ROBOTIC ARM

A Minor Project Report

Submitted in Partial Fulfillment of the Requirements
for the Degree of

BACHELOR OF TECHNOLOGY

IN

ELECTRONICS & COMMUNICATION ENGINEERING

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CERTIFICATE

This is to certify that the Minor Project Report entitled**"Robotic Arm"** submitted by **Maulik Patel (**Roll No. **12BEC066) and Mohak Patel(**Roll No. **12BEC067**) as the partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Electronics &Communication Engineering, Institute of Technology, Nirma Universityis the record of work carried out by them under my supervision and guidance. The work submitted in our opinion has reached a level required for being accepted for the examination.

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ABSTRACT

This project is to design and develop a “Robotic Arm” for Pick and Place application using Arduino. This project combines the knowledge of electronics and electrical. The objective of this project is to design and build a more compact, usable and cheaper pick and place robotic arm for educational purpose. The main function of Arduino is to generate pulse width modulation (PWM) signals which are applied to servo motors for achieving the desired rotation. Each servo has a different specifications. Therefore, a PWM pulse could have a different effect on servos. The main advantage of controlling the servo motors with PWM signals is that they can be programmed to have an initial position and to rotate with an exact degree with respect to the requirements.

The entire designing of the robotic arm was done on “Autodesk 123D” and acrylic sheet is used as the body of the robotic arm. In this project, six servo motors are used in which four servos are utilized to control the body motion including base, shoulder and elbow. Also two smaller servos are employed for the motion of the end effector (gripper).

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Chapter 1

Introduction

With the growth of technology, the need of new devices grows accordingly. Computer and electronics sciences is mostly premier in rising the new technologies. Of course the new technology could affect different engineering fields. For instance, if the robotics and artificial intelligence are considered, it reveals that the technology with its high potential, affected many different fields of studies. Therefore related fields of study could be combined to generate new technologies that can be use in wide fields. The robots play important role in our lives and are able to perform the tasks which cannot done by humans in term of speed, accuracy and difficulty. Robots can be employed to imitate human behaviors and then apply these behaviors to the skills that leads the robot to achieve a certain task.

They do not get tired or face the commands emotionally, and since they are designed by humans. They can be programmed and expected to obey and perform some specific tasks. In some cases the use of a robotic hand becomes remarkable. Robotic is applied in different forms and fields to simulate human behavior and motions. The idea of robotic is to create practical and useful robots that facilitate our daily tasks. Because of the independencyof the robots, they have longer life time comparing with the humans and can be helpful in industry, dangerous tasks and nursing homes.

Most of tools, vehicles, electronic devices and cuisine are built and prepared with the help of industrial robots. For instance, there are industrial robot assembly lines which help in many cases that can operate more accurate and faster than humans. Recently, robots operate in almost all human labors mostly in the fields which are unhealthy or impractical for workers.

This fact causes the workers to have more free time to spend on skilled professions including the programming, maintenance and operation of the robots which are essential. There are situations where a robot is a replacement for human because the human does not have the capability to work under the specific conditions, such as working in the space, under the water and etc, unless the person is equipped with some expensive special clothing and equipment. Therefore, while designing a robot, considering the factors such as concept and techniques, artificial intelligence and cognitive science are essential in order to obtain an effective design.Obviously, building a robotic arm is not a new idea, but still the design and the specifications can differ from other designs. For instance, the circuitry, degree of freedom (DOF), algorithm, program, attachments, equipment, accuracy and speed, completely depend on the designer's tact.

1.2 Objective of the Project

The objective of the project is to be able to perform some physical tasks close to a human's hand actions, such as replacement and grabbing, under the conditions where a human hand is not a particular solution. Therefore, a robotic arm can be designed to perform the required actions which can be controlled by the humans.

1.3 Robotic Arm Details and Summary

The robotic arm will be controlled via Arduino Uno and it will be able to grab, pick up and move objects according to their weights and shape. The design is mostly expected to pick up cubes and the geometric shapes like a box. Depending on the numbers of joints, DOF differs, but generally robotic arms operate using 6 servo motors. The servo motors are popular for their desirable characteristics for robotic application.

1.4 Problem statement and solution

The project intends to investigate the design, implementation and control of a 5 DOF articulated robotic arm using servo motors and Arduino Uno. The main reason of using Arduino is because it provides power supply to the servo motors and also it has the inbuilt provision of pulse width modulation(PWM) pins. A pulse could have a different effect on servos with different specifications. Therefore, most of the time it is crucial to be able to give the exact PWM pulse in order to rotate a servo to a specific rotation. The main advantage of controlling the servo motors with PWM signals is that they can be programmed to have an initial position and to rotate with an exact degree with respect to the requirements.

Chapter 2

Literature Review

2.1 Building the Kinematic Structure

The first step of designing a robot is to decide the dimension and workspace configuration according to the requirements. The next step is to decide the specification of each actuator. The structure of the robot is built with compacted acrylic sheets in order to decrease the overall weight of the robot. The compacted acrylic sheets are also strong enough to keep and hold the whole parts tightly together. The arm is attached to a base which is the most bottom part of the robot. It is important to mention that the base ought to have considerably heavy weight in order to maintain the general balance of the robot in case of grabbing an object.

Although the idea of using stepper and gear motors is brilliant, but physical movement of the robot is done by using servo motors. The advantage of the servos is that they can be programmed to return to their initial position. Since the servo motors operate using the signals received from the microcontroller, they could be programmed according to the requirements. However, this characteristic of the servo motors is actually a disadvantage, because the chance of sending and receiving a wrong signal is high which causes the servo to operate incorrectly.

The developed robot in this study is a stationary articulated robotic arm with 5 DoF with only revolute joints which includes base, shoulder, elbow, gripper pitch and gripper spin.All parts of the robot including the parts for shoulder, elbow, gripper and etc, were drawn by a penicl on the acrylic sheet and cut accurately. Some machinery process where applied to the sheets to make the necessary holes and cuts to connect the parts to each other and to keep the actuators tightly.

The gripper of the arm is designed in a way which uses a single actuator and follows a basic physical gear concept. This means that when the mini servo actuates, it turns the gear which is attached to it causing the gripper to expand and contract. Figure 2.5 shows the template of the gripper with its magnitudes. The design of the base, shoulder and elbow with their measurements are shown in Figure 2.6.

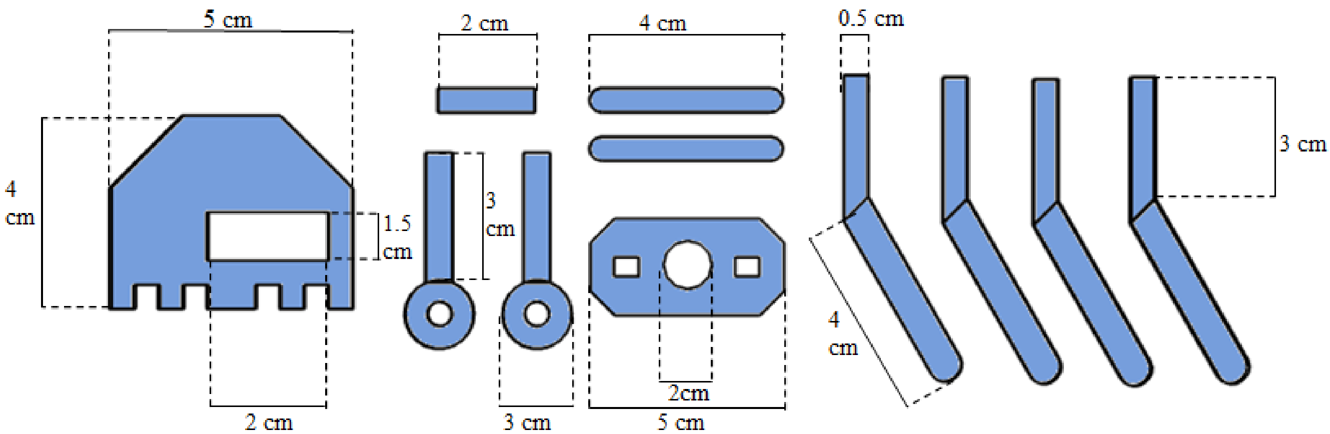
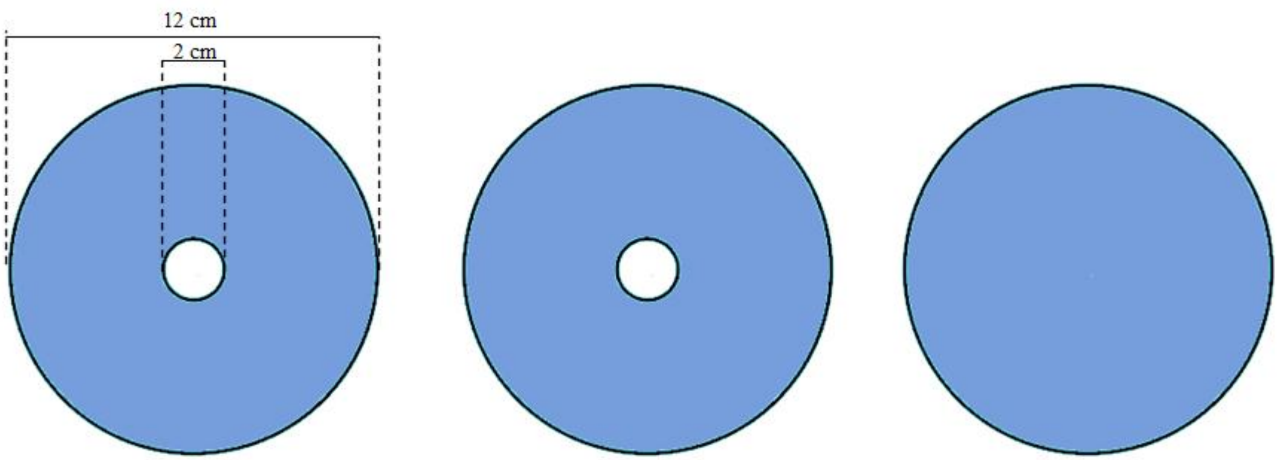
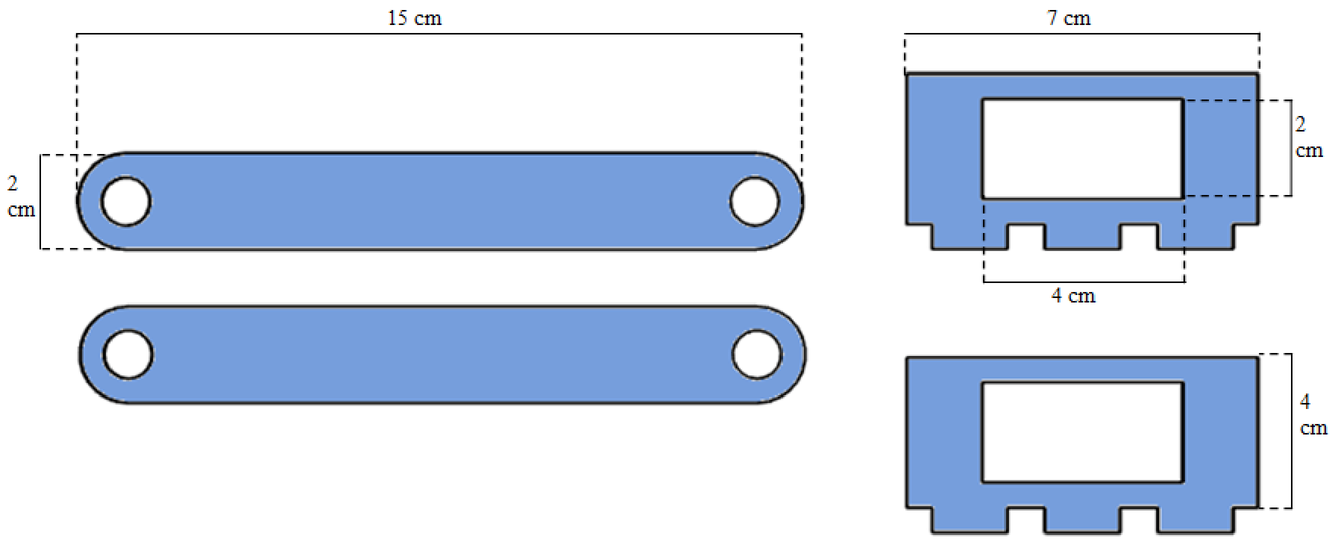


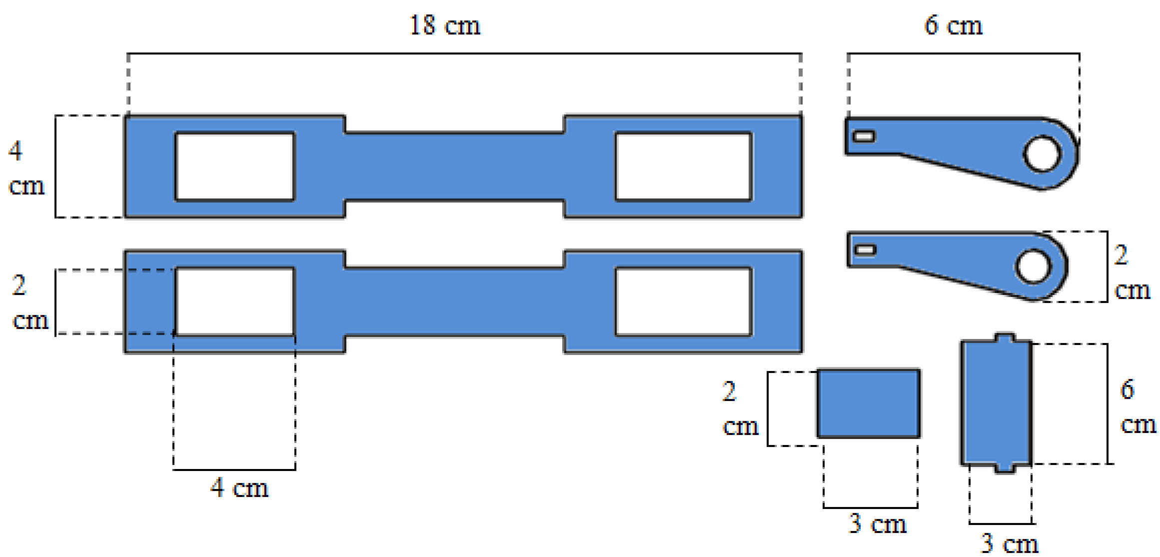
Figure 2.1: Gripper Template



(a)



(b)



(c)

Figure 2.2 : Template of (a) base, (b) shoulder, and (c) elbow

The dimensions can differ for different designs, but this should be mentioned that the dimensions given in this study are chosen with respect to the servo motors which are used in the robot. The power, torque and size of the servo motors can affect the dimensions.For instance if the servo motor used in the elbow is changed with a lesspowerful servo, the length of elbow should be decreased accordingly, because the servo may not have enough power to pull the elbow up.

On the other hand, if a longer elbow is required in order to enlarge the workspace of the robot, the height of shoulder and elbow from the base should be changed respectively in order to maintain the physical balance of the robot. In general, if one part of the structure is changed in dimension, the change should be applied for all parts of the robot accordingly in order to eliminate the instability problem.

The entire designing of the robotic arm was done on “Autodesk 123D” and acrylic sheet is used as the body of the robotic arm. All the parts were cut and drilled properly according to the design template. Then, all parts were painted and the robot was assembled. Figure 2.4 shows the final look of the robotic arm.

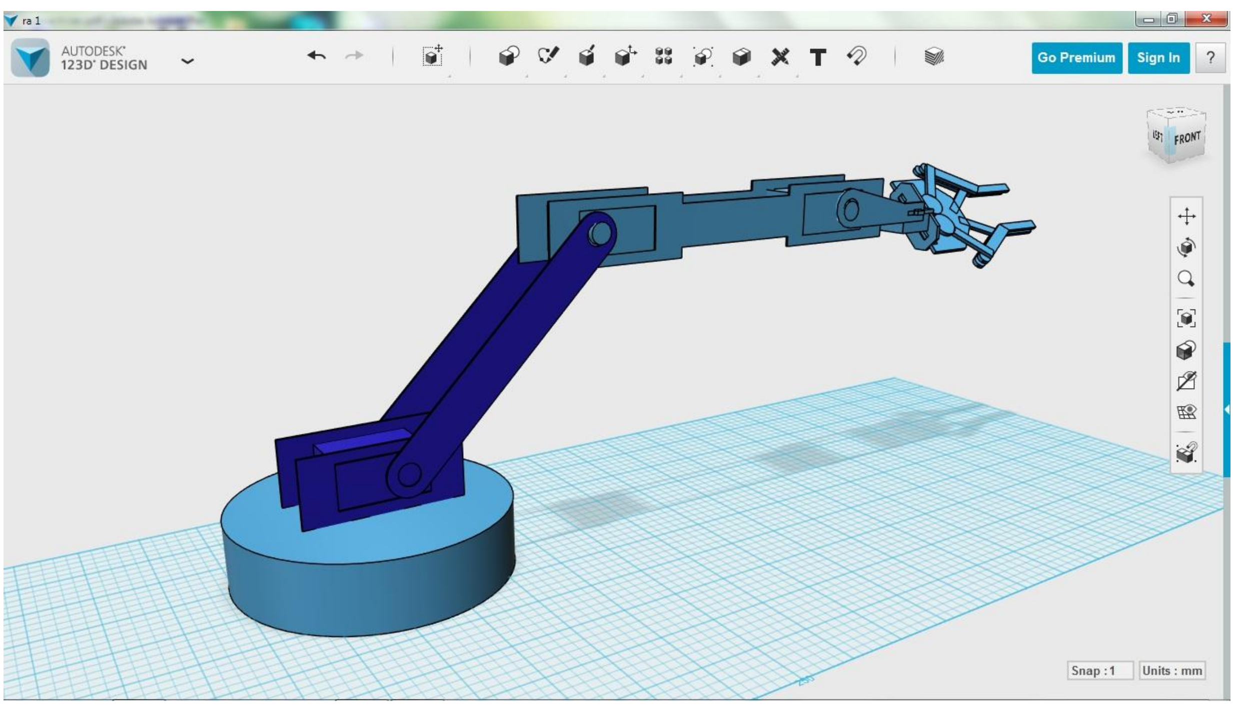


Figure 2.3: 3D Model in Autodesk 123D

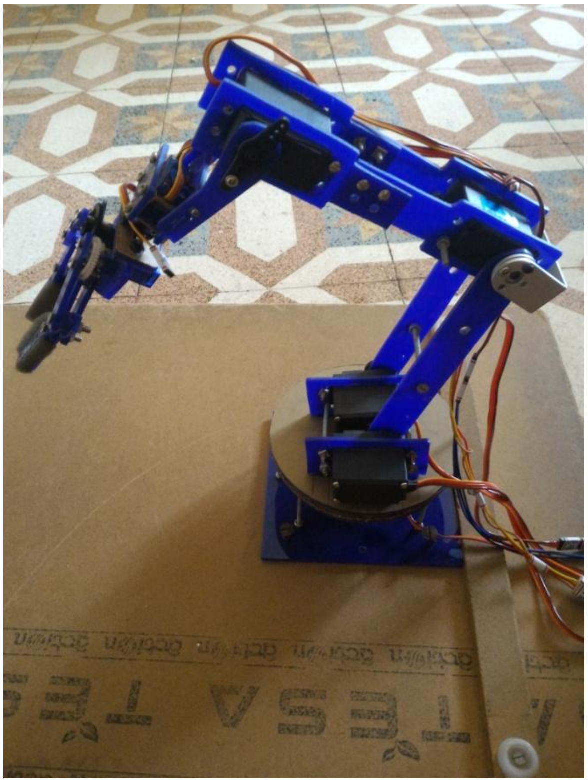


Figure 2.4: Robotic Arm

2.2 Hardware implementation

In the current robotic arm, Arduino Uno is chosen as the main processor. Since it has a good range of interfaces, including analogue and digital pins, pulse width modulation (PWM) and in-circuit debugging. This microcontroller can generate PWM signals on six pins. The rest of the electronic equipment, and sensors, are decided according to the tasks which the robot is expected to achieve.

2.2.1 Arduino Uno

Arduino/Genuino Uno is a microcontroller board based on the ATmega328P (datasheet). 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. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.. You can tinker with your UNO without worring too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start over again.

"Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards.

Technical specs:

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P)

	of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
Length	68.6 mm
Width	53.4 mm
Weight	25 g

In addition, some pins have specialized functions:

PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analogWrite() function.

Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

2.2.2 Servo Motors

Servo refers to an error sensing feedback control which is used to correct the performance of a system. Servo or RC Servo Motors are DC motors equipped with a servo mechanism for precise control of angular position. The RC servo motors usually have a rotation limit from 90° to 180°. But servos do not rotate continually. Their rotation is restricted in between the fixed angles.

The Servos are used for precision positioning. They are used in robotic arms and legs, sensor scanners and in RC toys like RC helicopter, airplanes and cars.

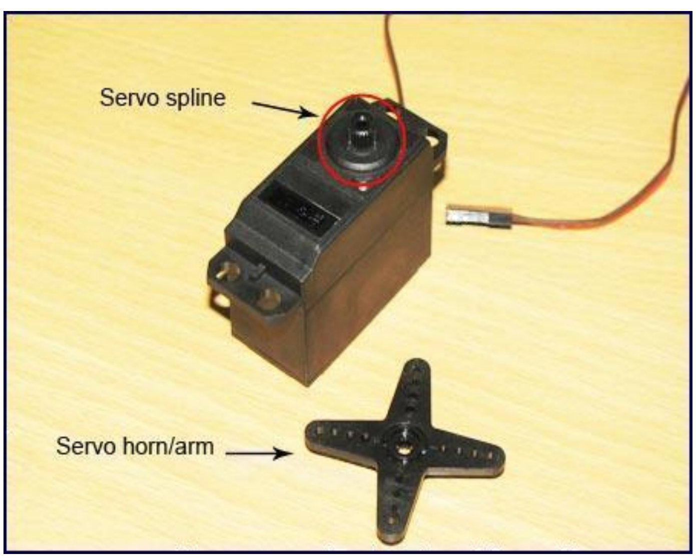


Figure 2.5: Servo Motors

The Servo Motors come with three wires or leads. Two of these wires are to provide ground and positive supply to the servo DC motor. The third wire is for the control signal. These wires of a servo motor are colour coded. The red wire is the DC supply lead and must be connected to a DC voltage supply in the range of 4.8 V to 6V. The black wire is to provide ground. The colour for the third wire (to provide control signal) varies for different manufacturers. It can be yellow (in case of Hitec), white (in case of Futaba), brown etc.

Futaba provides a J-type plug with an extra flange for proper connection of the servo. HITEC has an S-type connector. A Futaba connector can be used with a HITEC servo by clipping of the extra flange. Also a HITEC connector can be used with a Futaba servo just by filing off the extra width so that it fits in well.

HITEC splines have 24 teeth while Futaba splines are of 25 teeth. Therefore splines made for one servo type cannot be used with another. Spline is the place where a servo arm is connected. It is analogous to the shaft of a common DC motor.

Unlike DC motors, reversing the ground and positive supply connections does not change the direction (of rotation) of a servo. This may, in fact, damage the servo motor. That is why it is important to properly account for the order of wires in a servo motor.

A servo motor mainly consists of a DC motor, gear system, a position sensor which is mostly a potentiometer, and control electronics. The DC motor is connected with a gear mechanism which provides feedback to a position sensor which is mostly a potentiometer. From the gear box, the output of the motor is delivered via servo spline to the servo arm. The potentiometer changes position corresponding to the current position of the motor. So the change in resistance produces an equivalent change in voltage from the potentiometer. A pulse widthmodulated signal is fed through the control wire. The pulse width is converted into an equivalent voltage that is compared with that of signal from the potentiometer in an error amplifier.

The servo motor can be moved to a desired angular position by sending PWM (pulse width modulated) signals on the control wire. The servo understands the language of pulse position modulation. A pulse of width varying from 1 millisecond to 2 milliseconds in a repeated time frame is sent to the servo for around 50 times in a second. The width of the pulse determines the angular position.

For example, a pulse of 1 millisecond moves the servo towards 0°, while a 2 milliseconds wide pulse would take it to 180°. The pulse width for in between angular positions can be interpolated accordingly. Thus a pulse of width 1.5 milliseconds will shift the servo to 90°.

It must be noted that these values are only the approximations. The actual behavior of the servos differs based on their manufacturer.A sequence of such pulses (50 in one second) is required to be passed to the servo to sustain a particular angular position. When the servo receives a pulse, it can retain the corresponding angular position for next 20 milliseconds. So a pulse in every 20 millisecond time frame must be fed to the servo.

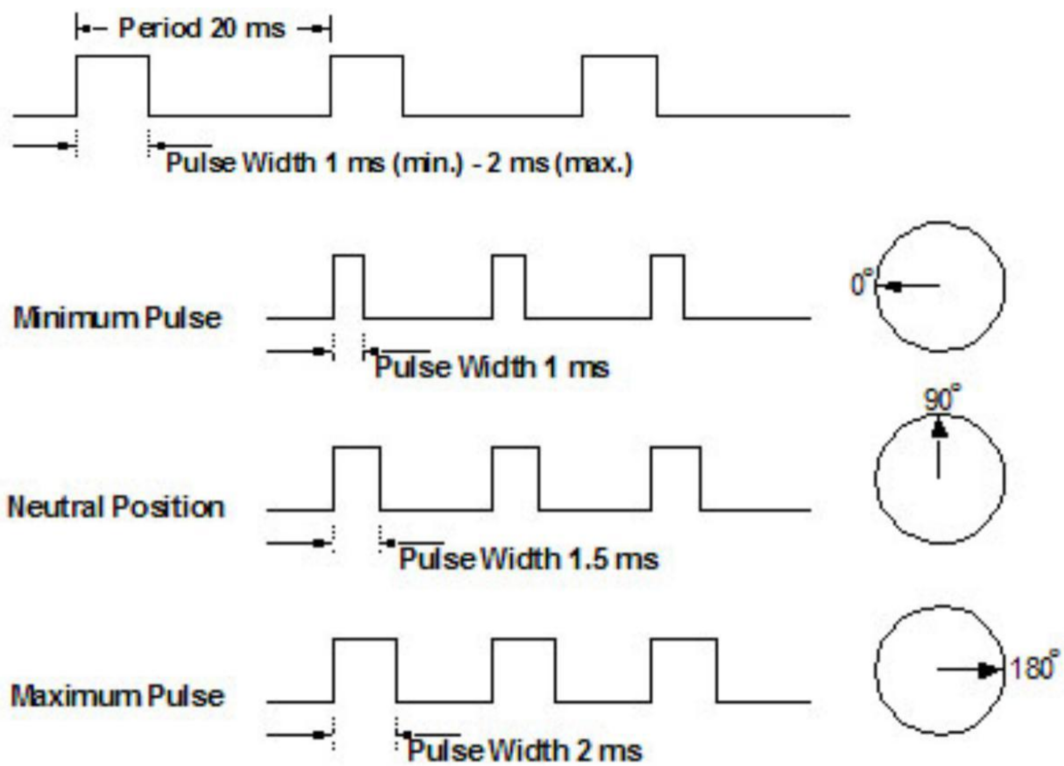


Figure 2.6:Effect of pulse width on direction of servo motor

Torque of each Servo Used

	Minimum Necessary (kg-cm)	Use (kg-cm)
1.Base	4.0	6.5
2.Shoulder	19.2	24
3.Elbow	12.2	14
4.Wrist	4.4	6.5

2.2.3 Bluetooth Module HC-05

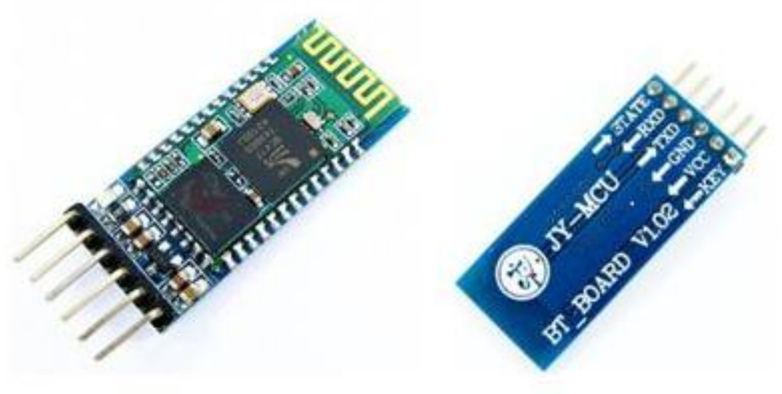


Figure 2.7: BT HC-05

Bluetooth protocol: Bluetooth Specification v2.0+EDR

Frequency: 2.4GHz ISM band

Power supply: +3.3VDC 50mA

Modulation: GFSK (Gaussian Frequency Shift Keying)

Emission power: 4dBm, Class 2

Sensitivity: -84dBm at 0.1% BER

Speed: Asynchronous: 2.1Mbps (Max) / 160 kbps Synchronous: 1Mbps/1Mbps

Security: Authentication and encryption

Profiles: Bluetooth serial port

Power supply: +3.3VDC 50mA

Working temperature: -20 +75 Centigrade

Dimension: 26.9mm x 13mm x 2.2 mm

The serial o/p of the Bluetooth module will be received by arduino which has been programmed to receive the data serially. The received data from the Bluetooth module is compared with the predefined data by arduino and if the match is found then the required action will be performed.

Step to connect:

1) Connect the wiring, power up, while the device is not connected, the bluetooth module board has a white LED flashing.

2) At PC side, search bluetooth device.

3) Found name called "HC-05" device.

4) Connect it, and passcode is "1234".

5) While connection is ok, you can see the LED become always on.

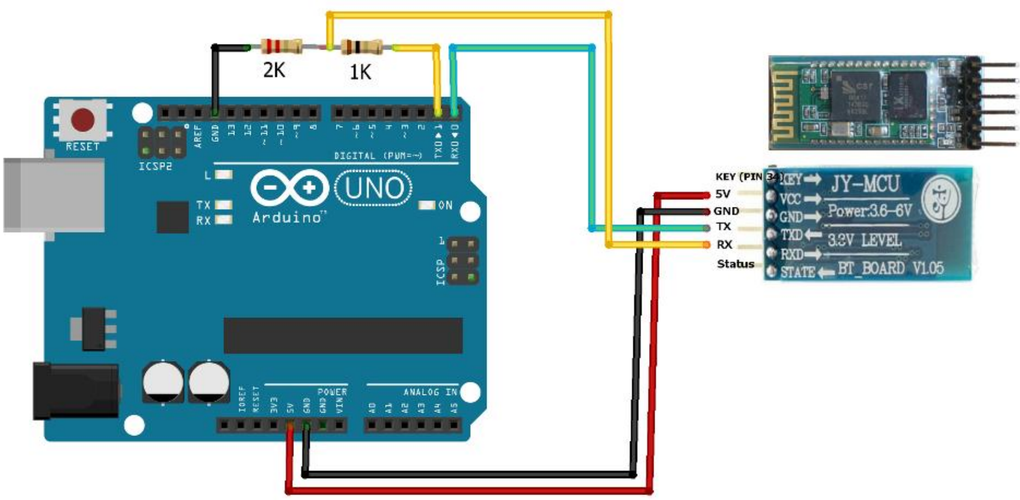


Figure 2.8: Circuit diagram of BT connection

The HC-05 is a 3.3V system while Arduino Uno is a 5V system. The HC-05 breakout board we are using here accepts 5V power and converts it to 3.3V to power the HC-05 but it does not level-shift output from Arduino's pins to 3.3V from 5V. There is more than one way to handle the level-shifting. The simplest way is a voltage divider from two resistors but you can use a level shifter such as the CD4050 level shifter IC. We use 2K & 1K resistors as voltage divider to drop the Arduino's 5V TX pin to 3.3V, which is the operating voltage of the HC-05 pins.

2.2.4 Accelerometer and Proximity sensor

Accelerometer:

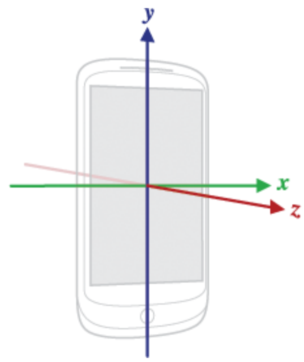


Figure 2.9: Accelerometer sensor axis

An acceleration sensor measures the acceleration applied to the device, including the force of gravity. Conceptually, an acceleration sensor determines the acceleration that is applied to a device by measuring the forces that are applied to the sensor itself. However, the force of gravity is alwaysinfluencing the measured acceleration.

For this reason, when the device is sitting on a table (and not accelerating), the accelerometer reads a magnitude of g = 9.81 m/s2. Similarly, when the device is in free fall and therefore rapidly acceleratingtoward the ground at 9.81 m/s2, its accelerometer reads a magnitude of g= 0 m/s2.

Accelerometers use the standard sensor coordinate system. In practice, this means that the following conditions apply when a device is laying flat on a table in its natural orientation:

- If you push the device on the left side (so it moves to the right), the x acceleration value is positive.
- If you push the device on the bottom (so it moves away from you), the y acceleration value is positive.
- If you push the device toward the sky with an acceleration of A m/s2, the z acceleration value is equal to A + 9.81, which corresponds to the acceleration of the device (+A m/s2) minus the force of gravity (-9.81 m/s2).
- The stationary device will have an acceleration value of +9.81, which corresponds to the acceleration of the device (0 m/s2 minus the force of gravity, which is -9.81 m/s2).

In general, the accelerometer is a good sensor to use if you are monitoring device motion. Almost every Android-powered handset and tablet has an accelerometer, and it uses about 10 times less power than the other motion sensors.

One drawback is that you might have to implement low-pass and high-pass filters to eliminate gravitational forces and reduce noise.

Proximity sensor:

A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact. A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal. The object being sensed is often referred to as the proximity sensor's target. Different proximity sensor targets demand different sensors. For example, a capacitive or photoelectric sensor might be suitable for a plastic target; aninductive proximity sensor always requires a metal target.

The maximum distance that this sensor can detect is defined "nominal range". Some sensors have adjustments of the nominal range or means to report a graduated detection distance.

Chapter 3

Implementation and Coding

The electronic circuit of the robot arm is simulated and tested on Proteus simulation software. Considering the results and behavior of the system derived from the simulation of the user button control diagram as shown in Figure 3.1, the actual circuitry is designed and implemented on bread board. Figure shows the implementation of figure on bread board. It should be mentioned that since the shoulder servos operate simultaneously, S2 and S3 (shoulder servos) are both connected to the pin A4 of the arduino to receive an identical PWM. As seen in Figure 24, each servo motor is operated with a button. Each button causes the arduino to generate the necessary PWM signal and send it to the corresponding servo motor.

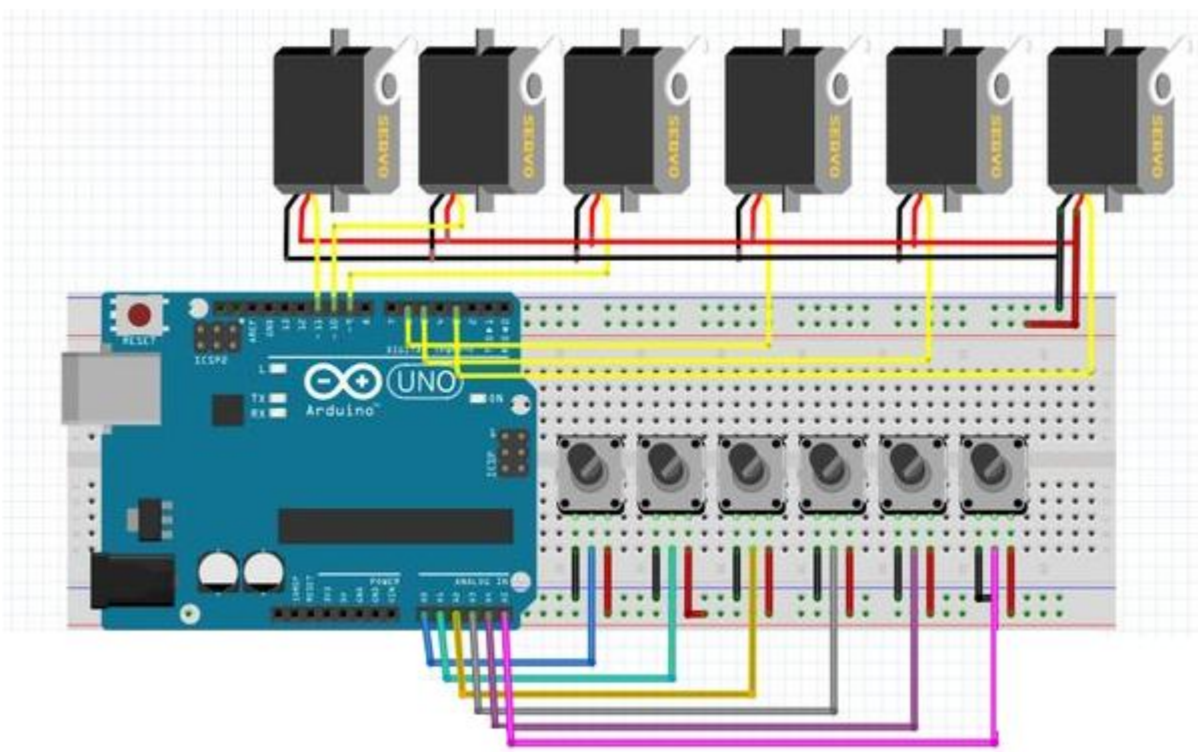


Figure 3.1: Circuit diagram of Robotic arm (Manual control)

Setup the hardware connections with the arduino and the servo motors. The continuous rotation servo motors are those kinds of servo motors that cannot be controlled or set at a particular angle unlike normal servos. Servos have three wires coming from them : Red- Power , Black -Ground, White/Yellow- PWM /PPM Signal. The left servo motor (white/yellow wire) is hooked up to arduino digital pin 9 and right servo motor (white/yellow wire) to arduino digital pin 10. The black wires of both the motors are connected to arduino GND and the Red wires to the positive terminal of the battery holder. Connect the RX pin of bluetooth module to TX pin (digital pin 1) of arduino and TX pin of module to RX pin of arduino (pin 0). Connect Vcc and Gnd of module to the arduino. Connect the negative terminal of battery holder to arduino GND. The connections will look like this :

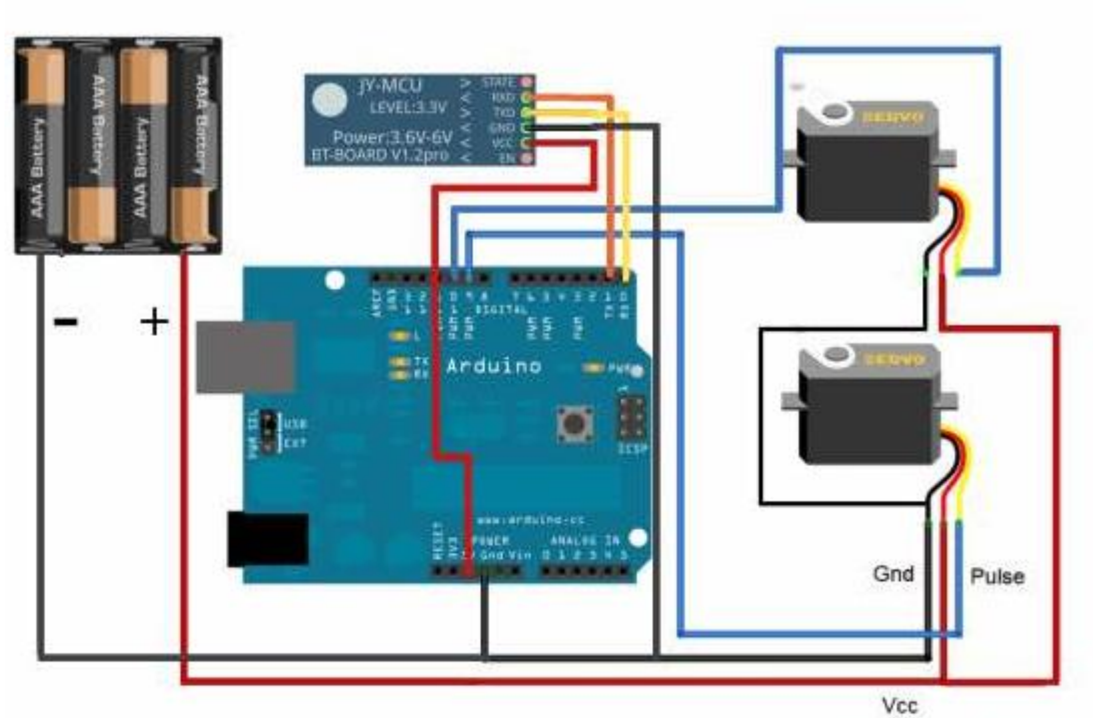


Figure 3.2: Circuit diagram of Robotic arm (Wireless control)

The android application controlled robot communicates via bluetooth to the bluetooth module present on the robot. While pressing each button on the application, corresponding commands are sent via bluetooth to the robot. The commands that are sent are in the form of ASCII. The arduino on the robot then checks the command received with it’s previously defined commands and controls the servo motors.

Coding

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them.

```
#include <Servo.h>

Servo myservo3;   //gripper
Servo myservo5;   //shoulder
Servo myservo6;   //shoulder
Servo myservo9;   //wrist
Servo myservo10;   //elbow
Servo myservo11;   //base

intpotpin = 0;  //gripper
int potpin1 = 1; //wrisht
int potpin2 = 2; //elbow
int potpin3 = 3; //shoulder
int potpin4 = 4; //base

intval = 0; //gripper
int val1 = 0;   //wrisht
int val2 = 0;   //elbow
int val3 = 0;   //shoulder
int val4 = 0;   //base

void setup()
{
  myservo3.attach(3);
```

```
  myservo5.attach(5);
  myservo6.attach(6);
  myservo9.attach(9);
  myservo10.attach(10);
  myservo11.attach(11);
}
void loop()
{
  //gripper
val = analogRead(potpin);
val = map(val, 0, 1023, 0, 179);
  myservo3.write(val);
  delay(15);

  //wrist
  val1 = analogRead(potpin1);
  val1 = map(val1, 0, 1023, 0, 179);
  myservo9.write(val1);
  delay(15);

  //elbow
  val2 = analogRead(potpin2);
  val2 = map(val2, 0, 1023, 0, 179);
  myservo10.write(val2);
  delay(15);

  //shoulder
  val3 = analogRead(potpin3);
  val3 = map(val3, 0, 1023, 0, 179);
  myservo5.write(val3);
  myservo6.write(val3);
  delay(15);
```

```
  //base
  val4 = analogRead(potpin4);
  val4 = map(val4, 0, 1023, 0, 179);
  myservo11.write(val4);
  delay(15);
}
```

Chapter 4

Results and Conclusion

This control mechanism provides an easy movement& control of arm but doesn't facilitate the teaching and learning. Thus, a cheap and easy way of control using popular Arduino Uno and Bluetooth devices is implemented. The structure of arm platform as shown in figure 5.1.

Figure 5.1: Robotic Arm

Conclusion

- In this thesis, the procedure of building an articulated arm robot using aarduino and servo motors with the help of PWM has been discussed.
- The building procedure consists of building the kinematic structure of robot, hardware design and implementation, software design and implementation and microcontroller programming.
- The motion of the robot is controlled via PWM signals which are generated with the arduino and discussed the effect of these pulses on the servo motors using both software simulation and real-time experiment.

Future Work

As the future work of the developed arm robot, a voice-controlled robot can be considered where the user can simply control the robot by giving voice commands such as giving directions (up, down, left, right) and actions (grasp, drop, rotate left, and rotate right).

References

[1] http//www.arduino.cc / Arduino – Servo

[2] http//www.electricalfun.com

[3] http//www.societyofrobots.com

[4] http//www.robotshop.com