Arm_for_Lifting_Part1