# Controlling Robot Arm Using Kinect

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**Abstract** Nowadays, technology is advancing to keep up with the growing demands of society, and this progress is primarily focused on robotics. The term "robot" now encompasses any artificially created machine that can complete tasks that are typically carried out by humans, either autonomously or by remote control. Robots have become increasingly popular due to their precision and ability to perform tasks that are too dangerous for humans to undertake. Scientists are continually striving to improve robotics by developing new controllers and designs that increase efficiency and reliability. In our project, we built a robot arm with five degrees of freedom (DOF) that can perform pick-and-place operations using several implemented methods. However, the current controller is inflexible, requiring a reboot and a new program design to update the arm's movements. As a result, we opted for an unconventional approach and utilized an image processing device known as Kinect to control the robot arm.

**Keywords** Robot arm · Kinect · Arduino

## 1 Introduction

A robot is a machine created to carry out one or more tasks automatically with precision and speed [1]. Robots are often preferred over humans as they are cheaper to use, and some tasks are easier or even only possible to accomplish with them.

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Robots can venture into locations too hazardous for humans, such as inside gas tanks or volcanoes, or traverse the surface of Mars. Robotics is an interdisciplinary field that combines mechanical engineering, electrical engineering, computer science, and other disciplines [2]. It encompasses the design, construction, operation, and utilization of robots, as well as computer systems that control them, provide sensory feedback, and process information. Robotics systems have been widely adopted in manufacturing, military, and medical fields as they offer many benefits and serve as a solution for tasks that cannot be performed optimally by humans [3].

Robots have diverse applications in industries such as manufacturing, military, space exploration, and healthcare. These machines are classified as manipulator robots and are integrated with other components of automated or semi-automated equipment to perform tasks like loading, unloading, spray painting, welding, and assembling. Typically, robots are constructed, programmed, and controlled using a computer or a controlling device that utilizes a specific algorithm or program. The design of programs and robots is flexible, allowing for changes in behavior when the program is altered. Robots are categorized based on their generation, intelligence, structure, capabilities, application, and operational abilities [4].

Robots find extensive use in various industries, including manufacturing, military, space exploration, and healthcare. These machines are classified as manipulator robots, and they are combined with other components of automated or semi-automated equipment to carry out tasks like loading, unloading, spray painting, welding, and assembling. Typically, robots are created, programmed, and operated with the aid of a computer or a controlling device that utilizes a specific algorithm or program. The design of robots and programs is flexible, allowing for changes in behavior as the program is modified. Robots are classified based on their generation, intelligence, structure, capabilities, application, and operational abilities [5, 6].

The focus of this project is on a 5 DOF robot arm that has multiple applications, such as manipulating and lifting objects. It can also be utilized in medical procedures that demand precision and prolonged use. Additionally, the robot arm has the potential to serve as an artificial limb for individuals who have lost their limbs. The central concept behind this project is to incorporate a Kinect device as an image processor. The Kinect device captures images of the body and relays them to the controller to execute specific tasks [7, 8].

Our research aims are outlined as follows:

- Create and construct a robot arm with five DOF and a gripper (end effector) that can be utilized for educational and demonstrative purposes, as well as holding or repairing objects due to its extensive work envelope.
- Utilize the Kinect device as a means of controlling the robot arm, and successfully accomplish the task of transferring an object from one location to another based on a programmed sequence.
- Develop the capability to employ this robot arm in hazardous or toxic environments to execute tasks based on commands similar to that of a human arm.

## 2 Methodology

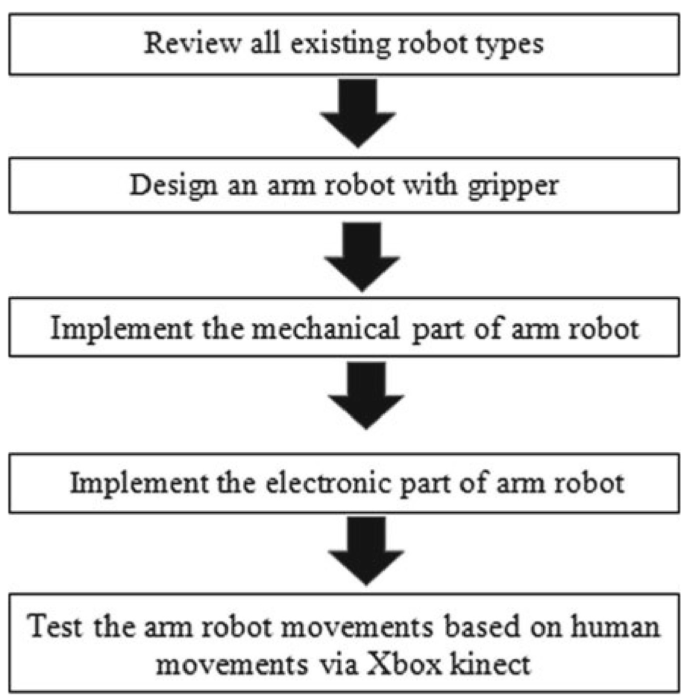
The scope and methodology of this project is illustrated in Fig. 1, which begins with a review of various load shedding techniques in order to experimentally verify the proposed approach.

Figure 2 displays the electronic circuitry of the robot arm. The user stands in front of the Kinect, and the processing software divides the body into joints and sends the joint angles to the Arduino. The Arduino mega then transmits control signals, representing the angles, to the servos in order to execute the necessary movements.

The initial stage of robot design involves determining the dimensions and workspace configuration based on specific requirements. Once this is determined, the next step involves selecting the specifications for each actuator. The robot arm is mounted on a base which is located at the bottom of the robot. It is crucial for the base to be sufficiently heavy to maintain the overall balance of the robot, especially when grabbing objects. Although stepper and gear motors are viable options, physical movement of the robot is achieved using servo motors. The key advantage of servo motors is their ability to return to their initial position, and they can be programmed based on specific requirements using signals received from the microcontroller. The diagram illustrating the robot arm and its coordinates prior to construction is depicted in Fig. 3.

The robotic arm developed in this research is a stationary articulated arm with 5 DOF, comprising of a base, shoulder, elbow, gripper, and two revolute joints (wrist and base). Prior to constructing the robotic arm, the controller for the 5 servo motors

**Fig. 1** Flowchart of the methodology



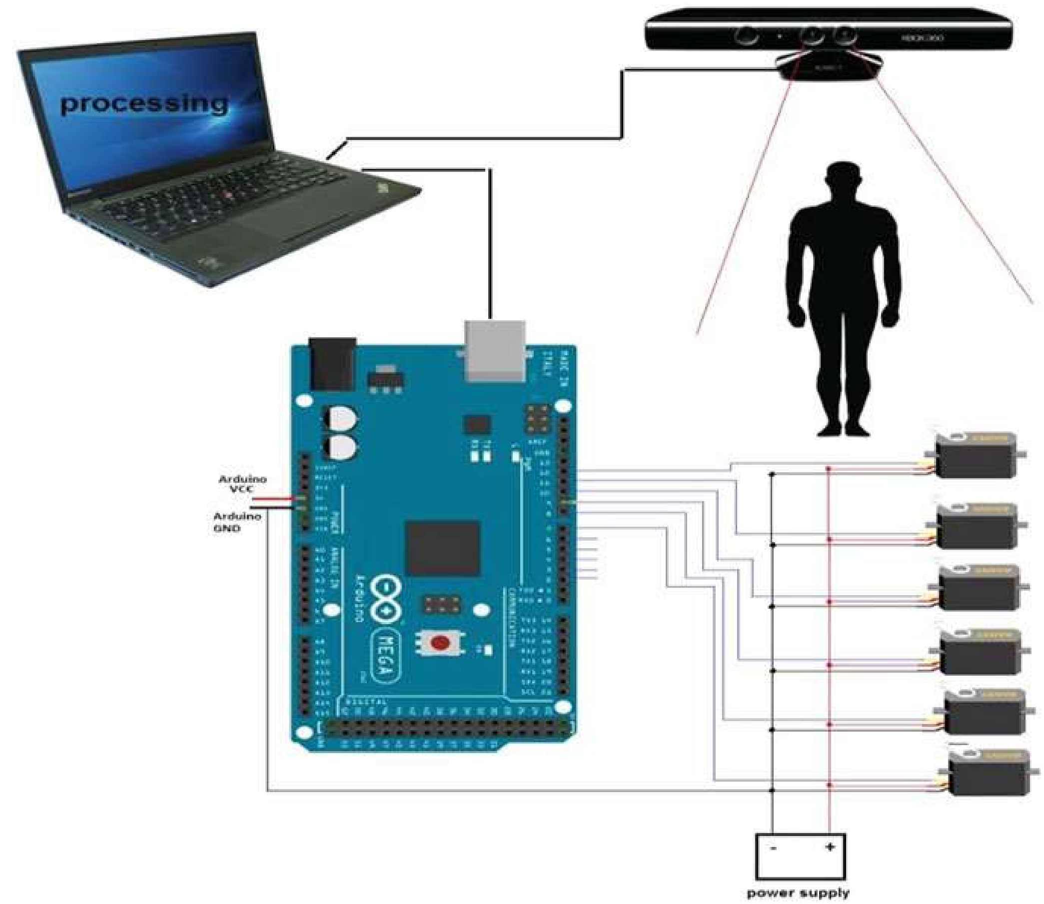



**Fig. 2** Analysis net magnitude and direction force

needs to be built first. To ensure proper functioning, a servo motor bracket was assembled beforehand, prior to integrating them into the robotic arm.

Once the project components were linked, the next step was to attach the elbow joint. This was accomplished by adding an A bracket that included a servo motor, similar to the previous steps. Then, a servo motor was attached vertically to the elbow joint to represent the rotating wrist. Finally, a gripper hand was added to the wrist joint, resulting in the completed robot arm as depicted in Fig. 4.

The software code is shown in the Fig. 5.

The algorithm for this project consists of two parts: the processing program, depicted in Fig. 6, and the Arduino program, illustrated in Fig. 7.

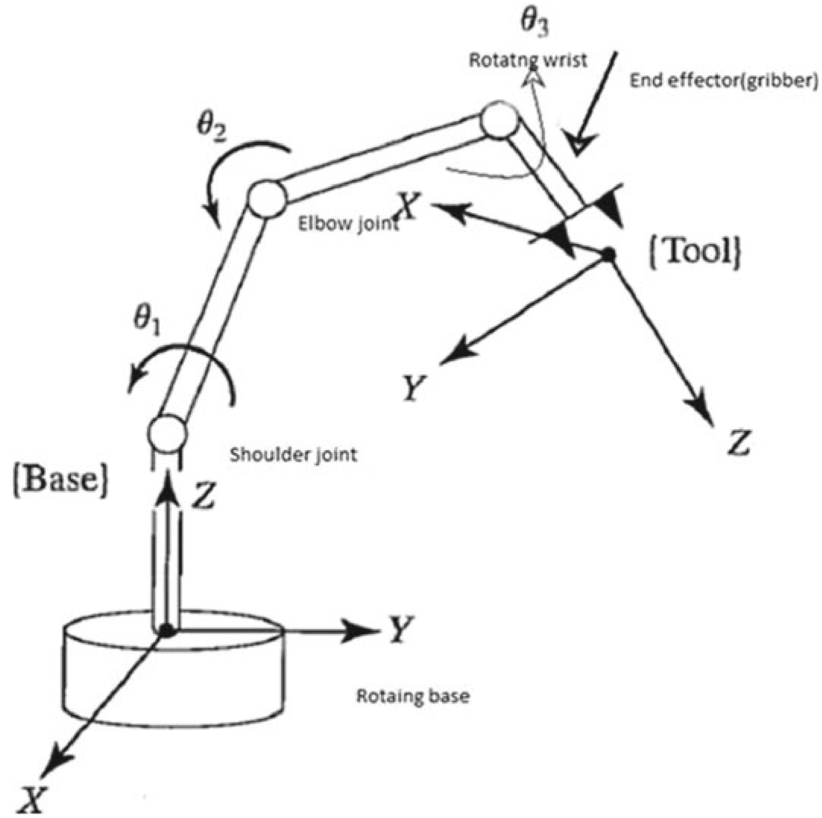



**Fig. 3** Robot arm diagram

**Fig. 4** Robot arm after construction


## 3 Results

Once the design process and review are complete, the final step is to perform testing. The robotic arm is assembled according to the design specifications, as depicted in Fig. 8, and programmed with various sequences to evaluate the system's performance. The processing program successfully responds to the Kinect, and when a human body

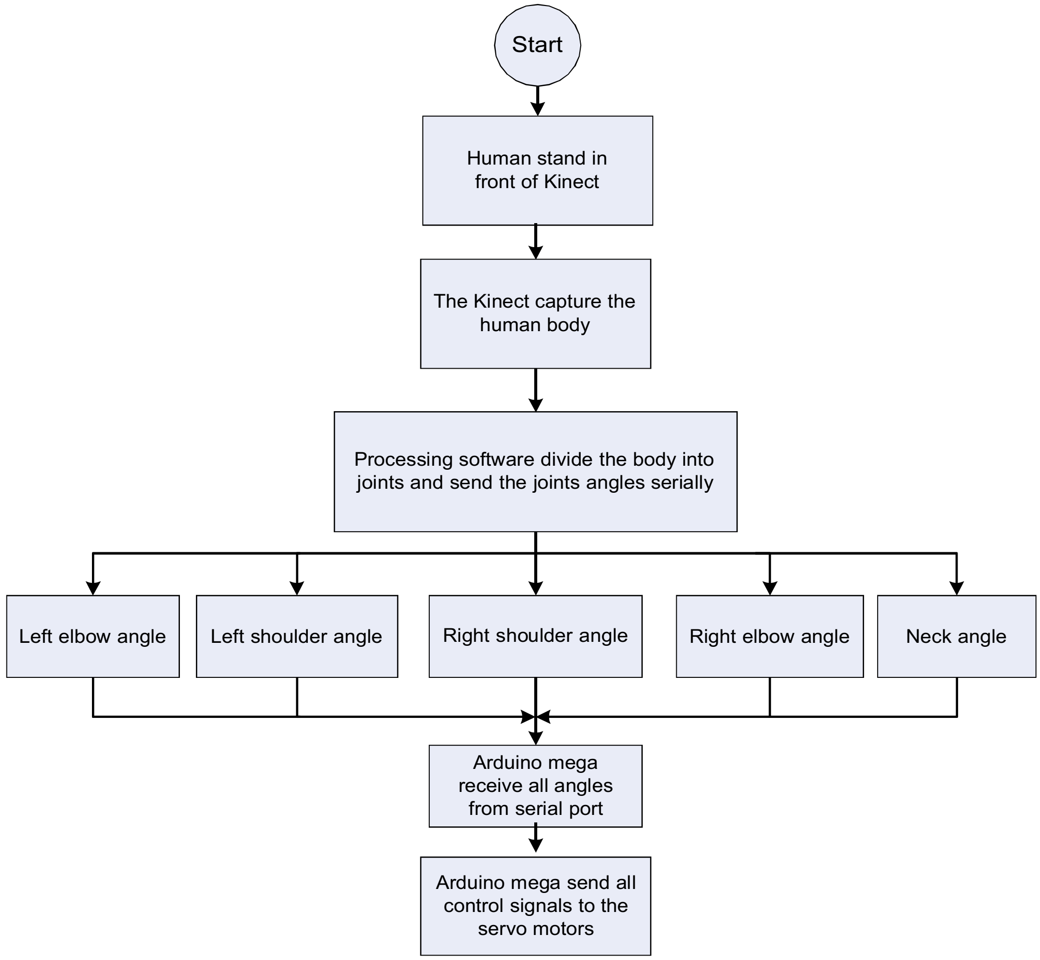



**Fig. 5** Software block diagram

stands in front of it, a scope window appears showing the body skeleton divided into joints, as illustrated in Fig. 8.

As shown in Fig. 6, the processing program is expected to provide a response for the 5 joints of the body. However, when the robot was connected to power, all joints successfully provided the desired motion except for the last joint. Specifically, when the left shoulder moved, the base of the arm rotated in either direction, and when the left elbow moved, the shoulder of the arm moved. Likewise, when the right shoulder moved, the elbow of the arm moved, and when the right elbow moved, the wrist of the arm rotated in either direction according to the angle.

However, there is an issue with the neck joint as it doesn't respond accurately and only moves a limited degree which is not sufficient for holding or grasping objects. This problem arose from the command in the processing program.

(float NECKM = angleOf(NECK2D, torsoOrientation, torsoOrientation);

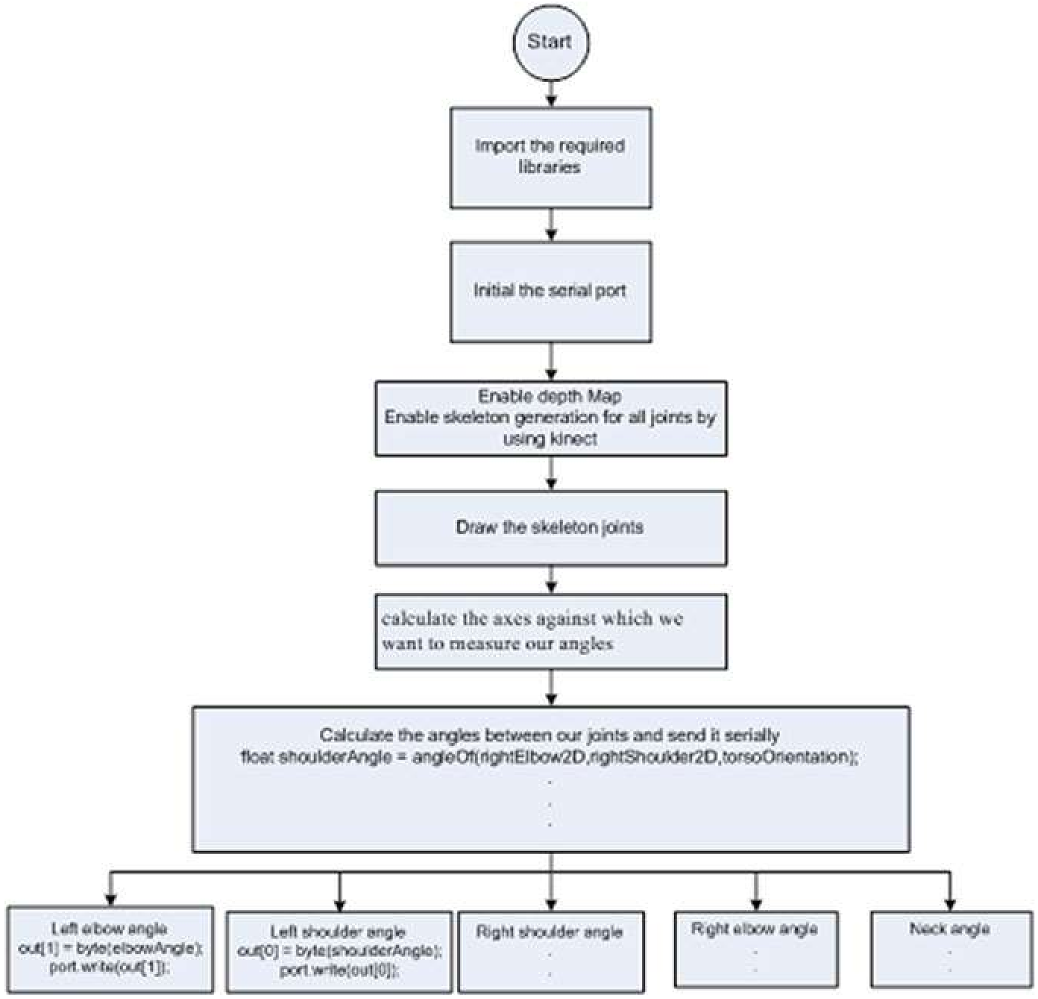



**Fig. 6** Processing algorithm

As the neck angle moves in relation to the torso of the body, measuring its angle in relation to something else becomes necessary since the current approach is not effective. However, individuals who wish to attempt this project can overcome this issue by modifying the processing program commands to achieve the desired outcome.

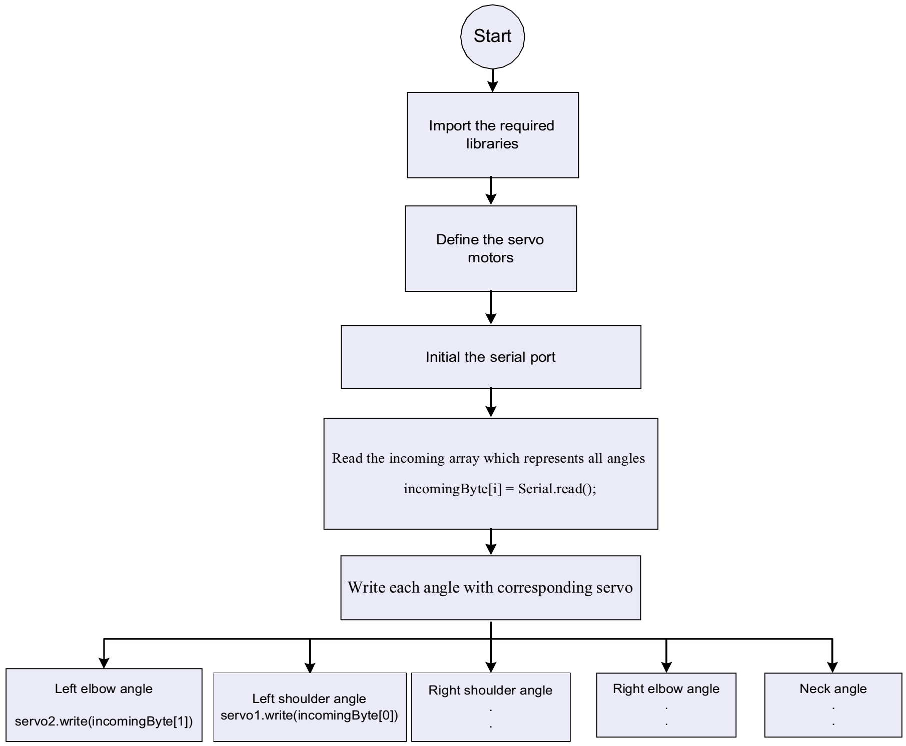



**Fig. 7** Arduino algorithm

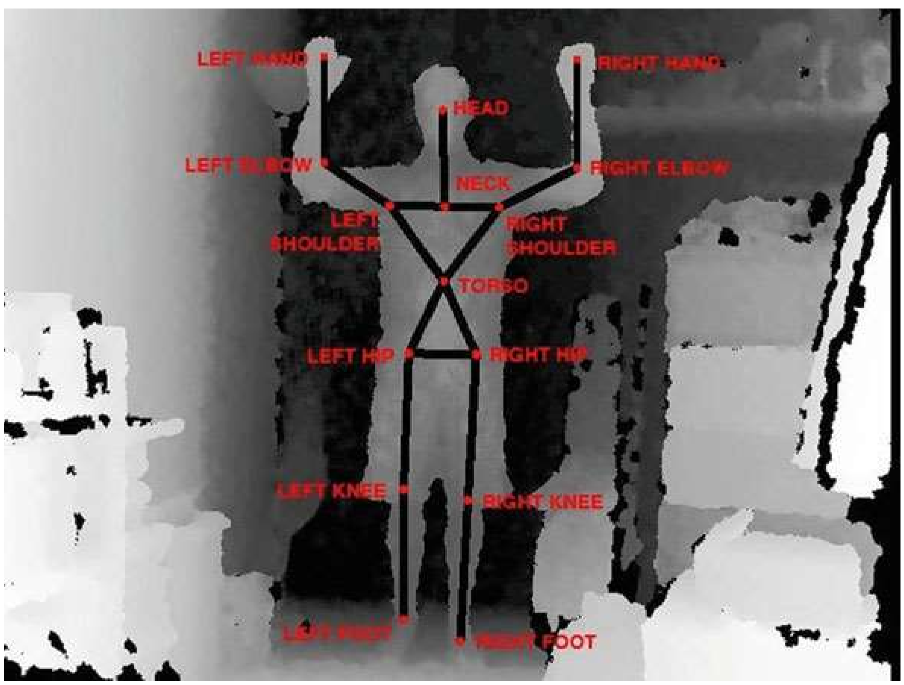



**Fig. 8** Skeleton included body joints

## 4 Conclusion

This project demonstrates that the Kinect tool is not limited to gaming, as it can also be used for controlling various types of machines. Throughout the development of the project, we discovered that the processing language (JAVA) has made significant strides in the technology field. This prototype serves as a stepping stone for a vast number of projects, ranging from military and medical to social, educational, and industrial applications, as well as for individuals with special needs. Furthermore, we realized that integrating multiple programming languages, as we did in this project by using the serial port to merge the processing program (JAVA) with the Arduino program (C), is necessary to accomplish certain tasks.

## 5 Limitations

The robotic arm project faced two issues. The first issue was insufficient torque from having only one servo in the shoulder joint, so an additional servo was added in an antiparallel configuration. The second issue arose during testing with the "sweep" code, where the shoulder servos were not operating in the same direction. This was resolved by reversing the angle of one of the servos to make them move together in the same direction (Fig. 9).

**Fig. 9** Shoulder joint issues

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