STUDY, ANALYSIS, THE VIBRATION AND STABILITY FOR THE ARTIFICIAL HAND DURING ITS DAILY WORKING

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ABSTRACT

The recent events in Iraq draw attention to the upper limb field due to the increase in number of amputees and it becomes necessary to increase researches in this field to help reduce the suffering of patients. Upper limb prostheses are devices designed to replace a missing part of the arm that can be either functional or cosmetic. This paper proposes constructed the prosthetic hand is constructed by the 3D printing technique from resin and Polylactic acid. The prosthetic hand model have five fingers which are under the actuated prosthetic hand with the palm and socket that possess 10 degree of freedom in which each finger in controlled by single motor to allow the flexion and extension of fingers. The different components were separately built and then assembled. It will be actuated by servo motors located inside the palm with tendons and pulleys. The tendons are flouracardon tendons mainly made from fishing line that will be used to transfer the motion between the motor and the corresponding finger. The whole system will be controlled by the EMG signal collected from the upper limb muscles. The signals will be collected using muscle sensor (Myoware muscle sensor) located on the surface skin of the arm and the whole system will be controlled by microcontroller (Atmega2560). The residual limb test showed a promising ability of working with the proposed design of the prosthetic hand. The EMG signal recorded is valuable that has a clear, located threshold value that can control the prosthetic hand and the prosthetic hand was able to produce number of movement’s gesture and grasping some objects.

KEYWORDS: Prosthetic hand; Bebionic hand; 3D printing; EMG.


http://www.iaeme.com/IJMET/issues.asp?JType=IJMET&VType=09&IType=13

1. INTRODUCTION

Prosthesis is an artificial device that replaces a part of the human body which is missing because of disease, damage or disfigurement. The plan and development of any prosthesis depend both
on the many-sided quality of the body part being supplanted and rehabilitative necessities of the prosthesis client [1]. Upper limb prostheses are set for those individuals who have either part or whole upper limb absence, which may either be acquired (through amputation) or inborn.

The human hand is an amazingly complex set of mechanisms. It can be said that the hand is the brain’s ultimate tool, and loss of even one of these amazing tools has a profound impact on a person’s life. The human hand has a full of 27 degrees of freedom which are created by 27 unique bones and 30 muscles [2]. Muscle groups include both extrinsic muscles that are located in the trunk of the forearm and inserted into the hand via tendons, and intrinsic muscles which originate and terminate within the anatomy of the hand itself.

In C. Pylatiuk at el, a new experimental hand prosthesis design is presented that differs from that of traditional prostheses. With the target of tending to patients prerequisites, usefulness was expanded and cosmetic prosthetic became more natural. By coordinating a water powered framework with 8 little fluidic actuators at the digit joints, diverse significant getting a handle on examples of regular daily existence can be performed [3].

In D.S.V. Bandara at el, an anthropomorphic transhumeral robotic arm prosthesis is proposed in this study. It is capable of generating fifteen degrees-of-freedom, seven active and eight passive. In order to realize wrist motions, a parallel manipulator-based mechanism is proposed. It simulates the human anatomical structure and generates motions in two axes [4].

In general the subject for prosthetic investigated from multi researchers with various parameters and geometry. There, first at 2011, M. J. Jweeg et. al, [5], investigated the life and dorsiflexion angle for ankle foot with various materials used. Then, at 2012, M. J. Jweeg et. al, [6], studied the fatigue and creep behavior for socket below knee with various materials parameters effect. After this, at same year B. A. Bedaiwi et. al, [7], studied the vibration behavior for below knee prosthesis by using experimental technique. Also, at 2013, A. M. Takhakh et. al, [8], investigation the vibration behavior for knee ankle foot with various materials effect. After this, at 2014, investigated the impact behavior of prosthetic lower limb with various laminated effect, by J. S. Chiad, [9]. Also, at same year, S. H. Bakhy, [10], modeled the distribution for contact pressure of soft fingers robotic. Then after this at 2017, M. J. Jweeg et. al, [11], Investigated the stress of Syme’s prosthetics with opening effect. Also, at same year, M. A. Al-Shammari et. al, [12], studied the stress analysis for knee prosthesis, in addition to, the characterization for materials used. also, Z. Y. hussien et. al, [13], investigation, at same year, the effect for ultraviolet radiation on the fatigue of below knee sockets.

Then, at 2018, multi researchers investigation the prosthetic part with various parameters effect, as, M. R. Ismail et. al, [14], analyzed the biomechanical of braced legs by using mathematical model. S. M. Abbas et. al, [15-17], investigated the fatigue for foot and the manufacturing of socket with various materials used. Then, M. J. Jweeg et. al, [18-19], analysis the effect of temperature on the new prosthetic foot design, in addition to, investigated the optimized for sockets. Also, A. M. Takhakh et. al, [20-22], studied the partial foot, knee foot, and the below knee prosthetic with various materials parameters effect. F. M. Kadhim et. al, [23], investigated the knee joint with smart transfemoral prosthetic. Also, A. K. Abdulameer et. al, [24], analysis the fatigue behavior for Syme’s prosthesis with various materials characteristics effect. After this, L. E. Yousif et. al, [25], investigated the effect of temperature on the mechanical characterizations for new design foot. Then, by using photo elasticity technique and numerical method, analyzed the stress distribution for knee joint, N. D. Yaseen, [26]. Finally, J. K. Oleiwi et. al, [27], investigated the lower limb, made from composite polymer, by using numerical and experimental techniques. Then, in this paper, design the bebionic prosthetic hand by using EMG.
2. METHODOLOGY

2.1. Geometry Design

This part will explain the geometry design procedure used to design a mechanical function for prosthetic hand, the design of prosthetic hand draw by using Solidwrok, Since solidworks is introduced, it has been a great tool to every engineer who is interested in designing. It is a complete Cad package that offers modeling of complicated structure as parts the first part to design was a finger.

In figure the distal phalange exists a hitch in back who the tendon pull up the finger, while the proximal and middle phalanges are rigidly connected in one phalange. A link between the servo motor and phalanges (distal interphalangeal) (DIP) and metacarpophalangeal (MCP) by tendon wire extend form palm to phalanges, when servo motor pull the tendon the distal move up and linked with metacarpophalangeal (MCP) by pin and the metacarpophalangeal (MCP) linked with palm. This mechanism mimics the human hand motion when grasping as shown in figure (1).

In thumb there are three parts design of the thumb represent the three bones of natural thumb and color red and green represent as tendon of the thumb. The hinge in design thumb make the abduction and adduction movement is very smooth, the servo motor in the palm pull up the thumb to gripping objects as shown in figure (2).

The palm divided to tow region one handling little, ring, middle, index and another one handling the thumb, these divided part Work is similar to the human hand and it help to grip object. The bottom of palm is protected by a cover screwed by a small bolt to prevent the components from falling as shown in figure (3).

The socket design for prosthetic to give prosthetic hand a capable of wearing to help the patient to control on prosthetic hand by different way, the socket design consist of one parts is join with ambition upper limb, as shown in Figure (4).

Figure 1: index finger with tendon mechanism
Figure 2: design of thumb

Figure 3: the palm of the designed hand.

Figure 4: Socket of hand
2.2. Prosthetic Hand manufacture

The prosthetic hand was executed by 3d printing, which is a method to construct almost any computer aided design (CAD) model using thermoplastics such as the ABS, PLA, and SLA. The 3D printing technique is so simple; the printer requires the user only to input the thermoplastic filament and the file to be printed. As long as there exist filament enough for the print, the printer will operate for the duration of the print by its own [28].

The 3D printer that used was Union Tech stereolithography 3D Printing machine and the designed prosthetic hand was printed in china by Shanghai Union Tech company [29]. The palm was made of resin which meet the requirement of the application which are light in weight while remaining stiff and easily mountable. The socket was made of PLA by normal 3d printer by the use of FDM (Fused deposition molding) technology which works by using a filament or metal wire unwound from a coil and supplies the material to an extrusion nozzle which turn the flow on and off.

Each finger of the prosthetic hand is actuated by a servo motor located at the palm. The servo motors used are (Tower mg90) for fingers actuation shown in Figure (6). The proposed design of the hand was interred in the printer software and the parts were printed. The implementation of the proposed design was interred in the printer software and the parts were printed. Each finger is composed of two parts with pin and spring at each joint as shown in Figure (7). The printing technique promises a very high accuracy when it comes to dimension; i.e., there was not much difference between the final shape dimensions and the cad design.

The parts that connected together and fastened by pins which were metal screws with the end removed. Figure (8) shows the finger in its final assembly. The palm on the other side was printed as two part as designed. The fingers were connected to the palm in a very easy, in simple way; all parts are fitted together without noticeable clearance. Figure (9) shows the final shape of the palm and finger with tendons inside. The socket is connect to the amputated arm as show in Fig. (10).

![Figure 5: complete assembly design](image)

![Figure 6: Servo Motors inside the palm](image)
Figure 7: Parts of each finger

Figure 8: Assembly of the finger

Figure 9: Palm and the fingers of hand
2.3. Setup the Control System

The complete control system is shown in Figure (11). The Complete Control System is composed mainly of muscle sensor, microcontroller and servo shield. The shield is responsible to work as a connection part that supplies the power for the servos from a traditional 5V battery and connects the servos data wire to the microcontroller pins in the hand. The electrodes are placed on the surface of the skin on a located, the microcontroller and shield is powered with 5V battery each as shown in Figure 12. The complete hand design with the control system is presented.

3. RESULTS AND DISCUSSION

The result shows the capable movement of modified bebionic of prosthetic hands dealing with object compared with original bebionic prosthetic hand: gripping and released objects.
3.1. Bebionic hand

![Figure 13](bebionic-hand-movement.jpg)

**Figure (13)** bebionic hand movement

3.2. Modified bebionic hand

![Modified bebionic hand](modified-bebionic-hand.jpg)

3.2. Modified bebionic hand
4. CONCLUSIONS

The modified bebionic prosthetic hand designed approximate the function abilities of bebionic prosthetic hand very well. A number of movements are produced and number of variety objects can be grasped and can wearable from disable person in a natural way. The five fingers have 10 degrees of freedom driven by five actuators which enables the movements of each finger independently which offers more manipulation abilities. The kinematic motion analysis of the finger showed that: the fingers is not overlapping between them except the thumb In order to get the best gripping of object wit out slipping.

REFERENCES

International Mechanical Engineering Congress and Exposition IMECE2013, November 15-21, San Diego, California, USA, 2013.


Study, Analysis, the Vibration and Stability for the Artificial Hand During its Daily Working


