

Design and Development of Prosthetic Arm Prototype

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Abstract- The movement of the hands and fingers in hand amputees are possible through robotic prosthesis. The development of prosthetic arm deals with replacing the artificial arm for the amputees. In the current paper, the prosthetic arm prototype has been developed to help the amputees to carry out general purpose applications, such as pick and place, to grab the materials etc.. The current paper aims to design and develop low cost prosthetic arm which consists of robotic hand, Arduino board, braided wire, Servo motor, Mini Breadboard and 9V Battery. Each finger has been designed and developed to achieve 3 degrees of freedom.

Index Terms- Amputees, Prosthetic arm, Prototype, Arduino, Degrees of freedom, Servo motor

1. INTRODUCTION

Prosthesis is an artificial part of the body that replaces a part or limb missing below the elbow. The artificial part of the body can be hip, knee, tooth, eye, facial bone, leg, arm, joints etc. Most commonly used prostheses for joints include the knee, elbow, hip, ankle, joints etc.



Fig.1. Developed Prosthetic Arm

Theoretically, any part of the body from head to toe that can be replaced can be called as prosthesis. Complete or partial replacement of any part of arm or leg can be practically classified into four types.

Below the knee (BK, transtibial)

It includes a prosthetic lower leg attached to the upper leg.

Above the knee (AK, Transfemoral)

It includes a prosthetic upper and lower leg, including an artificial knee.

Below the elbow (BE, transradial)

It includes an artificial fore arm.

Above the elbow (AE, transhumeral)

It includes an artificial lower and upper arm, including an elbow.

Till date, there has been a lot of development in the types of robotic arms replacing human hands for carrying out various tasks. The robotic arms can have end effectors or tools to carry out multiple operations

Which can be applied to field of engineering, medical electronics etc. However the robotic arm in human beings is restricted due to its high cost. The result being the use of prosthesis as replacement in humans for multitasking. The current work involved the development of prosthetic arm for carrying the required tasks.

The objective of the current paper includes the following

- To design a prosthetic arm prototype for the amputees.
- Development of prosthetic arm prototype using PLA material.
- Testing the prototype for simple pick and place applications.

2. METHODOLOGY

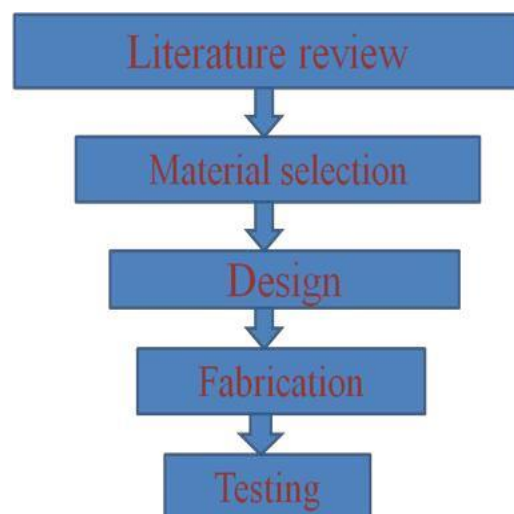


Fig.2. Methodology of Prototype

2.1. Literature review

The literature review showed that various methodologies used to control the movements of prosthetic arm included voice control, modular prosthetic limb, five fingered prosthetic arm etc. some literatures showed that the prosthetic arm could be used to perform most complex applications. In the current paper, the design and development of four fingered prosthetic arm with 3 degrees of freedom in each finger has been developed to perform simple pick and place application helping the human beings.

2.2. Material selection

The parts of the prosthetic arm include robotic Hand, Arduino Board, Braided Wire, two Servo Motor, two Mini Breadboard, and 9V Battery for Servo Motors. PLA material is used for the body of the prosthetic arm.

2.2.1 Robotic Hand

Properties	MATERIAL 1	MATERIAL 2
Materials	Acrylonitrile butadiene styrene (ABS)	Polylactic acid (PLA)
Design	3D print	3D print
Cost	SUSD 28	SUSD 22
Tensile Strength	27 Mpa	37 MPa
Melting Point	N/A (amorphous)	173 °C
Biodegradable	No	Yes, under the correct conditions

Table 1: Material and Cost Justification

Based on the above cost analysis, PLA material was selected for the manufacture of prosthetic arm using rapid prototyping techniques.

2.2.2 Servo Motors

The servo motor that was selected, based on the calculations, was four small servos with torque of 1.8 kg-cm. These motors were used as it is much cheaper than any other motor with same specifications. Other relevant characteristics of the motors, which can be shown in Figure 3, are that they can turn 360 degrees in 130 milliseconds with a weight of 47.9 grams each.

Once the initial dimensions for the prosthetic arm and the motor were defined, the design was carried out using the Solid edge platform design.



Fig.3. Servo Motor

2.2.3. Micro Controller

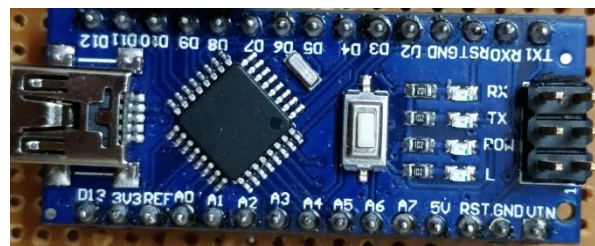


Fig.4. Microcontroller

Arduino, 5V micro-controller with bit size of 32 bit was used in the development of prototype.

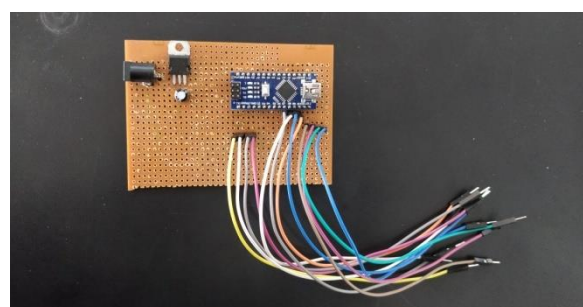


Fig.5.Circuit Board

2.3. Fabrication

The fabrication of prosthetic arm was done 3D printing of stereo-lithography technique using PLA material as shown in Fig.1

2.4. Circuit Diagram of Prosthetic Arm

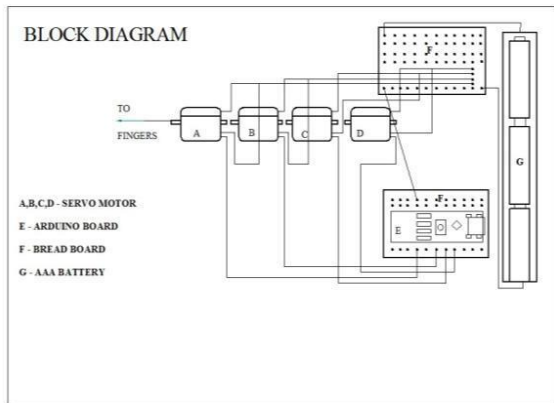


Fig.6. Circuit diagram of prosthetic arm



Fig.9. Assembly of Prosthetic Arm

2.5. Design Drawing of Prosthetic Arm

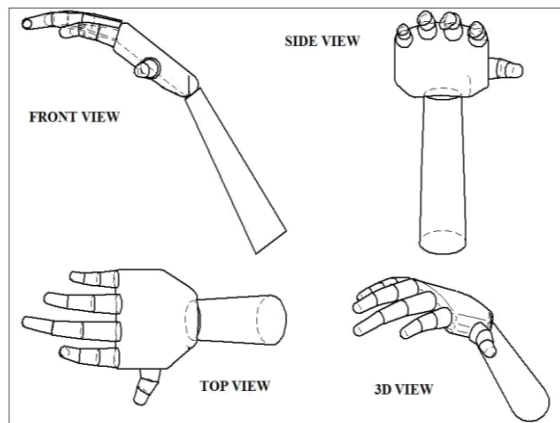


Fig.7. Isometric View of Prosthetic Arm

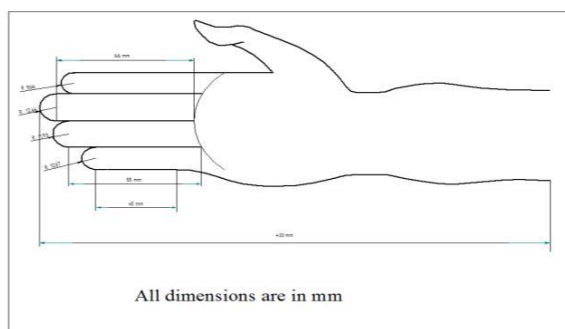


Fig.8. 2D Diagram of Prosthetic Arm

2.6. Design Calculations

$$\text{Force} = \text{Mass} \times \text{Acceleration} \dots \dots \dots \text{Eq. (1)}$$

$$\text{Acceleration} = \text{Gravitational Force} = 9.81 \text{ m/s}^2$$

Assume,

$$\text{Mass} = 0.2 \text{ Kg}$$

Then,

$$\text{Force} = 0.2 \times 9.81$$

$$\text{Force} = 1.962 \text{ kg-m/s}^2$$

$$\text{Force} = 1.962 \text{ N}$$

2.7. Testing

The prosthetic arm was tested for pick and place application using Arduino Nano as a microcontroller board based on the ATmega328P. 14 digital input/output pins are present in it out of which 6 can be used as PWM outputs, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack and a reset button. It contains everything needed to support the microcontroller. To get it started, it has to be connected to a computer with a USB cable or power it with an AC-to-DC adapter or battery.

The testing of prosthetic arm was done by using the below mentioned programme

```
#include <Servo.h>
Servo myServo;
Servo myServo1;
Servo myServo2;
Servo myServo3;
void setup() {
  myServo.attach(7);
  myServo1.attach(8);
  myServo2.attach(9);
  myServo3.attach(10);
```

```
/*myServo.write(0);  
myServo1.write(0);  
myServo2.write(0);  
myServo3.write(0);  
delay(100);*/  
}  
void loop() {  
  myServo.write(180);  
  myServo1.write(180);  
  myServo2.write(180);  
  myServo3.write(180);  
  delay(500);  
  myServo.write(0);  
  myServo1.write(0);  
  myServo2.write(0);  
  myServo3.write(0);  
  delay(500);  
}
```

3.CONCLUSION

In the current paper, the possibility of using a prosthetic arm for the amputees has been done. The main focus of this work was to design and develop the prosthetic arm with three degrees of freedom in each finger to accomplish accurately simple tasks such as pick and place applications, light material handling with the aid of several servo motors which do provide links between arms and perform arm movements. A microcontroller drives the servo motors with the capability of modifying position and controlling the prosthetic arm using android device. The design drawings and the prototype development of the prosthetic arm has been developed using stereo-lithography technique using PLA material with low cost technology. The prosthetic arm has been tested for pick and place applications. The load carrying capacity of prosthetic arm along with gripping force is done.

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