Improved Prosthetic Myoelectric Affordable Hand Design Sensitivity of an Open-Source

Abdullah J. H. Al Gizi, Hussein Togun

Abstract: Design and manufacture of tact hand an anthropomorphic, open-source(O-S), Myoelectric Prosthetic Hand (MPH) using persons with transradial amputations in emerging states are presented in this paper. The process of designing dependent on combining workability cost, performance, durability and effectiveness and then manufacturing by using the technology of 3D-printed(3D-P). The results showed that reduces in fatigue and pain caused by mass distributing to smoother tissues due to use materials are lighter and hollow instead of rigid injection molded plastic materials. Also improving in efficiency of performance represented by rotate and other movements in comparison with commercial sample. We label our diagram process, estimate the Sensitivity hand with together qualitative and measurable events of enactment, and show samples of the use of this hand to grip domestic objects.

Keywords: O-S, MPH, 3D-P.

I. INTRODUCTION

O
er the last little decades, there have been countless strides in the growth of novel prosthetic hands and terminal devices that take benefit of the latest technical improvements, moving in the direction of more expert, realistic hand devices. However, there is still a countless gap among the present state of the art and devices that have the perfect mixture of being highly useful, durable, cosmetic, and inexpensive. [1-3] are proposed the prosthetic hand has dense construction with 5 fingers and 4 Degree of Freedoms (DoFs) driven by 4 self-governing actuators. In this paper we set into view a review of presentation characteristics for both shared commercial prosthetics as well as anthropomorphic investigation devices[4]. While the functionality of myoelectric prosthetic hands (MPH) continues to increase, body-powered terminal devices continue to be preferred by upper-limb amputees[5]. The first portion of this paper labels the growth of a humanoid robot hand based on an endoskeleton made of unbending links linked with elastic hinges, activated by sheath routed tendons and enclosed by continuous acquiescent pulps[6]. This paper presents the mechatronic plan of an anthropomorphic 16 step of freedom, 4 step of flexibility prosthetic hand for usage by transradial amputees. Simple grippers with one or two steps of freedom are commercially obtainable prosthetic hands; these pinch type devices cannot knowledge small cylinders and spheres owing to their small step of freedom[7]. This paper presents a novel advanced multisensory five-fingered dexterous automaton hand: the DLR/HIT Hand II. The hand has an self-governing palm and five indistinguishable segmental fingers, each finger has three DOFs and four joints.[8] This paper presents an anthropomorphic prototype hand prostheses that is intended for use with a multiple-channel myoelectric interface. This paper describes the mechanical features of an experimental, multiple finger, prosthetic hand which has been designed for children in the 7–11 year age group[9]. This research concentration on an groundbreaking approach for the project and advance of prosthetic hands founded on under actuated mechanisms[10], [7,8]. The functional performance of currently available body-powered prostheses is unknown.[11] This paper presents the motorized project and employment aspects of the MANUS-HAND project to advance a multifunctional upper limb prosthesis. This paper presents the mechanical design and manipulation aspects of the MANUS-HAND project to advance a multifunctional better limb prosthesis.[12]. Adaptive sliding mode and essential sliding mode clutched object slip deterrence regulators are applied for a prosthetic hand and likened to a proportional derivative(PD) [13],[14] Children with hand reductions, whether congenital or traumatic, have unique prosthetic needs. [15, 16]are proposed the Project of a myoelectric prosthetic hand that contents the prospects of those who inappropriately lost a hand is deliberated. The higher limb amputations effects are deep because of a person’s hands are tools for everyday operative, expressive announcement, and other human needs [17],[18] Natural control methods based on surface electromyography and pattern recognition are promising for hand prosthetics. However, the control robustness offered by scientific research is still not sufficient for many real life applications. Shallow EMGs have been the main foundations for mechanism of prosthetic hands due to their ease and unaffectedness. The current advances in the progress of the prosthetic hands with numerous grades of liberty and numerous actuators, needs many EMG stations [19]. This hand competitions or surpasses the presentation of additional state-of-the-art MPH, but charges two instructions of greatness less ($250) and is informal to production with off-the-shelf parts and a 3D-printer [20]. A superficial electromyogram (EMG), which events a voltage waveform produced by skeletal muscles on skin, is an significant tool for requests sensing the human will of motion, such as upper or lower limb [21].

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In this study, a great variety of digit gestures are distinguished founded on the varieties of the weight delivery shaped by the motorized movements of muscles on the prepare[22]. [23] The higher coste constrains the usage of these devices in developing countries that have an unmet request for prostheses. The objective of our paper is to design and manufacture of tact hand an anthropomorphic, O-S, MPH with lower coste by using technology of 3D-printed to enable the people suffers from hand amputation in developing countries to use it.

II. METHODOLOGY

A. The producer of design
We designed the prosthesis system in a systematic way by combining workability Cost, performance, durability and effectiveness. Where the purpose of the design is to encounter the wants of the handicapped in emerging and poor countries so that the current industrial electrical device is supposed to be affordable to all while maintaining a similar performance as the real muscular limbs. The O-S, reasonable, MPH as shown in Fig.1

Fig. 1.Sensitivity: the O-S, reasonable, MPH.

B. 3D Printing
Laser toner container offers an excellent printing feature as shown in Fig.2. It gives a dependable enactment with a low printing fee, therefore it is the finest choice for broad printing necessity. These are mostly used for printing expert documents, though they can be a rummage-sale for both inhabited and profitable drives. So as to upsurge the superiority of prints, now carbon powder is mixed with the polymer. Color printers, Laser Toners derive in a set of four colors. The color arrangement is set by mixing Magenta, Yellow, Cyan, and Black colors. Toner Containers for laser printers are mostly used in workplaces and for profitable purposes.

C. Manufacturing sample
This type is important because a severe shortage due to the large number of missing limbs and prosthesis requires that the device be easily, cheaply and highly repeatable when used by anyone who needs it. As the design is durable, it is easy to design with common components, and it can be repaired. Further efficiency improvements have been made in designing robustness, cost, responsiveness and user-friendliness to encounter the wants of emerging countries. In order to improve affordability, show, and manufacturing capacity using common components, special consideration has been given to the choice of motors that are used, the operating method, the end joint, the assembly procedure, and the joint method. This is by comparing the motors in profitable prostheses with lower cost motors to decide if motors can provide appropriate torque. The co-operation method has been basic to consist of a DC motorized with a pulley rather using a fully stringed. The DC motor run a cable that was straight paired with the customer for output. All the end parts are designed to be grouped into two sets of pieces. Where only one part must be attached or devoted at a time during assemblage. In order to avoid this intricate interlocking process requiring hands. Whereas, the use of a four-strip linkage as a common coupling method in order to produce stable motion and greater strength at the tip. These design choices are made based on durability and effectiveness due to the lack of non-retractable gears, high-strength apparatuses and accuracy parts as shown in the Fig.3 whereas the Sensitivity finger (a) inflexed and A kinematic prototype of the finger combined coupler machinery as displayed in (b). (c) Demonstrating flexion compliance. Research that has developed an evaluation of the show stipulations of prosthetics urges a comparison with the latest findings of researchers [24]; and also the open-source artificial hand, dextrose [24, 25]. A new model of commercial hands specification has been widely proposed by Belter et al. [26]And also through the data published by the relevant developers researchers, which include these specifications,
kinetic properties, kinetic specifications, speed, strength, and general physical properties. As for the general physical properties, it depends on our mass and volume comparisons, the number of motors, the operating method, the number of joints, the number of DOFs, and the combined link technique for every of the prostheses. Where the mass of every hand was measured and noted where width, thickness and volume dimensions of length were measured. Whole number of connections in each artificial limb was determined in order to limit the resemblances in the construction in operation and also the numeral of DOFs and actuators used to device's evaluate functions was calculated. Since the method of operation often indicates the amount of the cost of the hand, and may require an increase in expensive costs or a similar method of transmission. Where the joint joint method was clarified to distinguish the modifications in the ways of connecting the junctions in the hand, which can touch the quality and work of consistency in holding things compared to the motor characteristics of these hands. To measure the quality of performance and dexterity in the hands, we measured the range of movement. We measured the range of motion and the extent of dexterity in the hands, we measured the range of gesture of the comb battalions (MCP), the proximal phalanges (PIP), and the distal phalanges (DIP). Meanwhile Sensitivity and deft take account of an engine for thumb giving, this array of gesture has also been verified. So as to reduction the cost of our hands, we had to choose a careful drive to upsurge the subsequent torque at a low cost while upholding a sensible mass and temperature sensing.

Fig. 3. The Sensitivity finger (a) inflexed and A kinematic archetypal of the finger joint coupler mechanism is displayed in (b). (c) Demonstrating flexion compliance.

Dexterous and Sensitivity enjoy a host of hand-motion, MCP and PIP and junctures ( seeTable II). Dexterous is one (hand) which has a static DIP connection, by DIP junctures designed for an angle of nearly 20 °. The bundle and Dexterous range of motion were slightly increased to excrete circumcision and thumb. The thumb axis was parallel to both hands and the wrist axis, as make straightforward the thumb movement for the period of the multiple grip of the trigger such as the three-jaw envelope, holding the keys and the pinch, which simplifies the implementation of holding the thumb matching to further moving parts. The intelligent hand to attain strength, adjacent sides, accuracy, and fixed points, as clear by classification recommended [27]. The engines that drive the industrial hand that enable access to size ,torque and appropriate group info. The nominal current and voltage required for the motor drive that enable us to calculate the energy consumed by it, which made it possible to calculate the efficiency of almost every engine when producing torque in order to obtain consistent movement [28] [29], [30] and compared them precisely with other researchers. Whereas, the engine torque and transmissions are the primary and primary responsibility for finger tying strength, flexion and extension speeds. We have followed the methods of Palter et al. [30] A fully extended loading, calibration and finger cell was fixed and fixed to guide the finger even when the sensitive touched the load cell. The finger move was tested, the resultant constant force was detailed and the initial rise in force was eliminated until we got to a steady level and this dynamism was detailed. And record an experiment for both Sensitivity and Dexterous fingers and temperature sensor. Sensitivity (used the optical encoder) and Dexterous motors to accouter the time obligatory to completely bend finger from 0-90. Meanwhile variety of motion of junctures was recognized, this led to the calculation of velocity in different degrees per second for flexing and extending the finger. In order to verify the hand's ability to perform the required functional tasks, we tested whether Sensitivity can accommodate and accommodate the ability to perform a variety of household purposes (water bottle, bottle cap, wireless drill, key), some of which were proposed as practical things by Klopsteg and others and also the temperature sensor. [21]. In addition, recognizing the EMG pattern for switching between a group of constipation showed that the pulp's ability to use it as an electro-muscle prosthesting using it

III. RESULTS AND ANALYZING THE GENERAL SPECIFICATIONS OF DESIGN

By analyzing the general specifications to the hands shown in Table I, the Sensitivity mass was 17-43% lighter compared to other types. The length and width of Sensitivity are within the same boundaries as other hand models. However, the Sensitivity is only 27mm thick, which is well below the (41-50)mm variation aimed at the break of plans. Number of joints for completely hands except for Dexterous is alike, with joints in Dexterous increasing due to the ability of the DIP joint to switch. Altogether hands have 6 DOFs, one for every finger plus thumb and circumcision is allocated. It all contains one trigger per finger with Sensitivity, Dexterous, i-LIMB and Vincent as well as additional thumb circumcision trigger. Using DC motor spools to treat tendons, and the operating methods of these hands vary according to Sensitivity and Dexterous. Vincent and other researchers usage a direct current motor in union by oblique and worm gears. Bebionic& Bebionic v2 handles usage a direct current motor with nails or lead screws to create a practice right actuator. Where using these dedicated gears in commercial hands will increase the cost, Dexterous and Sensitivity have a variety of motion similar to profitable hands of PIP and MCP junctions in the Table. II.
Dexterous is the lone hand tip that does not have a immovable DIP jumper, with DIP junctions designed for altogether at an angle of about 20. Sensitivity and Dexterous had a slightly greater than before range of motion for flexing circumscription and thumbs. The axis of the wrist with the axis of the thumb on all hands was parallel. This makes it easier to move your thumb while holding multiple fingers like holding the key, three-jaw envelope, and precise pressure, which simplifies the implementation of the thumb by insertion the thumb in a level matching to additional moving fingers. Every hand is talented to attain precision, strength, lateral side, finger and hook points, as clear by catchment classification suggested by Cutkosky [27].

Muscular electric hand requires size constraints in anthropomorphic and require some type of small motor and gear to produce enough power for ADLs. By comparison of the engine combination and the [24] i-LIMB (2009) pulse gearbox to that of Sensitivity in the Table. III., we discovery a alike torque output of (0.15Nm &0.14 Nm), correspondingly. By growing the insignificant voltage and stalling current drawn by the pulse i-LIMB / i-LIMB and Sensitivity, we discovery alike power desires for (3.6W & 4.1W), correspondingly. Though, during enactment with power needs are identical amid the motors used in the [24] i-LIMB (2009) Pulse & Sensitivity, the cost varies greatly with the mass and size of the electric motor. Inappropriately, because of the lack of info on the bionic, the (Bionic v2, & Vincent), it is difficult to make comparisons of those hands. Dexterous and Sensitivity's finger flexion / stretching speed exceeds the range of trading tips, with efficiency more than repetition the fastest trading hand in the Table IV. The resulting strength at the tip of the finger is inside the variety of forces generated by the profitable hands. The Dex-Truss hand of similar results might not estimate much lower than the comparative strength of hands. Where the functional benefit of using the hand to illustrate a variety of household items was shown as in Fig. 4. The tip was easily able to understand things like the water bottle and bottle cap, and the using a 3-jaw chuck, key grip, tool grip. These procedures require little or no help. Good tasks of holding a battery was using a micro-pinchn and compound due to the stain a plastic surface on the fingertips. These hardships can be minimized by using liquid rubber or adhesives to the fingertips. By means of electro-muscular controller, users have positively implemented these numerous understandings by a recognition pattern.

### Table I: General characteristics

| The paper No. | Creator | The Mass (g) | Dimensions (Long x Width xThickness mm) | No. of junctures | DOF | No. of actuators | DC Motor Actuation mode | Combined connector mode |
|---------------|---------|-------------|----------------------------------------|-----------------|-----|-----------------|------------------------|------------------------|
| 2015[23]      | University of Illinois | 350 | 200 x 98 x 27 | 11 | 6 | 6 | Tendons | Linkage Spanning MCP to PIP |
| (2010)[24]    | Touch Bionics | 460-465 | 180-182 x 75-80 x 35-45 | 11 | 6 | 5 | Worm Gear | |
| (2011) [29]   | RSL Steeper | 495-539 | 190-200 x 84-92 x 50 | 11 | 6 | 5 | Lead Screw | |
| Sensitivity   | Open Hand Project by technical collage | 450 | 205 x 88 x 45 | 15 | 6 | 6 | Tendons with temperature sensor | Tendon and free-spinning pulleys |

### Table II: Characteristics of Kinematic

| The paper No. | Mcp-Joints (Deg) | Pip-Joints (Deg) | Dip-Joints (Deg) | Thumb-Flexion (Deg) | Thumb- Circumduction (Deg) |
|---------------|-----------------|-----------------|-----------------|---------------------|--------------------------|
| Dexterous[2011][23] | 0-90 | 0-90 | 0-90 | 0-60 | 0-95 |
| i-LIMB (2009)[24] | 0-90 | 0-90 | 20 | 0-60 | 0-95 |
| Bionics (2011)[29] | 0-90 | Oct-90 | 20 | | 0-68 |
| Sensitivity | 0-90 | 20-90 | 20 | 0-90 | 0-95 |
IV. RESULT DISCUSSION AND COMPARATIVE WITH OTHER FINDING

The human hand has a typical mass 400 g [24], which stretches a common sense of the practical aspects of the artificial hand as a limb by comparing the physical properties of prosthetics. The people who use it are responsible for describing prosthetic devices around this block of perceptions that they are too heavy [25]. Because of the mass of the prosthesis that is used with the soft tissues of the limbs and not straight to the skeletal this collective spreading is directly or indirectly contributing to the feeling of discomfort and fatigue when working prosthetic devices. Prosthetic mass 450g, a little more than 400g a human hand block and a range of 420-615g for hands. Comparison. The main reason for lightness and agility is the use of 3Dprinted. The materials that are used in 3D printing as a basic method of manufacture using mostly lighter and hollow materials instead of rigid injection molded plastic materials use plastic bodies, and Minerals or compounds with a low mass, Sensitivity can more likely reduce fatigue and pain caused by mass distributing to smoother tissues. Regarding the size, Sensitivity both fall into the width, length and thickness of the two comparison hands. Sensitivity is 34–46% thinner at 45 mm thick. Comparative hands range from 41 to 50 mm, which reduces mass and interference when holding things. The hand with Dexterous, i-LIMB and Vincent Hand has a thumb drive for your thumb drive. This enables it to have an absorbing property and the ability to change between holding the thumb in multiple locations [14]. This made the thumb an acronym for artificial limb control and pattern recognition. Multichannel EMG is used, as the thumb will severely limit the user’s capabilities with swapping speeds between them. It is important to note when implemented by various means that all verified hands have an adaptive grip. It is integrated into Dexterous, i-LIMB and i-LIMB Pulse. Vincent's hand uses unique curves in connectors that permit the finger to be done as a flexible hand through the spring and tendons system. Elements in the series [14]. In Sensitivity hand, Pep Jun, and Jun Jun hands v2 adjustment grasp are applied with the flexible band mechanic. This technique do not ask for any extra parts or costs. The adaptive grip increases the strength of the hand, as extreme force just flexes the finger instead of shaving gears or harmful bonds. Her matina finger finger convergence MCP and PIP joints all hands compared except Dexterous. As the joint is secure in altogether of these hands to advance transmission and increase rotation quality as of the engine to the finger. Fix and improve this common, as it decreases the cost and difficulty moving of the finger.

Table- III. Motor specification

| The paper No. | Motor-model | Transformation Ratio of Gearbox | Rated Voltage (V) | Rated Current (A) | Watts (J) | Rated Torque (Nm) | Motor-Cost (USD) | Dimensions | Mass (grams) |
|---------------|-------------|---------------------------------|-------------------|------------------|---------|------------------|-----------------|------------|-------------|
| Dexterous (2013)[23 ] | Escap-16G-214E-MR 19 | 64:1 | 12 | 0.30 | 3.60 | 0.1430 | 13.950 | 16 Diameter(m m), 52 Length(mm) | 38 |
| Sensitivity | ESCAP-16 Coreless (DC 12V) 540RPM Gear Motor With Encoder(16MM) | Diameter(m m)16 Length(mm) 17 | 12 | 0.3 | 3.6 | 0.143 | 13.95 | 16 Diameter(m m), 27 Length(mm) | 38 |

Table- IV. Separate finger speed and holding force at tip

| Finger types | Speed Avg. (◦/s) | Force Avg. (N) |
|--------------|------------------|----------------|
| Tact | 249.8 | 4.21 |
| Dexterous | 175.4 | 1.71 |
| i-LIMB types | | |
| Large (middle) | 81.8 | 7.66 |
| Med (index/ring) | 95.3 | 5.39 |
| Small (little) | 95.4 | 5.17 |
| Pulse Med (index) | 60.5 | 4.15 |
| Pulse Large (middle) | 60.5 | 3.09 |
| Pulse Med (ring) | 74.3 | 6.43 |
| Pulse Small (little) | 82.2 | 4.09 |
| Bebionic types | | |
| (index) | 45.8 | 12.47 |
| (middle) | 45.8 | 12.25 |
| (ring) | 45.8 | 12.53 |
| Small (little) | 37.8 | 16.11 |
| v2 Large (ring, middle, and index) | 96.4 | 14.5 |
| Vincent types | | |
| Large (ring, middle, and index) | 103.3 | 4.82 |
| Small (little) | 87.9 | 3.00 |
| Sensitivity | 359.727 | 13.427 |

Fig. 4. The Sensitivity hand cases of household objects. (1) a battery tweak grip, (2) grip three-jaw chuck on the bottle cap, (3) a bottle control grip, (4) tool grip on a cordless drill, and (5) key grip.
Disobediently, the expert hand, usages a arrangement by a DIP combined that is permitted to alternate and also the arm is reductions the strength at the fingertip. The finger strength deft was underneath the profitable hand variety. The allowed DIP combined with tendon motivated proposal the Deft help to the phalangeal junctures to flex successively, resultant in an abnormal greedy gesture. In all other hands, PIP and MCP junctures the rotating gesture have a 4 bar connection immovable device. David,[14] suggested the employment of 4 bar connection generates a alteration in PIP cooperative and alteration in the MCP, terminating the fingers a reliable and usual style. To attain motorized presentation similar the paper suggested minor cost, we used a motor with a higher diameter (16mm for 10mm) and also nearly dual mass (38g for 18g). It had better too be distinguished that the paper[24] usages a 1:1 bevel gear that drives, a tradition 25:1 larva gear groups off finger. The Sensitivity proposal usages a 3D printed, ABS plastic reel, that censorships and undoes intertwined strengthen cable devoted to the minor helping of the section amid the MCP and PIP linkages to bend and stretch forth the finger (Fig. 3c). Whereas this gearing leads to added expenditure it likewise styles the [24]non spinal driveable. All the cost-effective hands take in this design the finger to be laden deprived of system control. Sensitivity hand and Dexterous, are control essential be directed 98853069566 for the fingers to save back it. This deprived efficiency reductions the functioning interval of the expedient, need more frequent battery changes. We in this time originate design by low-cost actuators, rather a DC motorized without gearing. The review paper.,[25] the 100% of mature ladies, 76% of mature males, and 50% of kids who used prostheses hands labeled the speediness of their prostheses as too boring. Speediness required for a finger flexion, extension among 172-200 s [9], [26]. The motor elect progressive haste and inferior rotation to attain this favorite variety of speediness, but yet maintain a strength inside the variety of marketable hands. Whereas normal hand can reach speediness of 2290 s, this is in extra to the basic purposeful. The movement of finger prosthetic hand devices (flexion, extension) rapidity are variety between 37.8-103.3 s. The speed response among preferred and real presentation of prosthetic hands gives our the good interpretation about the design quality. The Sensitivity prosthetic hand with an regular (flexion, extension) speed of 249.8 s lets for speeds superior than the preferred 172-200 s. The rapidity can be controlled automatically to deliver favorite rapidity, charitable the Sensitivity a more accepted skill. The cost of resources to construct the Sensitivity prosthetic hand less than $100, with the electric motor involving nearly $70 of this quantity. The use of electronic and machine driven parts and 3D printing technology reductions cost and improvement manufacturability. While O-S 3D printed prosthetic hands such offer reasonable prostheses to emerging states, the scheme guidelines comprehensive in our paper can be used to decrease price, manufacturability marketable. On the other hand Sensitivity prosthetic hand lessens the price of mechanisms, reductions industrialized time, make available reliable actions, and creates superior finger force. Reduced production time to 10 hours and the aggregation time to 2 hours. The design made the Sensitivity prosthetic hand accessible to all who need it.

V. CONCLUSION

We have developing an O-S muscular muscular prosthetic device with high efficiency, lower cost, lower maintenance, and easy and O-S design designed for people with upper limb amputations, we are dealing with various accidents, wars and diseases that lead to permanent limb loss. We have clarified the design process in detail and comparison with the types and models proposed by researchers through the detailing of the design process and we have expressed that Sensitivity meets or exceeds performance compared to current muscular and electric prostheses and can be easily manufactured. Where 3D printing and ready-made components were used, the Sensitivity can be brought to two orders of less size ($ 250) than comparable commercial hands. Made the prosthetic hand accessible accessible to all who need it, by providing parts and assembly orders.

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