GIVING A HAND

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Abstract

One of the industries that face a problem is artificial limbs as the cost of artificial limbs range between 5000 USD to 50,000 USD, which doesn’t make it a reliable solution, especially for children who need to change a hand every year and that makes it impossible with this huge cost ,also about 2millions of disabled from total 2.5 million are found in Africa and only 5 from each 25 can buy the hand from Europe . So, artificial limbs industry was chosen to work on. Our project is the prosthetic hand, one that aims towards the creation of an affordable hand for disabled. In the following pages we will add go in depth with our design and the processes that we went through as a team to create our final project The introduction will provide the background knowledge for what encourage us for this project and then we will talk about mechanisms and parts

Introduction

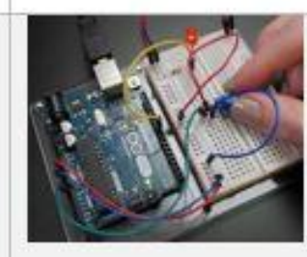
In earlier time, human being lost their human body part i.e. hands, legs etc. They did replacement of part by means of any wooden **(Fig. 1)** or metal prosthetic part. But that had many limitation. It was only a static part of the body. As that was made by wooden or metal material that would increase the weight of structure. Because of that it was hard to carry body part. Another limitation for same was it would create resistance to the regular human body motion. At some time it only be a non-useful human part. Only purpose of that would be for aesthetic criteria.

But as time passed, evolution occurred in that field. Human didn't want prosthetic hand for just an aesthetic purpose, they want fully functional prosthetic hand as replacement of it. As described above, earlier the main origin of this invention is to just provide the prosthetic hand. After that many development in this field occurred and now a day we had a fully functional prosthetic hand that can do most of every normal function of human hand. As improvement and development in technology in mechanical, electrical, electronics and communication, etc. we had technical gadgets like sensor that would help use to provide accurate and desired motion to the prosthetic hand.

(Fig.1)

Hence, our proposed solution is to literally give a hand for amputees specially children by constructing a 3D printed hand made of PLA plastic. This hand uses the signals from the muscle and moves by servomotors. In order to confirm the validity of the solution, a test plan was made to check the design requirements, which are: reducing the cost of the artificial hands, making the hand efficient enough to do the daily tasks , and reducing the weight of the artificial hand up to 300g to make the human able to carry it. It was found that the hand successfully addresses the design requirements as the cost of the hand doesn’t exceed $80 and the hand was able to do the daily jobs. The materials used were efficient, affordable, and can be found easily as it will be illustrated in the section below.

Materials

Material Name	3D printed parts	Servo motors	Arduino module	Fishing wires	Nylon wires	Power supply	Muscle sensor
Picture							
Description	5 fingers- Palm- Forearm	2 Standards 1 micro	Arduino Uno R3- jumpers- bread board	10 Meters	5 meters	2 batteries 9 Volts	Myoelectric sensor

(Table. 1)

Methods

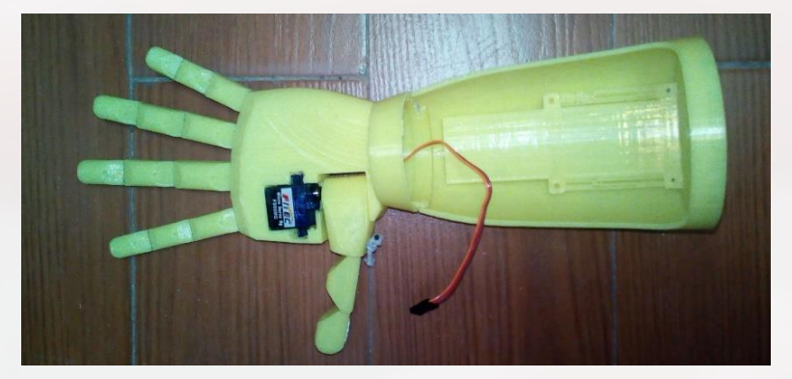
Many methods were implemented until reaching the satisfactory method to make our prototype.

Firstly, the 3D printed hand:

- A 3D design was made using 3D builder with dimensions similar to the real hand. **(Fig. 2)**.
- The design was put in the 3D printer to make the 3D printed parts.
- The fingers were connected to the palm using nylon wires as shown in **(Fig. 3)**.
- The thumb as glued to the micro servo and then glued to the palm.
- The hand was glued to the forearm. The solid design of the hand was shown in **(Fig. 4)**.

(Fig.2)

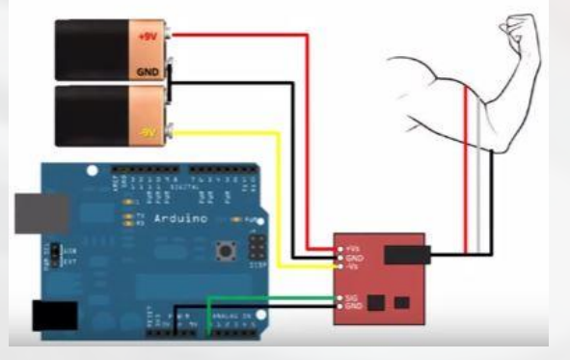
(Fig.3)



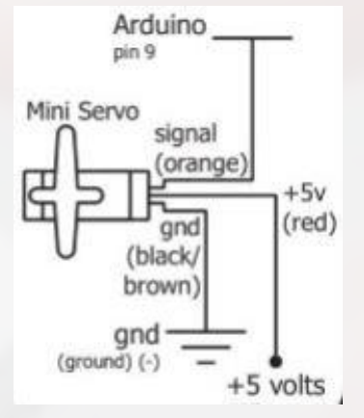
(Fig.4)

Secondly, the Arduino station:

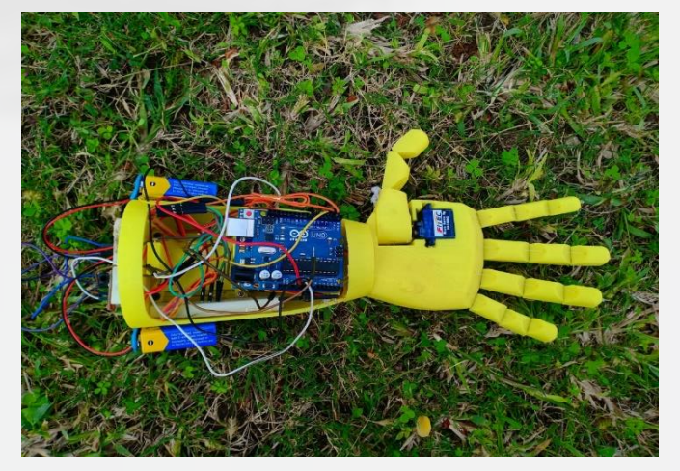
- The muscle sensor was connected to the Arduino and the battery, and the electrodes were directed to the human shoulder. The schematic shown in **(Fig. 5)**.
- The servo motors were connected to the Arduino and the battery, then connected to the fingers using fishing wires. The schematic shown in **(Fig. 6)**.
- The code was implemented to rotate the servo motors according to the muscle sensor signals. The connections is shown in **(Fig. 7)**.



(Fig.5)



(Fig.6)



(Fig.7)

The final design of the hand is shown in (Fig. 8)

(Fig.8)

Test plan:

The design requirements are:

1- reducing the cost of the artificial hands up to $80.

2- making the hand efficient enough to do the daily tasks that the human hand does.

3- reducing the weight of the hand up to 300 grams to make the human able to carry it.

The followings are the steps followed to check the validity of our hand based on the design requirements.

For the efficiency test,

1- The code was run to read the signals of the muscle sensor.

2- A lag test was made to measure the gap between the action and the reaction.

For the cost,

1- The cost of the total hand was measured.

2- The cost was compared to the chosen design requirement to test if the hand can achieve it or not.

For the weight test, the weight was measured and compared to the design requirement.

Results

At the beginning, our hand passed through a negative result, as there was a huge lag between the action of the body and the reaction of the hand, and there was a problem with holding objects. After improvements, the hand perfectly achieved the design requirements.

(Fig.9)

Efficiency test: **(Fig.9)**

To test the efficiency of the hand, it passed through a lag test. The lag of hand was tested for 5 trails and The results shown in (**Fig. 10**). The average lag was 1.41 second with error ±0.2 sec, which showed that the artificial limb received the signals with high functionality and speed, and The motion of the hand showed flexibility and grasp.

(Fig.10)

Weight test:

By measuring the weight of the limb, it was found that the weight is 315 grams with error ± 5 grams , as shown in **(Fig. 11).**

This shows huge success in decreasing the weight of the limb, nearly to the quarter, where the traditional limb weighs about 900 grams.

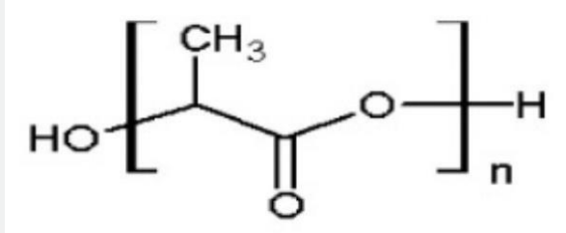
(Fig.11)

Analysis

After achieving the Design requirements, a deep explanation for every step in the project is desired to understand why the project might alleviate the industrial crisis in Egypt if applied on an industrial scale. First things first, the thought of how the hand reached the design requirement will be explained below:

- **PLA Plastic (Fig. 12) :**

PLA (Polylactic Acid) is selected from plastics because of availability of 3D printing process and low cost manufacturing process. It is made of renewable resources such as corn starch or sugar cane.



(Fig.12)

Most plastics, by contrast, are derived from the distillation and polymerization of nonrenewable petroleum reserves. PLA's light weight (Density = 1240Kg/m3), better load carrying capacity, and ability to be injection, molded, and extruded make it useful in manufacturing products compared with other materials.

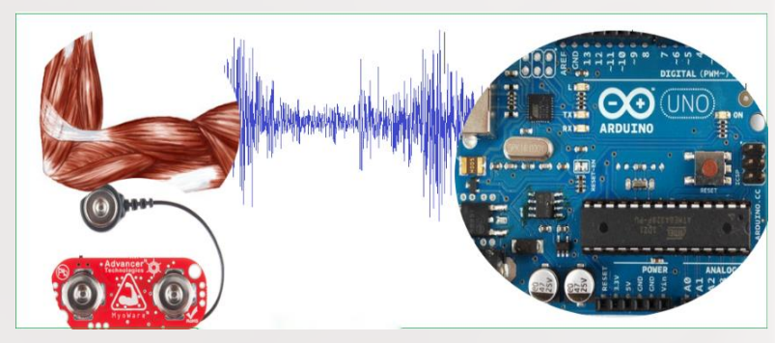
- **Hand design:**

The design of the hand consists of fingers, palm, and forearm. The design of the fingers was chosen carefully to hold objects, as the spaces between joints make it easy to be pleated. These joints offer low-friction bending while resisting lateral deflection.

The design of the thumb was chosen to provide a perfect close to the hand, as the thumb can rotate according to the shape of the object that will be hold. This design makes the control of the object easier.

- **The Muscle Sensor (EMG):**

The MyoWare Muscle Sensor from Advancer Technologies measures, filters, rectifies, and amplifies the electrical activity of a muscle and produces an analog output signal that can be read by a micro-controller, as shown in **(Fig. 13)**.



(Fig.13)

In order to attach to skin, the sensor requires three electrodes that snap into the sensor’s snap-style connectors, which make it easy to attach and detach electrodes. Two connectors are located directly on the PCB, and the third is located at the end of the attached reference electrode cable.

- **The Arduino board:**

The Arduino board acts as the brain of the system, as it is able to read the input signals from the muscle sensor and uses these signals to control the servo motors using a microcontroller.

- **The servo motors :**

The servo motors work as the task maker, as they receive the order from the Arduino, then rotate and pull the fishing wires. Unlike dc motors, with servo motors we can position the motor shaft at a specific position (angle) using control signal. The motor shaft will hold at this position as long as the control signal not changed, so it was used to open and close the hand according to the signals delivered to it.

- **The Hand Mechanism :**

When the human wants to move his hand, his brain deliver signals to the muscles, then the muscle sensor read this signals. The Arduino collect these signals and starts to give the order to the servomotors to rotate. The servo motors pull the fishing wires so that the fingers start to move.

- **Cost Analysis:**

components	Price (LE)
Muscle sensor	500
Servo motor	180
Arduino	120
Plastic	450
Battery and cables	50
	1300 LE

Conclusions

Achieving the design requirements showed that the solution is the one that can be applied in the industrial scale and can successfully solve the problems of artificial limbs industry. The PLA plastic and the muscle sensor have shown a great plot twist to help children start a new chapter of their life with a hand of decreased cost of about 98% and these children can now do the daily jobs with cost as low as 1300 LE. Even more, the hand is an optimal one with mass of about 315 grams only, and it provides low lag between given signals and executed instructions as low as 1.4 sec. The solution is one that clearly uses affordable, efficient, and light materials that approaches the design requirements and certainly provides a solution that solve a problem related to the challenge of the cost of industry.

Recommendations

3D scanning (Fig.14)

As the shape of the hand differ from one to another, we recommend 3D scanning to be made before making the hand. 3D scanning is a technique to capture the shape of an object using a 3D scanner. the shape of the object appears as millions of points called a “point cloud” on the computer monitor as the laser moves around capturing the entire surface shape of the object. The result is a 3D file of the object on a computer, which can be saved, edited, and even 3D printed.

(Fig.14)

Artificial skin with multi-modal sensing capability (Fig.15)

This new stretchable prosthetic skin comes equipped with ultra-thin, single crystalline silicon nanoribbon sensors for strain, pressure and temperature, as well as humidity sensors, heaters and stretchable multi-electrode arrays for nerve stimulation. The skin is tuned to stretch as befits its location on the prosthetic.

(Fig.15)

Solar powered hand

As the artificial hand needs electricity for moving fingers, we recommend to use flexible solar panel above the forearm to generate electricity able to move the servo motors. The electricity also saved in a battery in order to use it during the night.

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