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Design a Hand Robot Made by using 3D Printing

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Abstract: - Many studies carried out by researchers in the field of prosthetics have contributed to improving the lives of those who have lost limbs for whatever reason, and transforming their lives into a more natural and productive form in society after amputation problems lead the patient to withdraw and expose him to countless social problems. The importance of the research lies in Manufacture of a robotic hand using 3D printing, as a palm and five fingers were printed, each finger consists of three nodes connected to joints that can move through two strings, one to close the finger and the other to open the finger, as the two strings are connected to the servo motor to move each finger, and each motor takes the electrical signal from the Arduino Which receives the nerve signal from the amputated hand by means of the electrical signal sensor, the results obtained through pure research that the hand was manufactured with high efficiency, light weight and high response while receiving the brain signal to close and open the fingers for the purpose of lifting and moving objects with light weights to help Persons with special needs (amputated hands) from performing their daily tasks..

Keywords: Robotic hand, Receiving electrical signal, 3D printer.

I. INTRODUCTION

Evolution in the world has led to the emergence of what can repair and support parts of the body, in addition to the science that is responsible for replacing lost parts or organs of the body. The idea of prosthetic limbs began after World War II, when wood was the first material used to manufacture limbs and auxiliary devices, then some industrialized countries developed and manufactured them from plastic instead of wood, and later these limbs began to advance in terms of formality and mechanicalness. Now, prosthetic limbs are made of special, non-rusting materials that contain several elements such as aluminum and titanium, in addition to plastic and rubber. The computer is also used to manufacture and design prosthetic limbs and other auxiliary devices and to control them [1-2]. Many patients suffer from partial or complete loss of the ability to move their hands, and this loss of function can severely limit activities of daily living and make life difficult and painful for patients. Compensating the upper limbs that have been amputated or lost is one of the most important things to restore the function of the lost arm and hand [3-5]. Also, the robotic hand can continue in physical therapy, reducing the effort on medical personnel when a stroke occurs. Rehabilitation after a stroke requires labor-intensive and requires one-on-one manual interactions with therapists. Treatment protocols entail daily treatment for several weeks, which makes providing a very intensive treatment for it is difficult for all patients [6] therefore, a mechanic is required. Support this work automatically.

Many researchers have developed robotic devices for rehabilitation of the upper limbs [7-10] for replacement upper extremity (shoulder and elbow), or distal upper extremity (forearm and wrist). Many robotic rehabilitation systems have it. It was developed for the hand, which consists of exoskeletons that can move in multiple directions to perform different functions [11-16]. And these devices have a high cost and have a large weight, which makes it more difficult for people with special needs to use them.

An intelligent prosthetic hand refers to a hand that replicates the organic gestures of the human hand. To effectively emulate the movements of the human hand, a meticulous study of its natural motions is essential. For instance, examining the intricate rotations of the distal phalanx (fingertip) around its joint in conjunction with the rotation of the middle phalanx is crucial. Several papers also detail methods for achieving this replication.[17]. Nevertheless, bending the finger at the proximal joint while maintaining stiffness in the distal joint proves to be challenging and unnatural. The movements of these two joints are interconnected, necessitating synchronized motion. In contrast, the knuckle joint operates independently, enabling the entire finger to move without affecting the proximal or distal joints. Crafting a suitable knuckle for our robotic hand presents its own set of difficulties. An alternative method has also been proposed [18].

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The purpose of this paper is to manufacture a robotic hand using 3D printing of plastic material with five fingers and a palm that is controlled through brain directives by receiving the brain signal from the nerves of the severed hand and converting it into electrical signals for the purpose of moving the fingers, as it is very complex. It is of low cost, durability and light weight to help in performing functions and daily needs to replace the severed hand of the sick person.

II. RESEARCH METHODOLOGY

2.1 Anatomy of the human hand

The muscles that influence the hand can be categorized into two main groups: the extrinsic and intrinsic muscle groups. The extrinsic muscle groups consist of the long flexors and extensors. These muscles are termed "extrinsic" because their muscle bellies are situated in the forearm.. Its structure is shown at fig 1.

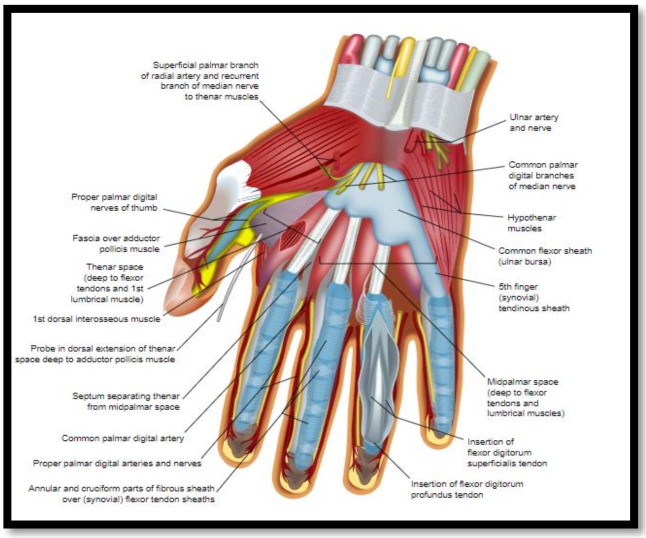

Fig 1: Muscles and other structures of wrist and palm.

One of the important anatomical parts that are responsible for closing and opening the fingers are the tendons, and they extend from the wrist to the inside of the finger, as they connect the muscles to the bones. It is characterized by being located on the inner side of the palm, where when it shrinks, it causes the finger to close, and when it expands, it causes the finger to open, and it prevents the fingers from bending and the palm and wrist outward. All of the tendons in the hand travel over the back of the wrist, and the extensor tendons pass through a series of tunnels called compartments. These compartments are lined with a slick substance called tenosynovium, which prevents friction as the extensor tendons slip inside. Its compartment integrity is so essential to our daily living. Our fingers are controlled by tendons attached to the muscles from the inside. This paper presents a simple method for making an artificial hand that humans can control through EEG or EMG signals; As a replacement part for a severed limb or can be used in a hazardous environment where the human hand cannot be used.[19]

2.2. Experimental part

The prosthetic limb was manufactured consisting of several elements, as the electrical signal is received from the severed arm by an EMG sensor, after that the received signal is transferred to a filter to filter the signal from noise, then the signal is transmitted after filtering to the Arduino for the purpose of processing it and controlling the servo motor for the purpose of shutting down Opening the fingers and all stages of signal transmission are carried out through the steps shown in Fig 2.

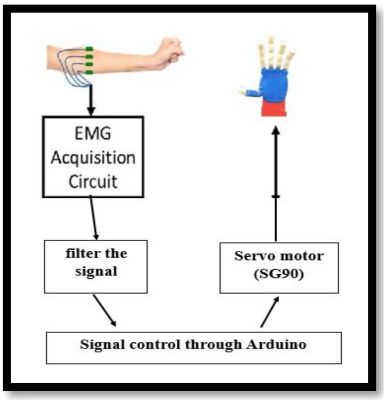

Fig 2: Block diagram of the proposed method for controlling prosthetic hands with raw EMG signals

The prosthetic hand was designed using (Solid Work) software and printed on a 3D printer. Fig 3 shows prosthetic hand.

Figure 3: prosthetic hand

The prosthesis consists of five fingers, the hand and elbow, with each finger having three nodes, and also contains two strings connected to a servo to control the closing and opening of each finger. The robot's finger movement controls the SG90 servo. It is small and light with high performance. servo motor can be rotated approximately 90 degrees in each direction.

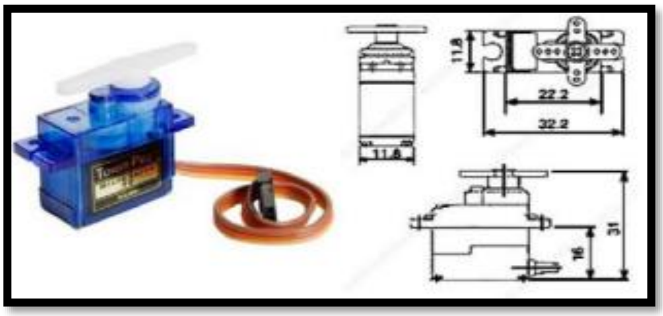

Fig 4: Servo motor (SG90)

That servo motor in Fig 4 has specifications as table 1.

Table 1: Specifications of servo motor (SG90)

Weight	9 g
Dimension:	22.2 x 11.8 x 31 mm
Stall torque	1.8 kgf·cm
Operating speed	0.1 s/60 degree
Operating voltage	4.8 V (~5V)
Dead band width	10 µs
Temperature range	0 ºC – 55 ºC

Fig 5 shows the method of receiving the electrical signal through the severed arm.

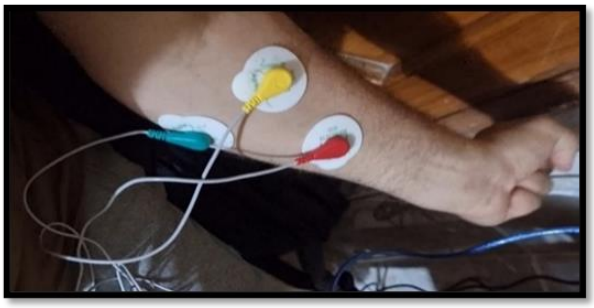

Fig 5: The method of receiving the electrical signal through the severed arm.

Fig 6 shows the presentation of the nerve signal received from the severed arm to be processed through a variable resistance and then sent to Arduino to rotate the servo motor to move the fingers.

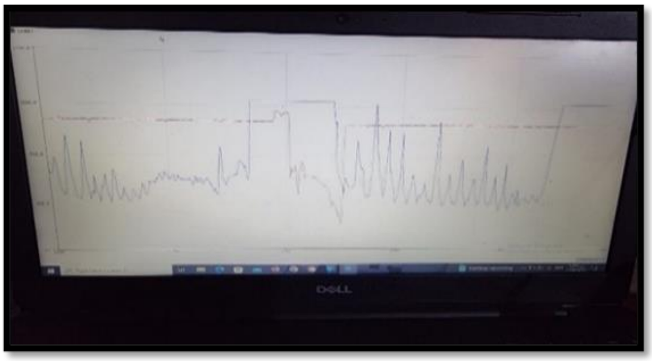

Fig 6: Receiving the electrical signal through the severed arm

III. EXPERIMENT RESULTS AND DISCUSSION

The fig 7 shows the prosthetic limb, as it consists of the fingers, the palm, the elbow, servo motors, Arduino, and the brain signal sensor.

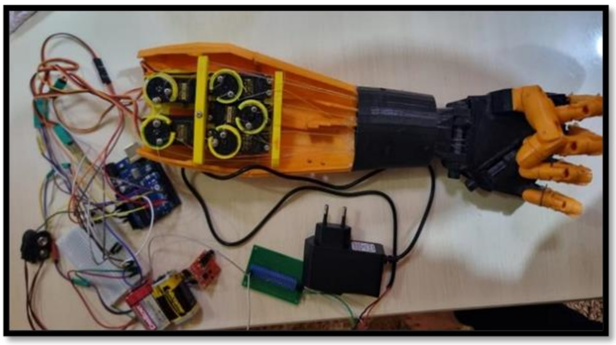

Fig 7: Hand robot components

The paper presents the design of a prosthetic hand and glove to control the prosthetic hand by receiving brain signals from the severed limb's nerves and processing them electronically with an Arduino and a variable resistor to use them to move the servos to move the fingers in a state relaxed or contracted. Arduino controlled servos are used to control the movement of the fingers on the wire. The finger is movable, presumably a real finger.

IV. CONCLUSION

The item features an innovative design and actuation system for a prosthetic hand. The actuation structure was shown to effectively spans two ranges of power to perform a pull configuration similar to those in base three human grips (power, grip and lateral). The project also demonstrated the ability to throw and film facility almost entirely pitched to exist in one launch system with very different types, without prejudice to the required dimensions, e.g., prosthesis weight. According to these results, a parallel boot structure is a good starting point for design. Also, the results confirmed that the project could be successfully operated by an EMG signal. Full parallel launch testing the performance of the system needs to be expanded to EMG inputs to perform various grips and manipulations.

V. FUTURE WORK

In the future, work will be done to increase the efficiency of the sensor used in receiving the nerve signal from the nerves of the severed limb, as well as using integrated circuits to reduce the cost, size and weight of the parts of the prosthesis.

REFERENCES

[1] Ingall T, ―Stroke--incidence, mortality, morbidity and risk, Journal of insurance medicine, 36(2), pp. 143-152, 2004.

[2] Prange GB, Jannink MJ, Groothuis-Oudshoorn CG, Hermens HJ, Ijzerman MJ, ―Systematic review of the effect of robot-aided therapy on recovery of the hemiparetic arm after stroke, Journal of Rehabilitation Research & Development, 43 (2), pp. 171-184, 2006.

[3] Barreca S, Wolf SL, Fasoli S, Bohannon R, ―Treatment interventions for the paretic upper limb of stroke survivors: a critical review,‖Neurorehabilitation and Neural Repair, 17(4); pp. 220-226, 2003.

[4] Feys HM, De Weerdt WJ, Selz BE, Cox Steck GA, Spichiger R, Vereeck CE, Putman KD, Van Hoydonck GA, ―Effect of a therapeutic intervention for the hemiplegic upper limb in the acute phase after stroke: a single-blind, randomized, controlled multicenter trial, Stroke,29(4); pp. 785-792, 1998.

[5] Kwakkel G, Wagenaar RC, Twisk JW, Lankhorst GJ, Koetsier JC. ―Intensity of leg and arm training after primary middle-cerebral-artery stroke: a randomised trial, Lancet, 354(9174), pp. 191-196, 1999.

[6] Krebs HI, Hogan N, Volpe BT, Aisen ML, Edelstein L, Diels C, ―Overview of clinical trials with MITMANUS: a robot-aided neuro-rehabilitation facility, Technol Health Care, 7(6), pp. 419-23, 1999.

[7] Reinkensmeyer DJ, Kahn LE, Averbuch M, McKennaCole A, Schmit BD, Rymer WZ, ―Understanding and treating arm movement impairment after chronic brain injury: progress with the ARM guide, Journal of Rehabilitation Research & Development, 37(6), pp. 653-662, 2000.

[8] Burgar CG, Lum PS, Shor PC, Machiel Van der Loos HF,―Development of robots for rehabilitation therapy: the Palo Alto VA/Stanford experience, Journal of Rehabilitation Research & Development, 37(6), pp. 663-73, 2000.

[9] Hesse S, Schulte-Tigges G, Konrad M, Bardeleben A, Werner C,―Robot-assisted arm trainer for the passive and active practice of bilateral forearm and wrist movements in hemiparetic subjects, Arch Phys Med Rehabil. 84(6), pp. 915-20, 2003.

[10] Susan C, Emma KS, ―Effect of robot-mediated therapy on upper extremity dysfunction post-stroke—a single case study, Physiotherapy, 91 (4), pp. 250–256, 2005.

[11] Panagiotis Polygerinos, Zheng Wang, Kevin C. Galloway, Robert J. Wood, Conor J. Walsh, ―Soft robotic glove for combined assistance and at-home rehabilitation, Robotics and Autonomous Systems, 73, pp. 135–143, 2015.

[12] Ueki S, Nishimoto Y, Abe M, Kawasaki H, Ito S, Ishigure Y, Mizumoto J, Ojika T,―Development of Virtual Reality Exercise of Hand Motion Assist Robot for Rehabilitation Therapy by Patient Self-Motion Control,‖ in: 30th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2008, EMBS 2008, 2008, pp. 4282–4285.

[13] N.G. Kutner, R. Zhang, A.J. Butler, S.L. Wolf, J.L. Alberts, ―Quality-of-life change associated with robotic-assisted therapy to improve hand motor function in patients with subacute stroke: a randomized clinical trial, Phys. Ther. 90, pp. 493–504, 2010.

[14] A. Polotto, F. Modulo, F. Flumian, Z.G. Xiao, P. Boscariol, C. Menon, ―Index finger rehabilitation/assistive device, in: 2012 4th IEEE RAS & EMBS International Conference on Biomedical Robotics and Biomechatronics, BioRob, pp. 1518– 1523,2012.

[15] M. Takagi, K. Iwata, Y. Takahashi, S. Yamamoto, H. Koyama, T. Komeda, ―Development of a grip aid system using air cylinders, in: IEEE International Conference on Robotics and Automation, ICRA‗09, pp. 2312-2317, 2009.

[16] K. Tadano, M. Akai, K. Kadota, K. Kawashima, Development of grip amplified glove using bi-articular mechanism with pneumatic artificial rubber muscle, in: 2010 IEEE International Conference on Robotics and Automation, ICRA, pp. 2363–2368, 2010.

[17] Peter Ohlmus, ―This Wooden Hand Can Teach You: Servo Control, Mechatronics, and Arduino Programming‖, online available at: http://www.servomagazine.com/index.php/magazine/i ssue/2015/08, August 2015

[18] EricoGuizzo, ―Building a Super Robust Robot Hand, 25 Jan 2011.

[19] Dawson-Amoah, K.; Varacallo, M. (2022). "Anatomy, Shoulder and Upper Limb, Hand Intrinsic Muscles". NCBI. PMID 30969632. Retrieved November 28, 2020.