M.L.V. Textile & Engineering College, Bhilwara

Project Report: Robotic Arm

Submitted by:
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(Students of 3rd Semester, 2022)

Submitted to:
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Abstract:- We are here to present the design of a Robotic arm which simulates the human hand movement to grip an object. The robotic arm is an Arduino controlled arm hence it can analyse hazardous areas and do material handling. Some tasks require heavy load lifting and some require precise movements. Robotically controlled arms can be useful. In order to examine those torque characteristics, we consider a model of humanoid robot arm and simulate typical object lifting and transferring tasks by using the robot arm. The majority of current robotic hands does not completely replace the functionality of a hand and cannot be used in environments which are designed for the use of the human hand.

I. INTRODUCTION

Nowadays, Robotic arms have been mostly used for industry automation and operation in hazardous environments. Many robotic controls are very expensive, due to high-precision actuators and custom machining of components. We recommend that robotic control research can advance more rapidly if robotic arms of valuable performance are highly reduced in price. Increased affordability can lead to wider acceptance, which in turn can lead to faster progress. However, drastic cost reduction will require design tradeoffs and compromises. In robotics research, some of these dimensions are more important than others: for grasping and object manipulation, high repeatability and low backlash are important.

Human-safety is difficult if the manipulator is to be used close to the people.

We used Cardboard for building the structure of the robotic arm due to its characteristics such as light weight and cost-effectiveness.

The robotic arm is controlled by an Arduino Uno microcontroller which accepts input signals from a user by means of an IR module. The arms are made from cardboard where the rotary motion is provided by servo motors. The Servo motors are assembled in a particular manner so that movement of the arm is most efficient. The Arduino has been programmed to provide rotation to each servo motor corresponding to the amount of rotation of the potentiometer shaft. This selective operation robotic control method is needed to overcome the problem such as placing or picking objects that are distant from the worker. The robotic arm has been developed successfully as the movement of the robot can be controlled precisely.

In this paper the representation of the design, development and implementation of the robotic arm is done, which has the ability to perform simple tasks, such as light material handling.

The robotic arm is designed and made from cardboard material where servo motors are used to perform links between arms. The servo motors consist of encoders so that there is no need to use a controller. However, the rotation range of the motor is less than 180º span.

II. WORKING PRINCIPLE

The robotic arm works on the principle of electrical input energy to perform some mechanical work effectively with the help of some automation and program based operations. The pick and place robotic arm consists of major hardware components such as servo motors, battery, IR module, jumper wire and other mechanical and electrical components. This project is designed for developing a pick and place robotic arm. The robotic arm consists of servo motors which are used for angular rotations of the arm for catching items (to hold items, to release, to rotate, to place). This servo motor works on the principle of PWM (Pulse width modulation) technique. This control technique generates analog signals from digital devices such as microcontrollers. Pulse width modulation reduces the average power delivered by an electrical signal by converting the signal into discrete parts. In the PWM technique, the signal's energy is distributed through a series of pulses rather than a continuously varying (analog) signal. The signal thus produced will have a train of pulses, and these pulses will be in the form of square waves. Thus, at any given time, the wave will either be high or low. This servo motor is controlled using an arduino circuit board.

III. COMPONENTS

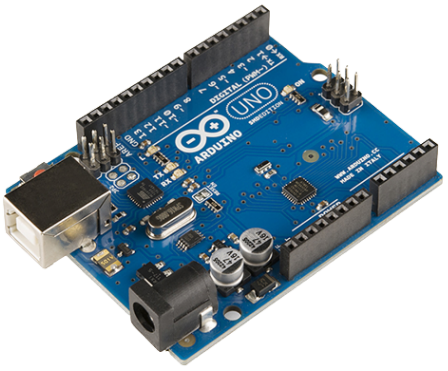
a) Arduino Uno CH340Q (Controller)

Arduino is a microcontroller that is the brain for the working of our robotic arm. It receives the signal from human input (in this case, ir module) and converts that signal for the servo to understand.

By sending a servo signals, a servo control can be obtained, a series of repeating pulses of variable width where either the width of the pulse (most common modern hobby servos) or the duty cycle of a pulse train (less common today)

- Determines the position to be achieved by the servo motor.
- Controller

The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable. It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts.



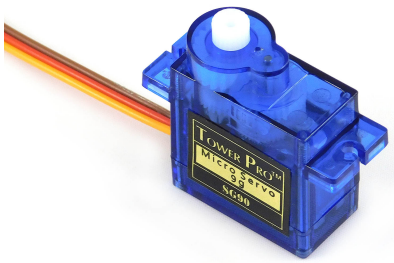
b) Servo Motor MG90s

Servo motors are the receiver of arduino signals and these present the output. The servo motor moves the arms and the grabber of the robot and enables it to perform the required tasks. The robot is

able to perform the pick and put tasks with its help.

This particular model of the servo was chosen, even when it was more expensive as this was more powerful than another similar model.

A servo motor consists of a gear assembly, a potentiometer, DC Motor and a controlling circuit. The DC motor used in a servo is a standard 4.8V DC motor that provides the rotation to the servo. The gear assembly reduces the RPM and increases the torque of the motor. The gear assembly is designed in such a way that the high rotational speed of the DC motor gets reduced so as to prevent sudden motion in the servo as well as to increase the torque output of the servo. The potentiometer helps the controlling circuit in knowing the current rotation of the motor shaft and it does this by varying the potential difference along its length as it rotates with the output shaft. The controlling circuit takes the input from the arduino and rotates the DC motor to the required angle while also checking its position using the potentiometer.



c) Breadboard

The breadboard is a circuit construction technique that is designed to allow the rapid creation of circuits without the need for soldering or making permanent connections. Breadboards are very useful for prototyping a circuit and preparing quick connections.

The inside of a breadboard is lined with small metallic clips that hold the jumper wire pins and create the circuit by also transmitting electrical signals along them and transferring them to the receiver.

d) Jumper Wires

These are wires that are used to electrically connect the servo to arduino through the breadboard. Jumper wires are easy to connect in breadboard and arduino. Jumper wire can transfer electric signals for the servo as well as power to run it.

These are small copper wires insulated on the outside. These have either male pins on either ends that make them male-male jumper wire or a female port on either ends to make female-female wires. These are also of the type where one end is male and other is female. These male and female ends are used in making the connections in the circuit.

e) DC Adapter (5V)

It is used as the power source for the Servo motor as well as the arduino. This adapter allows the power from the wall outlet to be converted into usable power for servo.

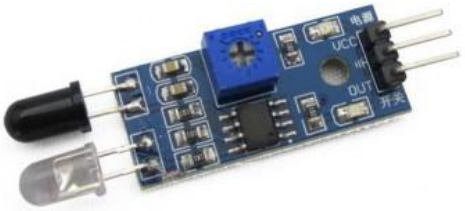
f) IR Sensor Module

IR Receivers are commonly used to control electronic devices wirelessly, mainly through a remote. It senses modulated IR pulses and converts them into electrical signals.An IR sensor can measure the heat of an object as well as detect the motion.Usually, in the infrared spectrum, all the objects radiate some form of thermal radiation. These types of sensors measure only infrared radiation.

It is based on three basic laws of physics: Planck's Radiation, Stephan Boltzmann & Wein's Displacement.

An infrared sensor includes two main parts namely the emitter & the receiver (transmitter & receiver), so this is jointly called an optocoupler or a photo-coupler. Here, IR LED is used as an emitter whereas the IR photodiode is used as a receiver. The type of incident that occurred is the direct otherwise indirect type where indirect type, the arrangement of an infrared LED can be done ahead of a photodiode without obstruction. In indirect type, both the diodes are arranged side by side through a solid object ahead of the sensor. The generated light from the infrared LED strikes the solid surface & returns back toward the photodiode.

It receives the signal from the user and decodes it for the use of servo. A TV remote is used to send the signal in this case. The IR Receiver used has a range of 1 to 30 cm. IR Receiver connects into the arduino.



g) TV Remote (User Control)

It is used to operate the servo motor motion wirelessly by sending signals to the IR sensor module which is connected to the arduino uno board. The IR module converts IR pulse to electric signals.These

signals further transmits to the arduino board. It converts that signal for the servo to understand. Then the servo motor starts functioning according to the signals it receives.

We used an old TV remote for user control. The signal from the TV remote is received by the IR receiver. Signals from different keys on the remote are different and using this, we set up our arduino to decode the signal from the remote and specified each signal with a particular task, like moving a servo by 10 degrees on each keystroke.

IV. CONSTRUCTION

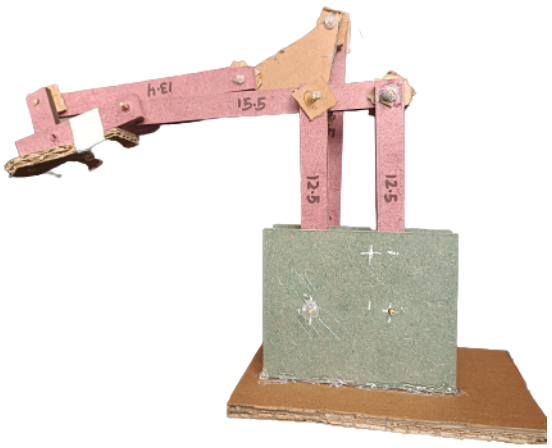
We began creating our first model using cardboard and some inspiration from the internet. We adopted a model design and started our work.

Cardboard strips were cut out using a cutter and were assembled into shape using all-pins and wooden skewers. A hot glue gun was used as the adhesive. The dimensions used for the model are as follows:

Rough Model

The cardboard model was our rough model for getting the idea of the design. Using this design we created a stronger model using MDF (Medium Density Fibre) material. This model was made from MDF material strips cut to length. Holes to join the pieces were made using a drill machine.

This model had two parallel strips along its base, which are meant to provide stable movement to the arm. A longer strip connects the top of these parallel base strips and moves to and fro parallel to the ground plane. This strip is what is used to support the grabber part of the arm. Another strip that moves up and down with the help of a servo motor tilts a triangular shape that creates a see-saw motion with respect to the front base strip. This see-saw motion of the triangle converts the up and down motion of the servo controlled strip into to and fro motion of another strip joined at the other end of the triangle (vertical motion to horizontal motion). This horizontal strip is the cause for the grabber part to tilt up and down.



MDF Model

We rejected this model for its disadvantages such as:

- Its limited range of motion.
- Complex construction.
- Difficult control.
- Unsmooth Motion

The final model was made using cardboard rolls. Cardboard rolls were chosen because of their light weight and high bending strength. Cardboard rolls were used for making the arms of the robot, the rest of the model was made using cardboard.

The new design consisted of a base made of cardboard containing all the electronics. Above that is a Cardboard plate that holds the servo motor responsible for rotation of the robot. This servo then connects to another round piece of cardboard that is the part that holds the leaning part of the arm. To make sure that the whole load of the arm comes through the shaft of the motor, standoffs consisting of rollers are placed at appropriate height.

A servo motor resting on the round piece supports the first arm of the robot. A wooden shaft is also attached to the arm as a support from the other side than that of the servo. This arm bears the most load as it is the lowest part of the robot as well as the furthest part from the most unsupported load at the top of the arm. This joint along with the base rotation forms the shoulder joint.

The second arm is also supported and rotated by another servo fixed at the top of the previous arm. The second arm acts as the elbow joint in the human hand.

The grabber has a self designed mechanism that opens and closes when the servo rotates. It has a base piece that connects the grabber to the rest of the robot and also holds the servo perpendicular to the plane of the base. The servo has a string attached to its shaft at an offset that varies the length of the string based on the servo's rotation. This string after passing through a tube that guides it to the fingers of the grabber splits into two and is attached to either fingers of the grabber. When the string is retracted due to the servo's rotation, the fingers of the grabber claws in and grabs the object. For pushing the fingers back into their original position, two springs are attached to them.

This whole assembly forms the robotic arm. The cardboard rolls are used to hide the wiring since it has empty space inside them and guide the wires to the circuit board.

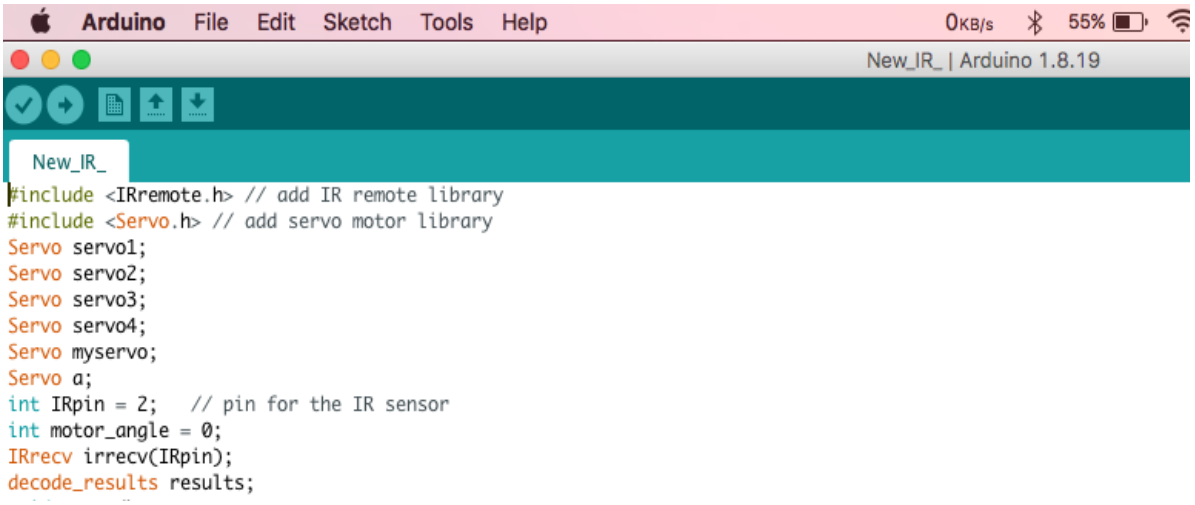
Final Model

This Robotic arm design has the range of a whole upper hemisphere having the radius that of the sum of both arm's length. It cannot lift very heavy objects since its structure is made of cardboard rolls and also because of the limitation of the lifting capacity of the servos used.

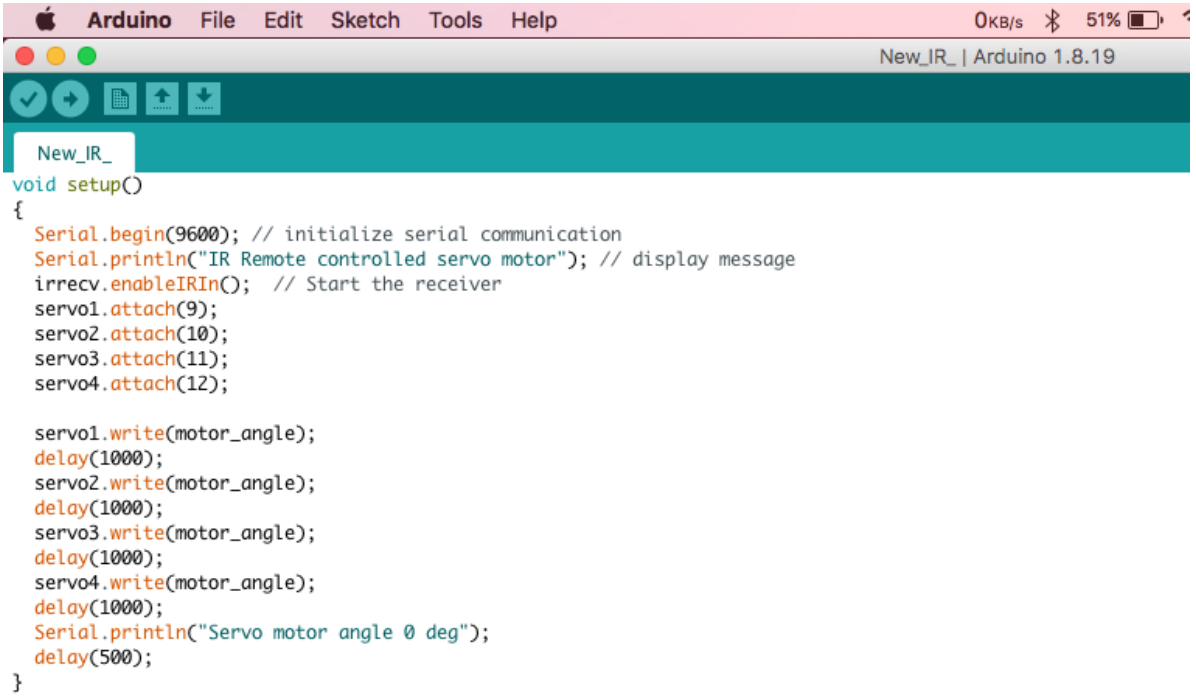
During construction and testing one of the servo motors

V. CODE EXPLANATION

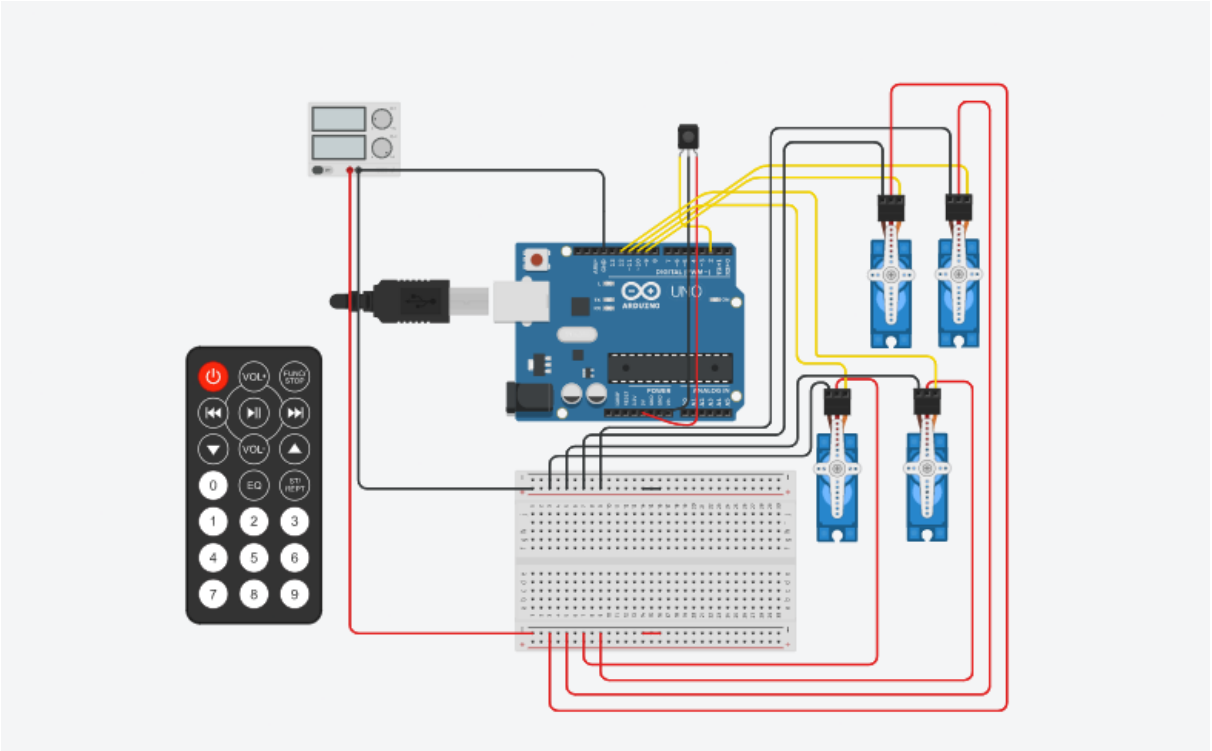
For the coding of the arduino board, we downloaded the arduino IDE software, which let us program the arduino to work according to our wishes.



In this part we have included a predefined library. IR library and servo library. With the help of these predefined libraries.we have defined our servo motor with their respective variable We have used *decode_result* to decode signal received.



In this Part of our Code we have used *void setup()* function to call our IR receiver for receiving signals from remote and we have defined our servo motor with their respective variable.We have initialised the servo motor angle with 0 degree with a delay of 1 second. We also attached our motor to their respective signal pins in the arduino board as shown in the circuit diagram.



Circuit diagram

New_IR_

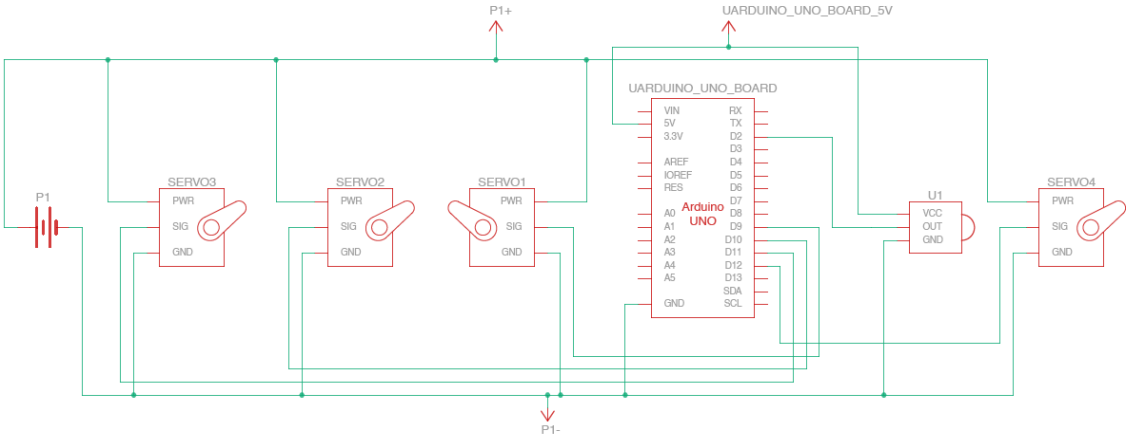
```
void loop()
{


  while (!(irrecv.decode(&results))); // wait until no button is pressed
  if (irrecv.decode(&results)) // when button is pressed and code is received
  {
    switch (results.value) {
      case 3772784863:
        a = servo1;
        break;
      case 3772817503:
        a = servo2;
        break;
      case 3772801183:
        a = servo3;
        break;
      case 3772780783:
        a = servo4;
        break;



  }
```

In this section we have defined a void loop function and in which we have initiated a while loop which will not work until we have sent any signal from remote. We have used a switch case statement here which will help us to select the motor using button 1,2,3,4.



Schematic Diagram

New_IR_

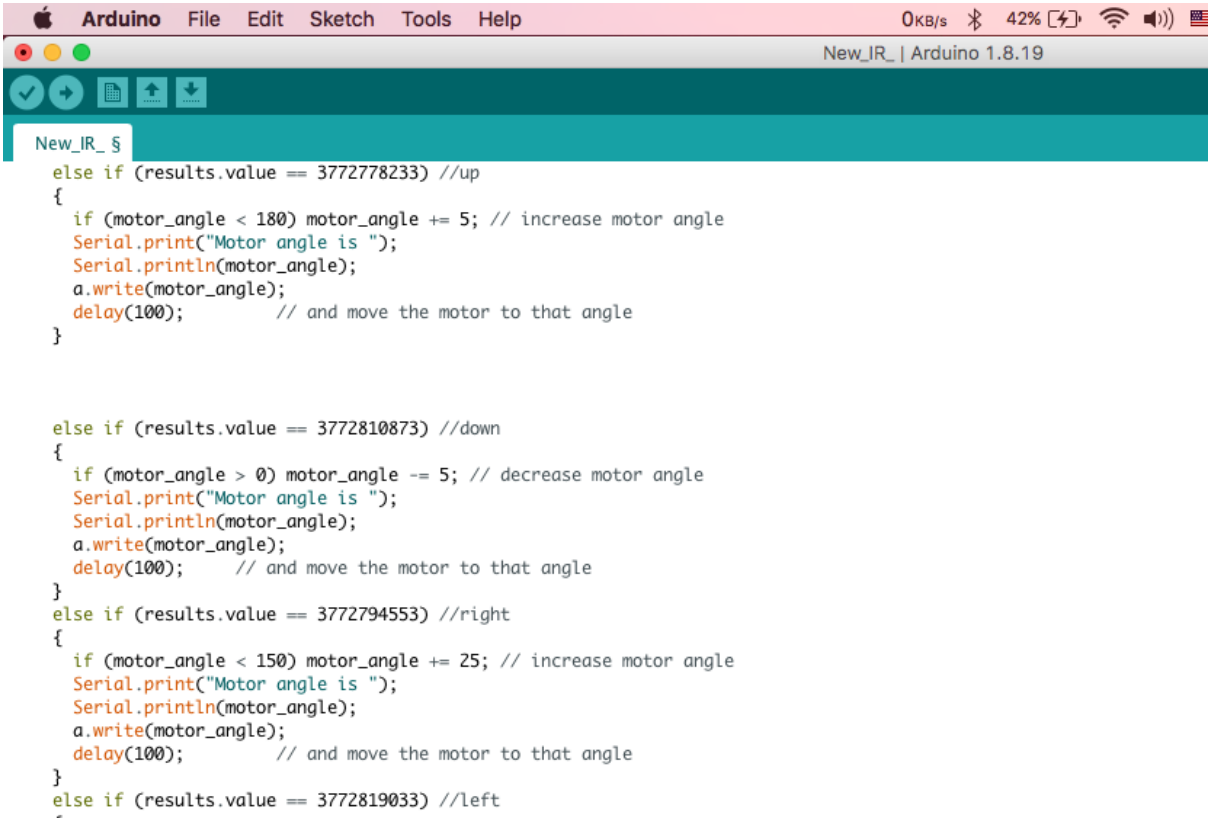
```
if (results.value == 3772811383) // 0
{
  Serial.println("servo motor angle 0 deg");
  motor_angle = 0;
  a.write(motor_angle);
  delay(1000);
  // move the motor to 30 deg
}
else if (results.value == 3772793023) // pow
{
  Serial.println("servo motor angle 0 deg");
  motor_angle = 0;
  servo1.write(motor_angle);
  delay(1000);
  servo2.write(motor_angle);
  delay(1000);
  servo3.write(motor_angle);
  delay(1000);
  servo4.write(motor_angle);
  delay(1000);

  // move the motor to 30 deg
}
else if (results.value == 3772813423) // 5
{
  Serial.println("servo motor angle 30 deg");
  motor_angle = 30;
  a.write(motor_angle);
  delay(1000);
}
```

Here we are checking for the received signal.

- If we receive a signal equivalent to button 0, the selected motor will be reset to 0 degree.
- If we receive a signal equivalent to button 5, the selected motor will be reset to 30 degrees.

- If we receive a signal equivalent to button 6, the selected motor will be reset to 60 degrees .
- If we receive a signal equivalent to button 7, the selected motor will be reset to 90 degrees .
- If we receive a signal equivalent to button 8, the selected motor will be reset to 120 degrees .
- If we receive a signal equivalent to button 9, the selected motor will be reset to 150 degrees ..
- If we receive signal equivalent to Up button, the selected motor will be reset to +5 degree




```
else if (results.value == 3772778233) //up
{
  if (motor_angle < 180) motor_angle += 5; // increase motor angle
  Serial.print("Motor angle is ");
  Serial.println(motor_angle);
  a.write(motor_angle);
  delay(100);         // and move the motor to that angle
}


else if (results.value == 3772810873) //down
{
  if (motor_angle > 0) motor_angle -= 5; // decrease motor angle
  Serial.print("Motor angle is ");
  Serial.println(motor_angle);
  a.write(motor_angle);
  delay(100);     // and move the motor to that angle
}
else if (results.value == 3772794553) //right
{
  if (motor_angle < 150) motor_angle += 25; // increase motor angle
  Serial.print("Motor angle is ");
  Serial.println(motor_angle);
  a.write(motor_angle);
  delay(100);         // and move the motor to that angle
}
else if (results.value == 3772819033) //left
```

- If we receive a signal equivalent to the Down button, the selected motor will be reset to -5 degree.
- If we receive a signal equivalent to Left button, the selected motor will be reset to -25 degree ..

```
    else if (results.value == 3772819033) //left
    {
      if (motor_angle > 25) motor_angle -= 25; // decrease motor angle
      Serial.print("Motor angle is ");
      Serial.println(motor_angle);
      a.write(motor_angle);
      delay(100);     // and move the motor to that angle
    }
    delay(200);       // wait for 0.2 sec
    irrecv.resume();     // again be ready to receive next code
  }
}
```

- If we receive a signal equivalent to Right button , the selected motor will be reset to +25 degrees.

Button	Use
0	Reset Selected Motor to 0 Degree
1	Select 1st Motor
2	Select 2nd Motor
3	Select 3rd Motor
4	Select 4th Motor
5	Move to 30 degree
6	Move to 60 degree
7	Move to 90 degree
8	Move to 120 degree
9	Move to 150 degree
	Move Forward by 5 Degrees
	Move Backward by 5 Degrees
	Move Forward by 25 Degrees
	Move Backward by 25 Degrees
	Reset All Motors to 0 Degrees

VI. SUMMARY

The robotic arm hence created has a large range of motion, though it cannot pick up heavy objects. It can be remotely controlled with a TV remote. This arm is made to mimic the motion and joints of a human hand. We used all the tools and knowledge available to us to complete this project and used the strengths of our fellow students to make the most of them.

This project took us over 14 days to complete and the cost of building was around 3000 Rs. The cost includes all the expenses regarding the components used in the project as well as the tools we had to purchase to aid the project. The list of all the components purchased and their cost is mentioned below.

S.No.	**Item**	**Quantity**	**Cost**
1	Arduino UNO	1	950
2	USB Cable	1	40
3	Servo Motor (4x MG90s + 1x SG90)	5	1050
4	Jumper Wires	60 (approx.)	300
5	Breadboard	1	140
6	DC Adapter	1	120
7	IR Receiver	1	120
8	Cardboard box	1	SELF
9	Glue sticks	5	50
10	Feviquick	2	80
11	Spray Paint (Black)	1	170
12	TV Remote (old)	1	SELF
13	Wooden Sticks (Support Shaft)	20	40
14	Battery (Testing)	2	40
15	Cutter	2	20
		Total	**3120 Rs.**

VII. LEARNING OUTCOMES

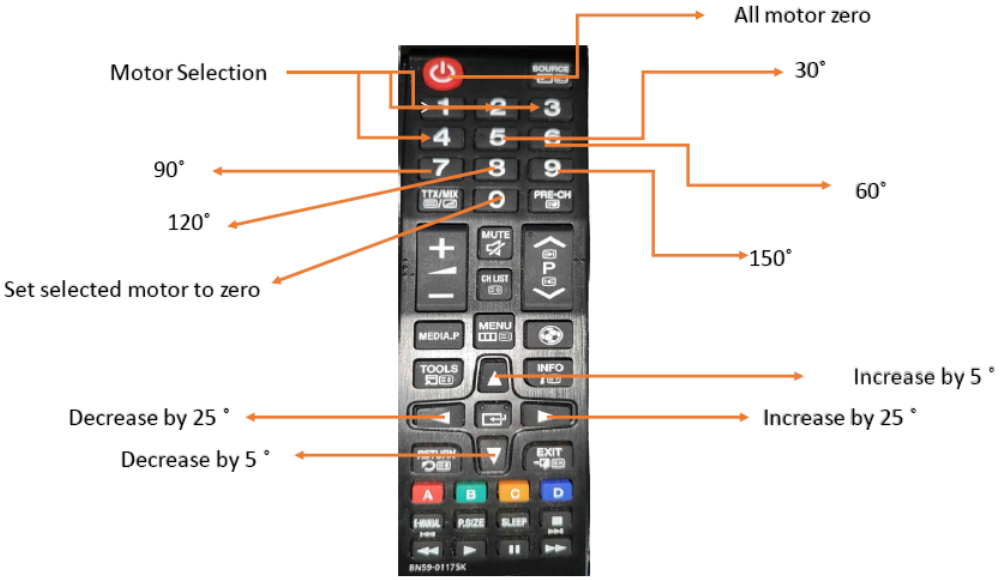
Through this project we learnt new skills such as:

- How to code using Arduino in C++ Language.
- How to control Servo motors using Arduino.
- How to use a TV remote and IR sensor to give remote control to anything.
- Relative motion between parts.
- Building complex structures using cardboard and other materials.
- Working as a Team in an interdisciplinary environment.

VIII. REFERENCES

- Arduino Website: www.arduino.cc
- International Journal of Innovative Science and Research Technology.
- Arduino IDE
- Reference videos from YouTube.

IX. APPENDIX


All motor zero
Motor Selection
30˚
90˚
60˚
120˚
150˚
Set selected motor to zero
Increase by 5 ˚
Decrease by 25 ˚
Increase by 25 ˚
Decrease by 5 ˚