



IJIRCCCE

e-ISSN: 2320-9801 | p-ISSN: 2320-9798



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

Volume 11, Issue 10, October 2023

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.379



9940 572 462



6381 907 438



ijircce@gmail.com



www.ijircce.com

Robotic Arm using PVC Pipe Sheet and Carbon Fiber Rod

Minto Hansraj Singh, Satyam Kumar, Abhijeet Nagnath Sawant

Department of Computer Engineering (CO), Jayawantrao Sawant College of Education, Hadapsar, Pune, India

ABSTRACT: A robotic arm is a mechanical arm that can be programmed to perform various tasks. It is a common concept used in the mechatronics and robotics industry. We will learn how to make a robotic arm with Arduino Uno. The robotic arm consists of 5 servo motors, which means that the degree of freedom for this robot is 5. Degrees of freedom (DOF) is defined as the minimum number of independent variables required to define the position of a rigid body in space. The robotic arm can be controlled in various ways, such as with two joysticks, potentiometers, or even with a smartphone via Bluetooth. Here we have discussed the working of the robotic arm, now first we have to build the robotic arm for that we are going to select a design, you can take a design from the internet, or we can design itself. We have not taken any help or reference from the internet to build the robotic arm body. Further, we are going to discuss how to build a body for the robotic arm. We don't have any design for making the arm but we will try to give you the proper direction and some pictures so that you will easily able to make the robotic. The advantage of this robotic arm is that it is made at a very low cost.

KEYWORDS: Arduino Uno, Servo Driver, Servo motor, Jumper wire, PVC Pipe, Heat gun, Carbon Fiber rod, etc.

I. INTRODUCTION

The Robotic Arm project involves designing and building a robotic limb to perform various tasks, such as lifting and moving objects. This project covers the mechanical design of the robotic arm, motor control, and the principles of kinematics. We already know about the robotic arm now we have to build the robotic arm. For making the robotic arm we have used a material called PVC pipe. It is a very important thing or going to play an important role in building the project. But first, we know that the robotic arm principle (DOF) in robotics stands for Degrees of Freedom, which is the number of independent parameters that define the position and orientation of a robot. It's very important to know the arm's initial and final position of the arm.

If you are trying to make this project so you know this, think that students should have a mechanics, electronics, and programming background to work on this project. Familiarity with microcontrollers and actuators, such as servo motors, is essential for building the robotic arm.

Learning outcomes:

- Mechanical design of robotic limbs
- Motor control and kinematics
- Programming for precise and coordinated movements

We already have made the robotic arm let you see the first picture of the robotic arm made by us.

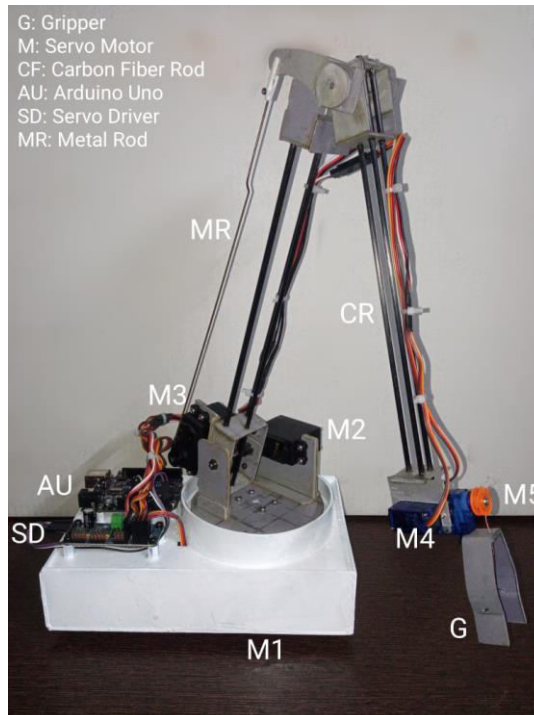


Fig 1. Robotic Arm

You can observe from the image that the material we have used is a PVC Pipe Sheet and one more thing is a carbon Fiber rod of 4mm and 3mm.

II. CONSTRUCTION

Now the construction work comes first we have to collect the necessary material to build the robotic arm.

A. Component

Component 1: Let us first make the building material. That is the PVC Pipe Sheet.

Step1. The first thing that we have to take is a PVC the thickness of the PVC pipe must be greater than 5mm and the diameter must be greater than 10cm.

Step2. Now we have to cut the pipe horizontally in between a straight line.

Step3. Now the critical part has come, we will require heat to melt the PVC pipe, you can use a heat gun or if you don't have one you also can use a Gas Stove but be careful while using it, so heat the pipe and then put a heavy plane material on it, and wait till it cool down.

Step4. Now you can make a design as per your need and cut it by the cutter. (Note. You can use sandpaper to give finishing.)

The below picture will make you more clarify the above procedure.

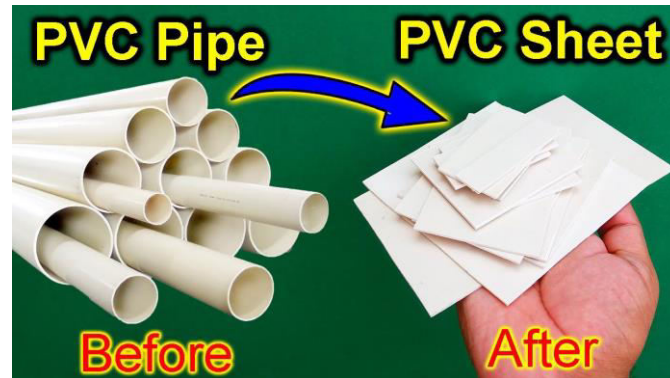


Fig 2. PVC Pipe Sheet

It was very simple to make a sheet, and now we are ready to make the body of the robotic arm. But first, we have to make the base of it. After reading the above steps even if you are not able to make the PVC sheet you also get help from the internet (YouTube) [9].

Component 2: The second component will be the base of the robotic arm; it is a very important part of the robotic arm. The whole body will be going to come on the base. There will be a servo motor inside that will move the arm left-right direction. The base body will be made from the PVC sheet that we have already made in the first component.

In this we have made a U Bracket that will be used to attach a servo motor, the measurement is given further on how to make a U Bracket. There is a piece of PVC sheet attached to the Metal rod to support the Joint Box. You will further come to know about this component.

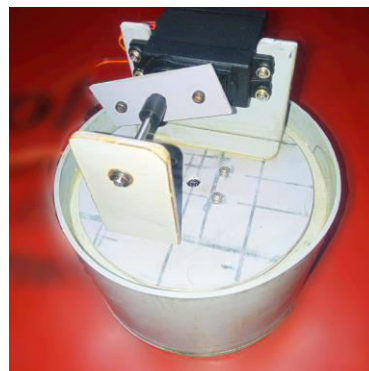


Fig 3. Robotic Arm Base

The above image shows the base of the robotic arm, then the above picture item is attached to the base in the rectangular box, and I have painted it with spray paint to give it a proper look. As shown in the Figure below. It is not necessary to make as it is as shown in the figure you can also make your design. Figure 3 which is the robotic arm base is circular so you do not need to use a PVC Sheet. And the height of it is 6.5cm.



Fig 4. Base

The base part is completed now the 3rd component is the upper body of the robotic arm.

Component 3: The upper body is a very complex and critical part; most of the components will be attached here. The total number of servo motors used in making the robotic arm is 5, and 1 is attached to the base; the remaining 4 will be attached to the upper body; and the upper body will be moved by the base servo motor.



Fig. 5 Circular Disc

You can see in the figure above the Circular Disc, we took a PVC sheet and drew the 10cm circle, we used 2 sheets and joints together to increase the thickness, and now you can place components on the Circular Disc. You can also observe the left side of the above image to get more about it. It consists of 2 high-torque servo motors, as you can see in the image.

Component 4: U Bracket will be used to connect the servo motor 2 that will move the robotic arm up and down. Here we will use 2 U Brackets in the base and also connect the SG90 9g motor for Degree of Freedom (DOF) M4. You can observe the image below.



Fig 6. Big U Bracket

For attaching the M4 we will use a small U Bracket. It's not necessary to make it as it is you can make it as per your needs.

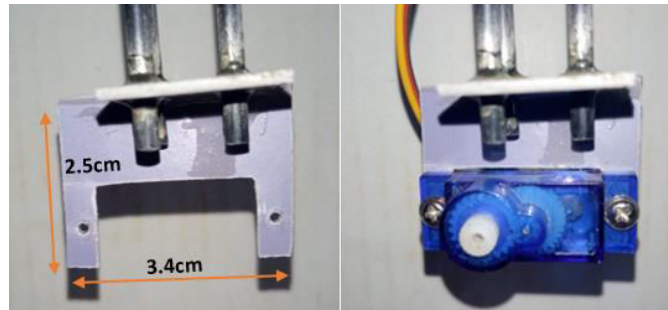


Fig 7. Small U Bracket

Component 5: The Joint Box will help us to connect the Servo with the Body. So, it can give movement to the Robotic arm. We will use two Joint Boxes at the bottom and upper part of the robotic arm.



Fig 8. Lower Joint Box

The above image shows the Joint Box, on the right side there is a supporter that will help to support the joint box. There is a bearing in between that will help the arm to move up and down. There is also a metal rod that goes through the bearing. The bearing and the metal rod have been removed from the old A2212 1000 KV BLDC Brushless DC Motor for the Drone, you can use any of it whether it's 1000kv or 2200kv we just want to use the Rod and the Bearing.

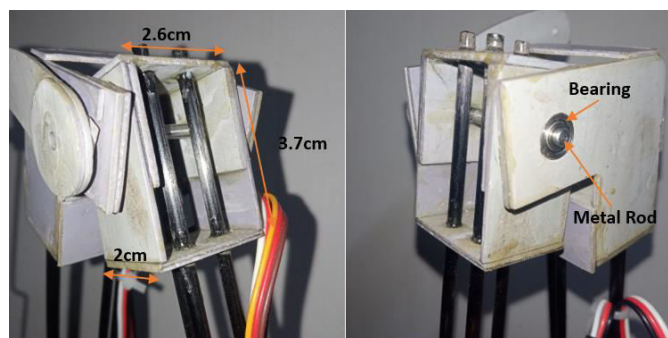


Fig 9. Upper Joint Box

Component 6: We have used 2 types of Carbon Fiber Rods. The first one is 4mm and the second one is 3mm. we have used in Triangular shape to increase the Strength of the arm. You can easily purchase Carbon Fiber rods from ROBU.in. Because Carbon Fiber Rod is very lightweight and strong. So, it decreases the weight of the Robotic arm.

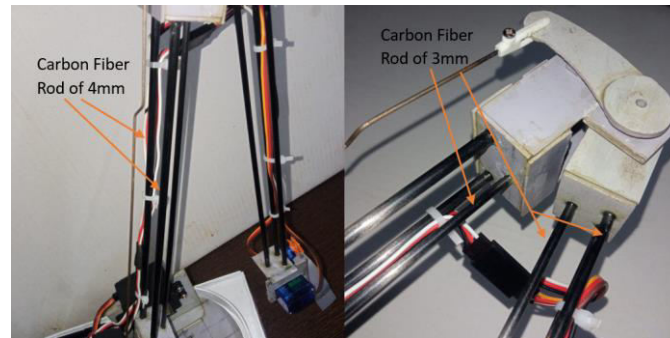


Fig 10. Carbon Fiber Rod

Component 7: The Upper Joint will help to support the overall frame. It is connected to the Carbon Fiber Rod. You can see the measurement below to make it, here also we are going to require a bearing to move smoothly. On the right side, a connected metal rod is attached to the Servo motor M3.

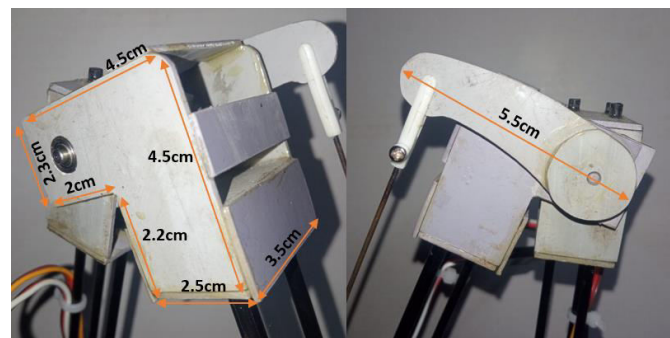


Fig 11. Upper Joint

The servo M3 is connected to metal rod that will move the joint backward and forward. The M3 motor will place over the Joint box so when the Servo M2 will move along with that the Servo M3 will move.



Fig 12. Servo M3

Component 8: A gripper as shown in Fig 5 is something that grips things or makes it easier to grip things. The gripper which is designed in this particular case is a pick-and-place gripper [1]. We didn't buy the gripper we made it with the help of a PVC pipe sheet. It was very difficult to make the gripper. It is a very important part of the robotic arm that will pick and place the object, there is also some other component that is used to pick and place such as Air suction. Here for making the gripper we have taken a piece of PVC sheet and with the help of heat we have bend the PVC sheet. The thread used in it is not a normal thread it's an earphone wire. The earphone is so strong that will not break in high

tension. We have Soldered the Earphone wire from the end so that it will not spread. The gripper servo motor is attached to the Servo M4.

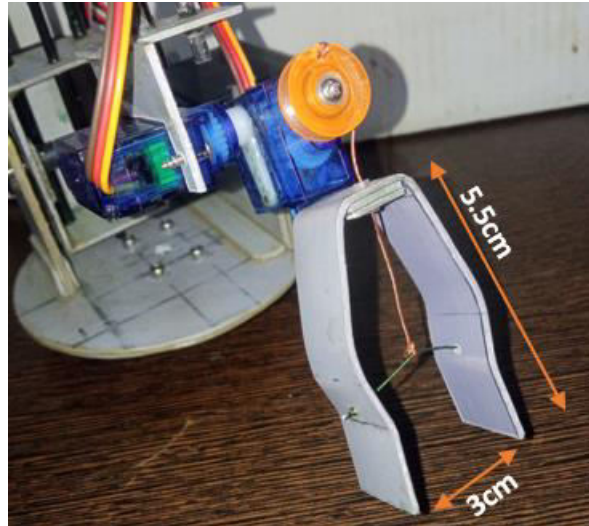


Fig 13. Gripper

For making the Gripper some other components are required such as a pulley. When the Servo will move clockwise or anticlockwise then the gripper will open and close. For making the gripper we have taken the help of youtube.com [8]. You can watch a video online to make the gripper.

Table 1 shows the total no of the components with their function. There is a total of 7 components it's a basic part of the Robotic arm for Functioning. The table will be required while calculating the Torque Analysis.

Components	Functions
Robotic Arm Base	Holding all the Upper body and Free to move.
Circular Disc	Rotating Base (Directly attached to base servo).
U Bracket	Manipulator Support link.
Joints Box	Free movement for joints.
Carbon Fiber Rod	Lightweight and Flexible.
Upper Joint	Support for Frame.
Gripper	Pick and place the link.

Table 1. Robotic Arm Base

B. Component

We will include all the electronic components that will play an important role in the functioning of the robotic arm. We have only used 3 electronic components. There are Arduino Uno, PCA9685 Servo Driver, and Servo motor of two types.

Component 1: Arduino Uno

Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header, and a reset button [7].

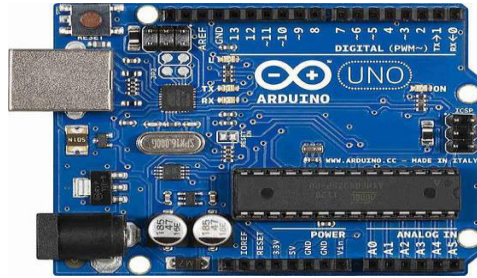


Fig 14. Arduino Uno

Component 2: Servo Driver (PCA9685)

The PCA9685 is an I2C-bus-controlled 16-channel LED controller optimized for LCD Red/Green/Blue/Amber (RGBA) color backlighting applications. Each LED output has its 12-bit resolution (4096 steps) fixed frequency individual PWM controller that operates at a programmable frequency from a typical of 40 Hz to 1000 Hz with a duty cycle that is adjustable from 0 % to 100 % to allow the LED to be set to a specific brightness value. All outputs are set to the same PWM frequency. If you want to know more about this driver you can refer to its datasheet.

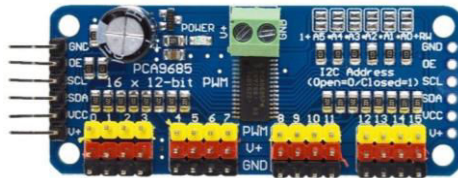


Fig 15. PCA9685 Servo Driver

Component 3: Servo motor

There are 5 Degrees of Freedom (DOF) so there will be 5 servo motors, and out of 5, there will be 3 high torque motors and 2 SG90 9g motors. Below is the information about both the motors.

- TowerPro Servo Motor
- SG90 9-gram Servo Motor

TowerPro Servo Motors are optimum-quality and affordable cost servos.! They are suitable for a wide range of applications, including RC aircraft, automobiles, and robotics, or just to have some fun with whatever crazy project you're working on.

A servo motor is a rotary actuator that is used for applications that require a great degree of accuracy for the rotation angle [5]. This is due to the presence of a feedback encoder in servo motors that measures the difference between the reference and required angle and ensures the final position is achieved with greater accuracy.

When using stepper motors, the absence of a feedback system can lead to the possibility of a lag due to inertia and an inevitable loss of accuracy in attaining the final position.[6] So, servo motors were chosen as the best available actuator for this application.



Fig 16. TowerPro Servo Motor

SG90 is a popular micro servo motor commonly used in hobbyist and DIY projects. It is a small, low-cost servo motor that can rotate 180 degrees with a maximum torque of 1.8 kg-cm. It operates at 4.8-6V and weighs approximately 9 grams, making it ideal for small-scale robotics and model control applications.

We are going to require two 9-gram servo motors to control 4 DOF (Degree of Freedom) and Gripper. For buying this servo motor you can visit ROBU.in which is India's Trusted high-quality electronics seller [10].



Fig 17. SG90 Servo motor

We don't want to give any more information about these servo motors because they are commonly used in Making Projects.

III. MODEL ANALYSIS

We have taken the calculation part from the [1] reference, mostly we have used the first reference paper. Through you will find similarities. But the Code and the Robotic arm differ or it's unique.

A. DOF Calculations

Total number of links are:

1. Robotic Arm Base + Base servomotor
2. Circular disc + U Bracket
3. Carbon Fiber Rod + Servo Motor 2 + Joint Box 3 + Metal Rod
4. Servo motors 3&4
5. Gripper + Servo Motor 5

$$DOF = 3(n-1) - 2j + 1 \quad [10]$$

n = Number of links

j = Number of Revolute Joints

$$\text{So, } DOF = 3(5-1) - (2*4) + 1 = 5$$

B. Torque Analysis

The critical case is in a horizontal position that gives the biggest perpendicular distance [1].

So, the Torque on the base motor is calculated as:

Circular Disc = 20g

One TowerPro Servo motor weight = 55g

One SG90 Servo motor weight = 9g

U Bracket = 12g

Joint Box = 15g

Carbon Fiber Rod = 20g

Gripper = 5g

$$\text{Total weight} = 20 + (3*55) + (2*9) + 12 + (3*15) + 20 + 5 = 285g = 0.285 \text{ Kg}$$

The center of gravity is located 20 cm from the circular disc.

$$T = W*L(CG)$$

$T = 0.285 * 20 = 5.7 \text{ Kg.cm}$

But the motor Stall Torque is 10kg-cm at 6 Volt.

Because the Total weight is less than the weight of the Servo capacity [1].

So, our design is successful and capable of working properly.

IV. WIRING AND CONNECTION

Here we are using an I2C interface we will only require two pins SDA and SCL. SCL is the clock line. It is used to synchronize all data transfers over the I2C bus. SDA is the data line. The SCL & SDA lines are connected to all devices on the I2C bus. The SDA will attach to the A4 and the SCL will attach to the A5 pin.

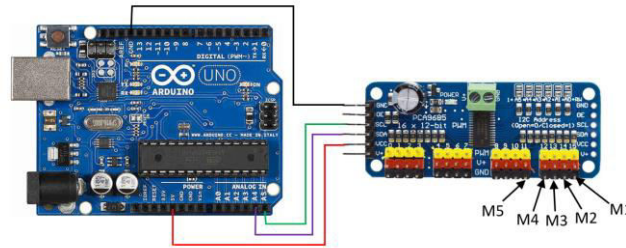


Fig 18. SG90 Servo motor

Standard servos allow the shaft to be positioned at various angles, usually between 0 and 180 degrees. Continuous rotation servos allow the rotation of the shaft to be set to various speeds [11]. The servo wire will be directly joined to Servo Driver PCA9685. You will require 5v for the external supply of the Servo Driver.

Type	Color	Connected Pin
Power	Red	External Power source (+)
GND (Ground)	Brown	External Power source (-)
Signal	Orange	PWM

Table 2. Servo Wires

V. ARDUINO CODE

An Arduino code is written including the libraries having controlling conditions and delay concept [1]. In this code, it is necessary to install the Adafruit_PWMServoDriver Libraire into your system. We will try to explain the code, here two methods will rotate the servo motor Clockwise and Anticlockwise. We just want to enter the Servo name, initial position, and final position. It will also show the Servo name currently moving in the Serial Monitor. The below code will help to pick up objects from one point and place them at another point. You can modify this code as per your needs.

```
#include <Wire.h>
#include <Adafruit_PWMServoDriver.h>
// Create the PCA9685 servo driver object
Adafruit_PWMServoDriver pwm = Adafruit_PWMServoDriver();
const int Base_Servo = 15;
const int Lower_Servo = 14;
const int Upper_Servo = 13;
const int Gripper = 12;
const int Up_Down = 11;
int servoIncrement = 5; // Increment for each step
int moveDelay = 20; // Delay between steps in milliseconds
void setup() {
  Serial.begin(9600);
  pwm.begin();
```

```
pwm.setPWMPFreq(60); // Analog servos run at ~60 Hz updates
delay(100);
}
void loop() {
forward(Base_Servo, 150, 600, servoIncrement, "Base Right");
delay(1000);
backward(Lower_Servo , 480, 430, servoIncrement, "Lower Down");
delay(1000);
forward(Upper_Servo, 300, 500, servoIncrement, "Upper UP");
delay(1000);
forward(Gripper, 200, 350, servoIncrement, "Close");
delay(1000);
backward(Up_Down, 350, 250, servoIncrement, "Up");
delay(1000);
backward(Upper_Servo, 500, 300, servoIncrement, "Upper Down");
delay(1000);
forward(Lower_Servo, 430, 480, servoIncrement, "Lower UP");
delay(1000);
backward(Base_Servo, 600, 150, servoIncrement, "Base Left");
delay(1000);
forward(Up_Down, 250, 350, servoIncrement, "Up");
delay(1000);
backward(Gripper, 350, 200, servoIncrement, "Open");
delay(1000);
}
void forward(uint8_t channel, int minValue, int maxValue, int increment, String name) {
Serial.println(name);
for (int i = minValue; i <= maxValue; i += increment) {
pwm.setPWM(channel, 0, i);
delay(moveDelay); // Adjust delay for the desired speed
}
}
void backward(uint8_t channel, int maxValue, int minValue, int increment, String name) {
Serial.println(name);
for (int i = maxValue; i >= minValue; i -= increment) {
pwm.setPWM(channel, 0, i);
delay(moveDelay); // Adjust delay for the desired speed
}
}
```

VI. THANKING

We hope we have given all the related information about the robotic arm building. If you have any issues while making the robotic arm you can contact us through our email. The main motive was to make the robotic arm either you can get code from anywhere. The robotic are is successfully working as we have expected. At last, we will thank to our guide Mrs. S. A. Kaulage mam for helping to make the project.

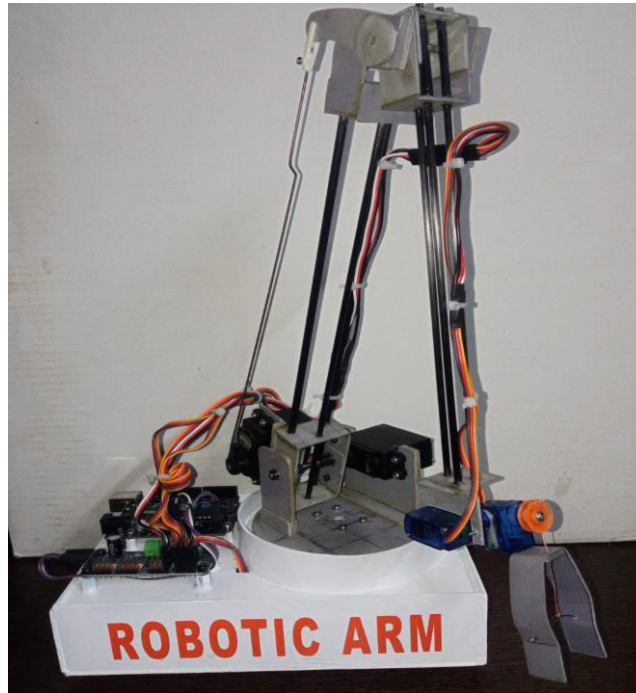


Fig 19. Robotic Arm

VII. CONCLUSION

A 5 DOF pick & place Robotic arm has been developed by using PVC sheet and Carbon Fiber Rod. The driver mechanism comprising an Arduino microcontroller with the help of PCA9685 Servo Driver has been successfully used to control the arm as per the inputs written by the user in the code.

ACKNOWLEDGMENTS

The authors would like to acknowledge Javawant Shikshan Prasarak Mandal (JSPM) at Handewadi, Hadpsar Department of Computer Engineering for the development of this robotic arm.

REFERENCES

- [1] Ankur Bhargava and Anjani Kumar., Arduino controlled robotic arm, (University School of Information, Communication, and Technology, Guru Govind Singh Indraprastha University, Dehli, India), 2017.
- [2] Mark S., Seth H. and Vidyasagar M., Robot modeling and control (John Wiley & Sons, 2006).
- [3] Jamshed Iqbal, Razaul Islam, and Hamza Khan, Modeling and Analysis of a 6 DOF RoboticA Manipulator, Canadian Journal on Electrical and Electronics Engineering, 3 (6), July 2012, 300– 306.
- [4] Rosidah Sam et al. " Simulation of pick and place Robotics system using Solidworks Softmotion", International conference on system Engineering and Technology September 2012.
- [5] Edwin Basil Mathew et al. "Robotic arm control through human arm movement detection using potentiometers", International Conference on recent developments in control, Automation and Power Engineering, 2015.
- [6] Sanjay Lakshmi Narayan, ShwetaPatil, Position Control of Pick and Place Robotic Arm, International Conference on Engineering Innovation and Technology, ISBN: 978-93-81693-77-3, Nagpur,1st, July, 2012
- [7] <https://www.arduino.cc/en/Main/ArduinoBoardUno>
- [8] https://www.youtube.com/watch?v=2UR_ioPrMFs
- [9] <https://www.youtube.com/watch?v=PsbRyihS3aE>
- [10] <https://robu.in/product-category/dc-motors/servo-motors/>
- [11] Edwin Basil Mathew et al. "Robotic arm control through human arm movement detection using potentiometers", International Conference on recent developments in control, Automation and power Engineering, 2015.



INNO  **SPACE**
SJIF Scientific Journal Impact Factor
Impact Factor: 8.379

doi[®]
cross **ref**

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

 **9940 572 462**  **6381 907 438**  **ijircce@gmail.com**



www.ijircce.com

Scan to save the contact details