Giving Hands: A New Developed prosthetic hand for amputees

Alaa Hamed Omar Hassan

Dakahlia STEM High School
Mansoura, Dakahlia, Egypt
Alaa.1319136@stemdakahlia.moe.edu.eg
DOI: 10.31364/SCIRJ/v9.i01.2021.P0121834
http://dx.doi.org/10.31364/SCIRJ/v9.i01.2021.P0121834

***Abstract*- Unfortunately, the whole world suffers from serious a grand challenge that represents a great obstacle that hinders its development. Lack of using technology and internet of things represents one of those most serious challenges that ought to be solved, as it affects health systems, education systems, and industrial systems. Numerous efforts have been made to solve the problem, but there is still a need for more innovative solutions. So, the proposed solution is to address IOT and its effects on health systems. Thus, a 3D printed hand was made to help amputees. This hand was connected to a system that measures heart beats, temperature of patient, and temperature of the hand to secure the safe use of the hand and ensures that the patient in a good condition. After that, the whole system is connected to a website application that receives and analyses this data, and sends a medical record for the condition of the patient to the physician. In order to check the validity of the solution, design requirements of lag time, cost, and weight were selected. The hand has successfully met the design requirements and proved to be a reliable solution that gives a hand to amputees.**

***Index terms*— Amputation, IOT, Arduino, Servo Motor**

I. INTRODUCTION:

The number of devices in this world is approximately 34.8 Billion - over 4 times the number of humans. This number is projected to increase massively to 50.1 Billion by 2025. IOT represents a revolution that can solve world industrial, health, and traffic challenges by connecting these devices together. However, Egypt can't keep in pace with the developed countries in the race of IOT; there has been a lack of innovative solutions to solve Egypt's problems using IOT.

One crucial problem that stood as a barrier in health care and industry is hand amputee. In Egypt, an estimated number of 45000 person suffer from hand amputee. The major problem with artificial hand limbs is its high cost that ranges between $3000-$30000, which makes it a burden, especially for children who need to change hand every year due to their growth rate.

Other prior solutions were made to solve this problem like: Titanium artificial limb, which has some points of strength like efficiency and other points of weakness like cost and weight. Another solution is the wooden prosthetic arm. The wooden prosthetic arm is an artificial arm that might be considered as a failed solution when considering its points of weakness: high weight and difficulty to control it.

Hence, our proposed solution is to literally give a hand for amputees specially children by constructing a 3D printed handmade of PLA plastic. This hand uses the signals from the muscle and moves by servomotors and uses heart beats and temperature sensors to provide data about the condition of the patient. By using IOT, the hand was connected to another system (the web application) that receives and analyses the data and sends a medical record to the patient.

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 315g 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 $100 and the hand was able the daily to do daily jobs. The materials used were efficient, affordable, and available as it will be illustrated in the materials section below.

II. MATERIALS:

1. 3D printed parts (finger- palm- forearm)
2. Servo Motors (4 Standards- 1 Micro)
3. Arduino Module (Arduino Uno R3- Jumpers- bread board)
4. Fishing Wires (10 Meters)
5. Nylon Wires (5 meters)
6. Power Supply (2 batteries provide 9 volt)
7. Muscle Sensor (Myoelectric Sensor)
8. Temperature Sensor DHT11- 1
9. Temperature Sensor IC- LM35- 1
10. ESP8226 Wi-Fi module-1
11. Heat Beat Sensor

http://dx.doi.org/10.31364/SCIRJ/v9.i01.2021.P0121834

III. METHODS:

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

Firstly, the 3D printed hand:

- A 3D design was made using 3D builder with dimensions similar to the real hand.
- 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. 1)**.
- The thumb as glued to the micro servo and the glued to the palm.
- The hand was glued to the forearm. The solid design of the hand was shown in **(Fig. 2)**.

Figure 1

Figure 2

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 servo motors were connected to the Arduino and the battery, then connected to the fingers using fishing wires.
- The temperature sensor LM35 is connected to the Arduino.
- The temperature sensor DHT11 was connected to Arduino.
- The heart beat sensor was connected to Arduino.
- The code was implemented to rotate the servo motors according to the muscle sensor signals.
- The final design of the hand is shown in **(Fig. 3).**

Figure 3

Thirdly, the ESP8266 module station:

- The ESP8266 module was connected to Arduino according to its schematic.
- The ESP8266 module was connected to the website (things speak) and send date from the Arduino to the website. There is a simple explanation to what happen during the connection.

The design requirements are:

1) reducing the cost of the artificial hands up to less than $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.

IV. 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 of all, the thought of how the hand reached the design requirement will be explained below:

PLA Plastic

PLA (Polylactic Acid) is selected from any other type of plastics because of availability of 3D printing process and low-cost manufacturing process. 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 Muscle Sensor (EMG):

The MyoWare Muscle Sensor from Advancer Technologies measures, filters, rectifies, and amplifies the electrical activity of a muscle

http://dx.doi.org/10.31364/SCIRJ/v9.i01.2021.P0121834

and produces an analog output signal that can be read by a micro-controller.

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 Hand Mechanism:

When the human wants to move his hand, his brain deliver signals to the muscles, then the muscle sensor read these 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.

The safety system for the patient:

To provide our patient more safety for this project and his life. There are three parts made to provide the safety:

1- Temperature sensor DHT11:

This sensor is provided to determine the temperature of internal system of the hand. If the temperature of the hand exceeds a certain degree, the whole system will be closed.

2- Temperature sensor LM35 and Heart Beat Sensor:

These sensors are provided to determine the temperature and the pulses rate of the human to send it as medical record for the doctor through the application.

The ESP8266 Module:

This module was used in the project to receive data provided by the Arduino. After that, it is connected to Wi-Fi network and sends the data to the website “things speak’’.

V. RESULTS:

At the beginning, the hand may pass through a negative result, as there will be a huge lag time between the action of the body and the reaction of the hand, a problem with holding objects, and a lag time between the code used to send the data between the Wi-Fi module and the website. After improvements on the code and constructing, the hand perfectly achieved its purpose. To test the efficiency of the hand, it will be passed through a lag test. This test will determine the functionality and speed of the artificial limb receiving signals. In addition to, the flexibility and movement of the hand After determining the materials used, the mass of the prototype is 315 grams. This indicates huge success in decreasing the weight of the limb, nearly to the quarter, where the traditional limb weighs about 900 grams.

VI. CONCLUSION:

Achieving the design requirement, the solution’s results, and analysis have all showed that the prototype is the one that can be applied to use Internet of things to successfully solve a challenge hinders that destroys lives of numerous people. 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 99% and these children can now do the daily jobs with cost as low as $80 and the web application was used to ensure the safety of the hand and the users. Even more, the hand is an optimal one with mass of about 315 grams only, and it provides low lag between given signals. The solution is one that clearly uses affordable, efficient and light materials that approaches the design requirement and certainly provides a solution that uses IoT and connects two systems to aid with the health systems challenge.

VII. REFERENCE:

1. Gregory-Dean, A. (1991). Amputations: statistics and trends. *Annals of the royal college of Surgeons of England*, *73*(3), 137.
2. M. C. Carrozza, B. Massa, S. Micera, R. Lazzarini, M. Zecca and P. Dario, "The development of a novel prosthetic hand-ongoing research and preliminary results," in IEEE/ASME Transactions on Mechatronics, vol. 7, no. 2, pp. 108-114, June 2002, doi: 10.1109/TMECH.2002.1011247.
3. J. Mesquita, D. Guimarães, C. Pereira, F. Santos and L. Almeida, "Assessing the ESP8266 WiFi module for the Internet of Things," 2018 IEEE 23rd International Conference on Emerging Technologies and Factory Automation (ETFA), Turin, 2018, pp. 784-791, doi: 10.1109/ETFA.2018.8502562.
4. Tyler, B., Gullotti, D., Mangraviti, A., Utsuki, T., & Brem, H. (2016). Polylactic acid (PLA) controlled delivery carriers for biomedical applications. *Advanced Drug Delivery Reviews*, *107*, 163-175.
5. Fraser, H., Biondich, P., Moodley, D., Choi, S., Mamlin, B., & Szolovits, P. (2005). Implementing electronic medical record systems in developing countries. *Journal of Innovation in Health Informatics*, *13*(2), 83-95.
6. Price, A. D. (2006). *Biologically inspired dexterous robot hand actuated by smart material based artificial muscles* (Doctoral dissertation, University of Ottawa (Canada)).

http://dx.doi.org/10.31364/SCIRJ/v9.i01.2021.P0121834