Indian Institute of Technology, Kanpur

SUMMER'17 PROJECT

ROBOTICS CLUB

Science and Technology Council

Prosthetic Arm

End-term Evaluation

Project Members

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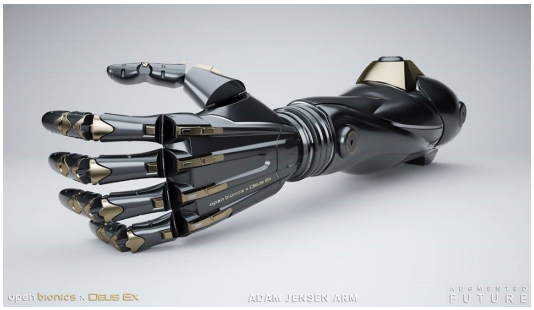
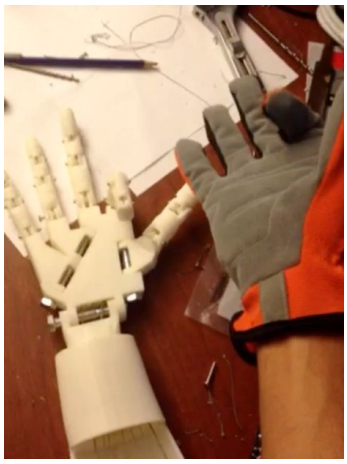


Aim and Objective of Project

- Artificial Gripper based on the concept of Prosthetic.
- Manufacture using 3-D Printing Technology.
- Motion of fingers to be controlled using Servo and Micro-Controllers.



Abstract

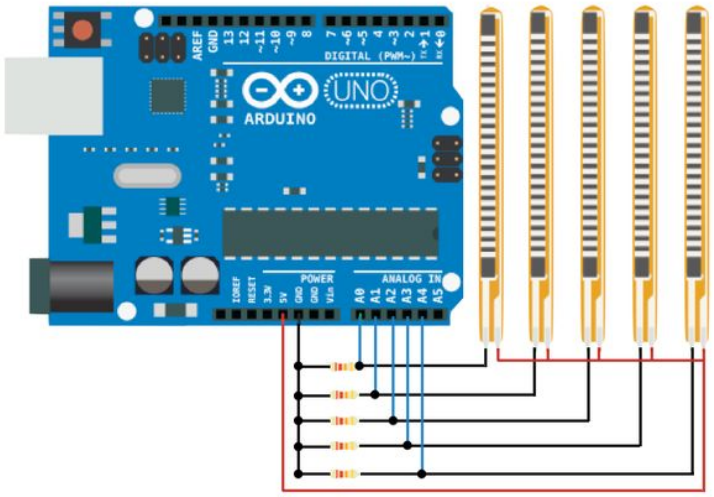
It involves the concept of Prosthetics which can be applied to other fields too. The basic components of the hand and glove are the hand itself, the servos, the Arduino, the glove,the Bluetooth modules and the flex sensors. The glove is mounted with flex sensors: variable resistors that change their resistance value when bent. They're attached to one side of a voltage divider with resistors of a constant value on the other side. The Arduino reads the voltage change when the sensors are bent and triggers the servos to move a proportional amount. The servos pull strings that act as tendons, allowing the fingers to move.

Contents

1. Flex Sensors

This flex sensor is a variable resistor like no other. The resistance of the flex sensor increases as the body of the component bends. The flex sensors require a circuit in order for them to be compatible with Arduino. It's a voltage divider: the flex sensors are variable resistors, and when paired with resistors of a static value, a change in resistance (in this case bending the sensor) can be sensed through the change in voltage between the resistors. This can be measured by the Arduino through its analog inputs. The schematic is attached (red is positive voltage, black is negative, and blue goes to the Arduino). The resistors in the photo are 22K. Physical wires are color-coded in the same way as the schematic so you can see more easily.

The main GND (ground) wire, which is connected to all the individual GND wires from the sensors, gets plugged into the Arduino's GND. The +5V from the Arduino goes to the main positive voltage wire, and each blue wire gets plugged into a separate analog input pin.

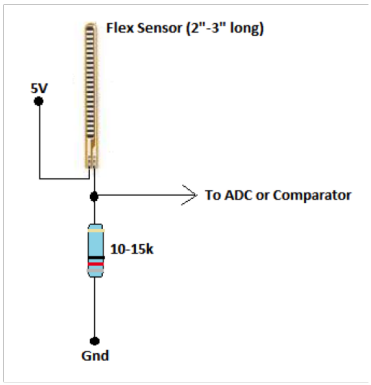


The circuit is soldered precisely on a small General Purpose Board, one that could be easily mounted onto the glove. We tried to minimize the design of our GPB so that it fits well on the gloves. Near the bottom, where the leads are attached, the sensors are a bit weaker and the tape ensures that they won't bend too far and won't get damaged.

1.1. Calculation Of Resistance

Resistance Of Flex Sensor can be calculated by Multi-Digital Meter(MDM).
For Calculation of Value of External Resistor(say r) to be use in Series with the flex , First we have to calculate the value of flex resistor in relaxed (let say R_1) and in folded state(say R_2).

1.2. Voltage difference Maximisation



Voltage Difference needs to be maximized, So as to differentiate between the folded and relaxed state of flex sensor accurately.
$(V_1 - V_2) = (\epsilon - \frac{\epsilon}{R_1+r}) - (\epsilon - \frac{\epsilon}{R_2+r})$
Differentiate above equation w.r.t. r , to get-
$r = \sqrt{R_1 * R_2}$

1.3. Threshold Value of Voltage

After setting up the whole circuit, we then calculate the $V_{th} = \frac{V_1+V_2}{2}$ and set it as threshold value to rotate the servo for $V > V_{th}$.

2. Arduino-Nano

The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328; offers the same connectivity and specs of the UNO board in a smaller form factor.The Arduino Nano is programmed using the Arduino Software (IDE), an Integrated Development Environment

2.1. Built-in Functions Used

1. analogRead() : Reads the value from the specified analog pin.
2. delay() : Pauses the program for the amount of time (in miliseconds) specified as parameter.
3. Serial.write() : Writes binary data to the serial port. This data is sent as a byte or series of bytes; to send the characters representing the digits of a number use the print() function instead.
4. Serial.read() : Reads incoming serial data. read() inherits from the Stream utility class.

Analog Pins are used here to take measure of voltage

3. Bluetooth Module

We first studied about bluetooth modules HC-05 and connecting them with arduino. Then we paired the Bluetooth devices by making one of them in Master mode and other in Slave mode, and then we worked on serial communication and data transfer between them.

3.1. Pairing of Master and Slave Bluetooth Module

For pairing of bluetooth module , connect RX of BT to RX of arduino and TX of BT to TX of arduino. We used the following command in Serial Monitor :

1. **AT+NAME?** : gives the name of bt module
2. **AT+ROLE?** : define BT as Slave or Master. Use 0 for slave and 1 for master.
3. **AT+PSWD?** : set the password. Default = 1234
4. **AT+ADDR?** : to note the address.
5. **AT+LINK=**$< address >$: to pair master with slave.

3.2. Serial Communication between Bluetooth Modules(HC-05)

Now connect RX with TX and TX with RX.
We decided to use Serial Port Bluetooth Module (Master/Slave) : HC-05. HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. We used Serial.write() and Serial.read() to transfer the information.

4. Inventor 2018 - 3D Design

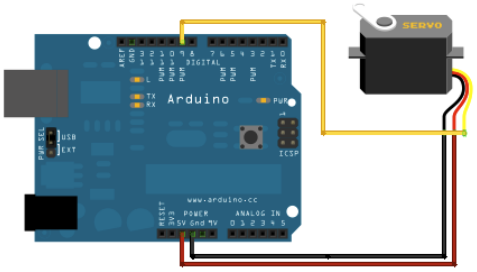
Inventor 2018 is a CAD Modelling Software manufactured by Autodesk, which we used to make and optimize our design for the prosthetic arm.

The inspiration of the design was taken from an old school project made by one of the team members.

Keeping the basic functioning and structure the same , we improved on the strength, durability,and appearance of the model. The software was used the design as well as simulate the model to enhance its working.

5. Servos

A Servo is a small device that incorporates a two wire DC motor, a gear train, a potentiometer, an integrated circuit, and an output shaft. Of the three wires that stick out from the motor casing, one is for power, one is for ground, and one is a control input line. The shaft of the servo can be positioned to specific angular positions by sending a coded signal. As long as the coded signal exists on the input line, the servo will maintain the angular position of the shaft. If the coded signal changes, then the angular position of the shaft changes.



We have used MG946R Towerpro Digital Metal Servo 13KG High torque. It is upgraded version of TowerPro MG945. The new PCB and IC control system which makes it more accurate. Its internal gearing and motor are also upgraded to improve dead bandwidth and centering.

5.1. Use of $< Servo.h >$ library in Arduino

1. **servo.attach(pin)** : Attach the Servo variable to a pin
2. **servo.write(angle)** : Writes a value to the servo, controlling the shaft accordingly.

5.2. Powering Servos

We gave power to servos through a battery. Most Important thing here was GND of Servo, Arduino and Battery should be made same, Otherwise servos will not work properly.

5.3. Rotation of Shaft of Servos

Each of the 5 servos is optimised to rotate through a particular angle to rotate the finger to grab a object.

6. 3D-Printing of Prosthetic Arm

3D printing or additive manufacturing is a process of making three dimensional solid objects from a digital file. The creation of a 3D printed object is achieved using additive processes. In an additive process, an object is created by laying down successive layers of material until the object is created. Each of these layers can be seen as a thinly sliced horizontal cross-section of the eventual object.

6.1. Material Used

For our project, we used the 3-D printer available to the institute in the 4i lab using PLA as feedstock material for the printing. PLA and ABS both were available there for printing purpose but we chose PLA based on our project requirements.

6.2. Brief about PLA and ABS

Polylactic Acid (PLA) is a biodegradable thermoplastic, made from renewable resources like corn starch or sugarcane. Outside of 3D printing, it's typically used in medical implants, food packaging, and disposable tableware. The main benefit of PLA is that it's easy to print.

Acrylonitrile butadiene styrene (ABS) is an oil-based thermoplastic, commonly found in (DWV) pipe systems, automotive trim, protective headgear, and toys (like Lego!). Objects printed with ABS boast slightly higher strength, flexibility, and durability than those made of PLA, at the cost of a slightly more complicated print process complete with nasty fumes.

6.3. Summarizing Table : PLA vs ABS

	PLA	ABS
Printing Temperature	180-230$^{\circ}C$	210-250$^{\circ}C$
Print Bed Temperature	20-60$^{\circ}C$	80-110$^{\circ}C$
Print Bed	Optional	Mandatory
Enclosure	Optional	Recommended
Clogs/Jams Nozzle	Occasionly	Never
First Layer Adhesion	Minor Problems	Minor Problems
Fumes	Little to none	Bad and Intense
Absorbs Moisture	Yes	Yes

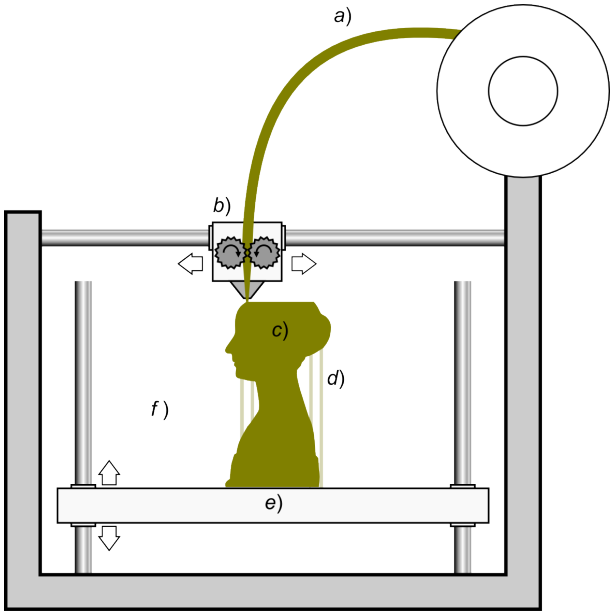
6.4. Our First Printout Of a Finger

First we got a single finger printed to check the strength of material and quality of printing. This was not upto our expectations in quality of printing and but it's strength was good.

6.5. Procedure

Schematic representation of the 3-D printing technique known as Fused Filament Fabrication. A filament a) of plastic material is fed through a heated moving head b) that melts

and extrudes it depositing it, layer after layer, in the desired shape c). A moving platform e) lowers after each layer is deposited. For this kind of technology additional vertical support structures d) are needed to sustain overhanging parts



6.6. 3-D printing in our lab

Currently, TECHB V30 printer is available in our lab. It has many limitations on material used as well as quality of printing. Its is due to these reasons that we chose PLA over ABS despite of certain benefits of ABs over PLA. Some images of 3-D printer available in our 4-i labs are :-

Front View Of Machine

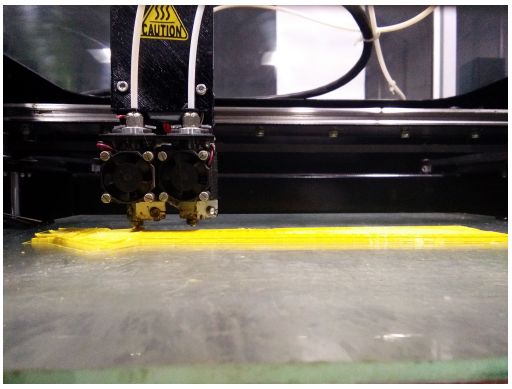
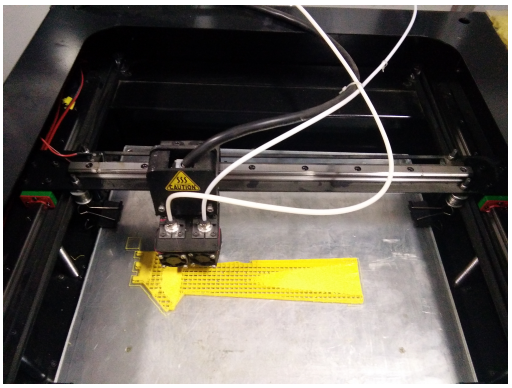
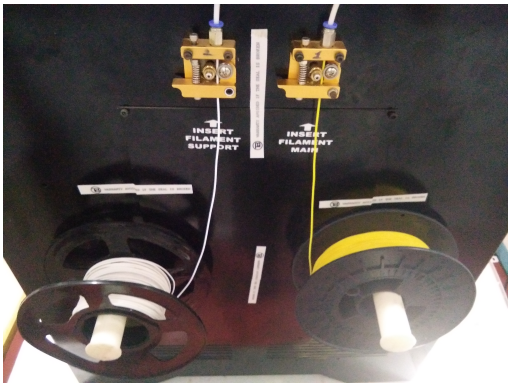


Image demonstrating layer by layer printing technique. In this image, the machine is printing layers of 150 micrometers thickness.



Our work of Printing Arm in progress.

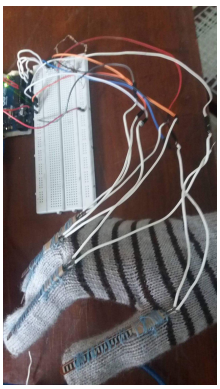


Back View of Machine - The raw material is used in form of these wires.

7. Hand Glove Design

7.1. Stitching Flex Sensor on Woolen Gloves

7.2. Circuit of Flex Sensor on Gloves



8. Links for Codes And Tutorials

Report on Previous Finger Design (for Internal Evaluation)

Github links for Code

Latest Designs

Old Models

Hand Design and instructions for Joining 3-D components

Connecting HC-05 bluetooth modules with arduino

Flex Sensors theory and circuit connections

Servo Motor MG-946R