ISSN (Online) 2395-2717
International Journal of Engineering Research in Electrical and Electronic Engineering (IJEREEE)
Vol 9, Issue 12, December 2022

A Review on Robotic Prosthetics for Restoring Mobility and Functionality of the Human Being

[1] Gaurang kulkarni, [2] Ashwinkumar Mahindrakar

[1] Student Dept. of Mechatronics & Automation Engineering MIT-ADT University Pune, India.
[2] Asst. Professor Dept. of Mechatronics & Automation Engineering MIT-ADT University Pune, India.
Corresponding Author Email: [1] gkulkarni248@gmail.com, [2] ashwinkumar.mahindrakar@mituniversity.edu.in

***Abstract*— The human body is a motor system with various bodily organs that function as motor units. The brain is the core control unit that links and controls all of the human components. In such cases, a person's loss of limb can be an extremely painful event. Prosthetic devices can restore some, if not all, of the wearer's movement and capability. These can include everything from oral prosthesis to limb prosthetics. Limbs are frequently amputated due to trauma, sickness, or a congenital defect. Amputations are becoming more common as a result of increased industrialization and a lack of understanding about safety criteria. The development of safer, simpler, and more automated prosthetic arms for controlling upper limbs is anticipated. In this paper the review on different types of prosthetics arm has been studied.**

***Keywords*—limb prosthetics, prosthetic devices, congenital defect.**

I. INTRODUCTION

The hands are the most important aspect of a person's daily existence. Even the loss or disappearance of one hand might alter how things typically operate. Amputees are those who have suffered such catastrophe. According to Approximately, between two and half people out of six billion have prosthetic arms. Few of these people are born without hands, while others may have lost a limb due to an accident or sickness. Amputations are most commonly caused by vascular disorders, diabetes, arterial disease, and malignancy. This illness can strike anyone at any time. The first prosthetic hand was invented around the turn of the twentieth century. Later, until the conclusion of World War II, proposals for producing myoelectrical prosthesis were developed [1]. In the late 1950s, these devices, which linearly converted the electrical activity of the remnant muscles of the stump into the velocity of griper closing and opening, began to be utilized in research facilities and offered on the market [2].

Recent research spanning the previous two decades have revealed substantial rejection rates of all types of upper limb prosthetic devices across a wide range of users [3-6]. While studying the population, rejection rates for myoelectrical devices range from 25% to > 50% and up to 35% for body-powered devices. However, these statistics have flattened out in comparison to past times [7-8], owing mostly to advances in technology. It is possible, though, that the tendency may ultimately reverse. Passive upper limb prosthesis has a tendency to be less sophisticated and lighter in weight. They were able to rescue very limited processing for the consumers. Upper limb prosthetic devices that are powered by the body and are applied by a cable and harness system to actuate the device. These types of gadgets are frequently the most preferred alternative for upper limb consumers, who frequently pick based on output value, toughness, and sturdiness [9-10].

Hand transplantation is an alternative to prosthetic arms that provide functionality, a good cosmetic appeal, and integrated sensors. [11]. However, these prosthetic alternatives require lifetime therapy, frequent rehabilitation, gripping power loss, and have a high risk of complication, which leads to high rejection among amputees. [12] When these concerns are coupled, the cost becomes too expensive.

D.S.V Bandara and others [13] in this paper they created a Prosthetic Arm with 15 degrees of freedom (DoFs), including seven active DoFs and eight passive DoFs. It gives the hand EFE, FSP wrist ulna/radial deviation wrist flexion/extension (WFE), and 11 additional DoFs. For wrist motions, an under-actuated mechanism is implemented, and for finger motions, an over-actuated mechanism is created. Dildar Ahmed Saqib and others [14] they have provided Upper limb prosthetic arm and hand model with three degrees of freedom that functions in parallel to the amputee's motions to which the sensor is linked and follows the amputee's instructions and gives support. Their model comprises three joints, each of which is controlled by a separate EMG sensor. , Dipali Pardhi and others [15] in this paper they created a hardware and software co-design of a robotic arm controller with five servomotors and a microcontroller. Dr. R. Satish Kumar and others [16] They created an EMG-based prosthetic arm. As a result, their project's purpose is to develop a low-cost prosthetic arm utilizing Electromyography data acquired from the forearm. They accomplished this by utilizing servo motors, an EMG sensor, and a flex sensor.

Ujwal R and others [17] in this paper they have designed 6 DoF prosthetic arm. Their design consists of 6 degrees of freedom from shoulder to wrist and 6 degrees of freedom on the palm along with the fingers. 2 degrees of freedom on the

ISSN (Online) 2395-2717

International Journal of Engineering Research in Electrical and Electronic Engineering (IJEREEE)

Vol 9, Issue 12, December 2022

shoulder joint, 2 on the elbow and 2 on the wrist which gives the overall movement of the prosthetic arm similar to a human arm.

Fig 1. Prosthetic Arm

II. INDUSTRIAL APPLICABLE PROSTHETIC ARM

When creating myoelectric prosthesis for various levels of amputation, the structure of the limb must be linked to the actuators (intrinsic actuation).

When traditional electro-magnetic actuators are interfaced with intrinsic actuation, the clawing effect of items between fingers and contacting regions is considerably decreased, resulting in severe gripping force to grasp any component. In general, prosthetic arms rely on frictional force to keep the object inside the confines of the hand. The final outcomes of any prosthetic arm copy include object gripping with reasonably good stability, as well as a large number of actuators with sufficient power for actuation.

These various ideas generate artificial limbs with just 2 degrees of freedom and a gripping force of 100N; in the following scenario, the motion of the appendages is defined from the beginning stage of design, making shape adaptability impossible [18]. The design of these devices is basic and easy to create, but they are inflexible when it comes to connecting different components [19].

The ideal method for making flexible prostheses is to use micro-actuators, which enhance the number of degrees of freedom. The approach behind employing micro actuators is fairly extensive since it provides a more realistic design than normal designs created from electro-magnetic actuators. This is owing to the scarcity of high torque micro-actuators, as well as the difficulty of integrating them into sophisticated control schemes, making DoF control impossible. According to Kanojia [20], the prosthesis should grab a range of complexed items while remaining stable, allowing it to use a simple control technique.

Fig 2. Industrial Prosthetic Arm.

III. EXISTING SOLUTIONS

On examination of the present market trends of the actuated myoelectrically controlled torso associated prosthetic devices, which may be classified as transradial/transcarpal, transhumeral, and a ball and socket impairments. All of these gadgets serve to extremely specific needs, and replacements are chosen based on these needs.

A. TRANSRADIAL SOLUTION

Human limbs have a sophisticated and convoluted anatomical structure that plays an important and fundamental function in component displacement and manipulation. Their replacements, prosthetic limbs, are constantly evolving and improving in functionality in the current age. Currently, basic grippers have taken over the market, and multi-actuated hands that exercise many grip kinds are gradually gaining popularity.

Some of the most promising commercial hand devices now on the market are Touch Bionics' i-limb Quantum [21], RSL Steeper's BeBionic v3 [22], and Ottobock's Michelangelo [23]. It is obvious from these artificial prosthetic devices that the usefulness of the arm does not significantly impact its size, weight, and gripping ability. And, given the current trend and the mentioned arms, it is apparent that there is still room for growth in the future market.

Fig 3. i-Limb Quantum.

Fig 4. BeBionic v3.

B. TRANSHUMERAL SOLUTION

The more the centralization of a limb or body portion, the less functional the limb. In transhumeral limb procurement, the absence of an elbow necessitates the adoption of an additional prosthetic joint to restore the two degrees of freedom lost. Despite the rotation of the forearm, which could

ISSN (Online) 2395-2717
International Journal of Engineering Research in Electrical and Electronic Engineering (IJEREEE)
Vol 9, Issue 12, December 2022

be replaced by the application of wrist arm application, might play a very important role in the reduction of handicap level and the decreased number of sources as well as techniques in order to manipulate all of the essential prosthetic elements of the arm.

When establishing the various locking positions, it is necessary to make the assumption that the wrist, prosthetic arm, and elbow might be mechanically active or passive. Passive elbows, also known as body powered elbows, are widely utilized in the market today, and an alternative is the electrically powered myo-electric control device, which is used industrially based on the necessity. The word "myo-electric" refers to the electric or neural qualities of the muscle, which also serve as signal conveyers in the muscle. As a result, a myo-electric prosthetic device that can be powered externally can function as an artificial limb by manipulating electric impulses identical to those created by our own muscles. If we examine the currently existing DEKA arm HC prosthetic arm. This arm features a motorized elbow solution that has a limited range of motion and so prohibits it from reaching the face for safety reasons [24]. Because of this disadvantage, persons who have lost their hands do not like this prosthetic arm.

Fig 5. DEKA ARM.

C. SOCKET TECHNOLOGY

The duration of time the user wears the artificial prosthesis as well as its design influence the role of the socket in a joint [25]. However, some challenges may arise during the fitting of the prosthesis, resulting in a limited range of motion as well as pain [26], leading to the overall poor performance [27] and therefore reduced utility and attractiveness to such a device [28].

Unlike the previously stated technologies, the transradial prosthetic arm socket has not altered considerably over time. As a result of this structural and technical setback, a flexible thermoplastic was created, resulting in significant improvement. The forthcoming thermoplastic-based technologies that were introduced were mouldable thermoplastics, which offer superior interior socket dynamics [29]. Following this are textile materials, which allow for improved cleaning and hygiene as well as less trouble in harnessing and fabricating custom fit upper torso limb amputations. This gradual and spontaneous progress in socket technology resulted in anatomically shaped sockets for all types of amputations imaginable in human physiology [30].

Figure 6. Socket Prosthetic Arm.

IV. CONCLUSION

The technique centered on the execution of under-actuation supplied us with current market trend solutions as well as an internal evaluation study programmed that will provide us with the passage of time. As new materials enter the market, they enrich users with superior linked socket designs that provide users with prosthetic experience. This well-defined manufacturing of the new socket fitting procedures has assisted orthopedic experts in matching the specific anatomy of each user's residual limb. The advancement in implanted sensor technology and the new socket design, which incorporates qualities such as harvesting the key functionality of these solutions with the adjoined transmitter/receiver coils. Even if there is a rising trend in its use, the discard rate of prosthetic technology is relatively high nowadays. This may be conceptualized as a noteworthy refinement in the activeness and hardware design. Several revolutionary approaches frequently fail to complete a secure transfer to the marketplace at the same time. All of the new technical solutions that have lately been created have yet to be clinically authorized for the general public. To counteract this impact, technology has been considerably developed to match the consumers' comfort.

REFRENCES

[1] D. Childress, "Historical aspects of powered limb prostheses," Clinical Prosthetics & Orthotics, Vol 9, Issue 1, pp.2-13, 1985.

[2] E. Marquardt, "The Heidelberg pneumatic arm prostheses," The Journal of bone and joint surgery. British volume, Vol 47, Issue 3, pp. 425-34, 1965.

[3] E. Biddiss, T. Chau, "Upper-limb prosthetics: critical factors in device abandonment," American Journal of physical medicine & rehabilitation, Vol 86, Issue 12, pp. 977-87, 2007.

[4] C. Pylatuik, S. Schulz, "Results of an Internet survey of myoelectric prosthetic hand users," Prosthetic and Orthotics International, Vol 31, Issue 4, pp. 362-370.

[5] M. Egermann, P Kasten, M. Thomsen, "Myoelectric hand prostheses in very young children," International Orthopaedics, Vol 33, Issue 4, pp. 1101-5, 2009.

[6] LV. McFarland, SL. Hubbard Winkler, AW Heinemann, M. Jones, "Unilateral upper-limb loss: satisfaction and prosthetic-device use in veterans and servicemembers from Vietnam and OIF/OEF conflicts," Journal of Rehabilitation research and development, Vol 47, Issue 4, pp. 299-316, 2010.

[7] SF. Burrough, JA. Brook, "Patterns of acceptance and Rejection of Upper Limb Prostheses," Orthotics and Prosthetics, Vol 39, Issue 2, pp. 40-47, 1985.

[8] M. Glynn, H. Galway, G. Hunter, "Management of the upper-limb-deficient child with a powered prosthetic device," Clinical Orthopaedics and Related Research, Vol 209, pp. 202-205,1986.

[9] G.H. Kejlaa, " Consumer concerns and the functional value of prostheses to upper limb amputees," Prosthetics and orthotics international, Vol 17, Issue 3, pp. 157-63, 1993.

[10] S.G. Millstein, H. Heger, G.A. Hunter, " Prosthetic use in adult upper limb amputees :a comparison of the body powered and electrically powered prostheses," Prosthetics and orthotics international, Vol 10, Issue 1, pp. 27-84, 1986.

[11] J.W. Jones, S.A. Gruber, J.A. Barker, " Successful hand transplantation. One year follow up. Louisville Hand Transplant Team," The New England Journal of Medicine, Vol 343, Issue 7, pp.468-73, 2000.

[12] S. Salminger, A. Sturma, A. Roche, "PROSTHETIC RECONSTRUCTION TO RESTORE FUNCTION IN TRANSCARPAL AMPUTEES," Journal of Plastic, reconstructive & aesthetic surgery : JPRAS, Vol 69, Issue 3, pp. 305-10, 2016.

[13] D.S.V. Bandara, R.A.R.C Gopura, "Development of A Multi-DoF Transhumeral Robotic Arm Prosthesis, Medical Engineering & Physics, Vol 48, pp.131-141, 2017.

[14] D.A. Saqib, U. Arif, "Prosthetic Arm and Hand Design," International Journal of Materials, Mechanics and Manufacturing, Vol 6, pp. 273-276, 2018.

[15] Dr. V.M. Vyawahare, D. Pardhi, "Design of a Prosthetic arm using flex sensor," International Journal of Electronics and Communication Engineering and Technology (IJECET), Vol 8, Issue 2, pp. 01-06, 2017.

[16] Dr .R. Satish Kumar, R. Manikumar, "Design and fabrication of prosthetic arm using EMG sensor," International Journal of Innovative Research in Advanced Engineering (IJIRAE), Vol 7, Issue 3, 2020.

[17] R. Ujwal, R. Narun, " Voice control based prosthetic human arm," International Research Journal of Engineering and Technology (IRJET), Vol. 5, Issue 7, 2018.

[18] M.C. Casrrozza, S. Micera, B. Massa, "The development of a novel biomechatronic hand-ongoing research and preliminary results," International Conference on Advanced Intelligent Mechatronics IEEE/ASME, Vol 1, pp. 249-254, 2001.

[19] D.H. Silocx 3rd, M.D. Rooks, R.R Vogel, "Myoelectric prostheses. A Long-term follow-up and a study of the use of alternate prostheses," The Journal of bone and joint surgery. American volume, Vol 75, Issue 12, pp. 1781-9, 1993.

[20] J.D. Crisman, C. Kanojia, I. Zeid, "Grasper: a flexible, easily controllable robotic hand," IEEE Robotics Automation Magazine, Vol 3, pp. 32-38, 1996.

[21] Touch Bionics, i-Limb Quantum Clinician Manual. Mansfield, MA: Touch Bionics; Issue 1, 2015.

[22] RSL Steeper, BeBionic v3 Product Brochure, Leeds: RSL Stepper, 2013.

[23] Otto Bock Healthcare GmbH, Michelangelo Technician Product Brochure, 2013.

[24] D.A. Bennett, J. Mitchell, M. Goldfarb, "Design and characterization of a powered elbow prosthesis," Annual International Conference of the IEEE Engineering in Medicine and Biology Society, pp.2458-61, 2015.

[25] L. Resnik, S.L. Klinger, "User clinician perspectives on DEKA arm: results of VA study to optimize DEKA arm," Journal of rehabilitation research and development, Vol 51, Issue 1, pp. 27-38, 2014.

[26] Lake, Chris, "The Evolution of Upper Limb Prosthetic Socket Design," Journal of Prosthetics and Orthotics (JPO), Vol 20, Issue 3, pp. 85-92, 2008.

[27] W. Daly, T. Rosenbaum-Chou, A. Arabian, "Socket pressure and discomfort in upper-limb prostheses: a preliminary study," Journal of Prosthetics and Orthotics (JPO), Vol 26, Issue 2, pp. 99-106, 2014.

[28] E.A. Biddiss, T.T Chau, "Upper limb prosthesis and abandonment: a survey of last 25 years," Prosthetics Orthotics International, Vol 31, Issue 3, pp. 236-257, 2007.

[29] J.E. Uellendahl, S. Ramdial, "Custom silicone sockets for myoelectric prostheses," From "MEC '05 Integrating Prosthetics and Medicine," Proceedings of the 2005 MyoElectric Controls/Powered Prosthetics Symposium, pp. 21-24, 2005.

[30] R.D. Alley, "Advancement of upper extremity prosthetic interface and frame design," From "MEC '02 Integrating Prosthetics and Medicine," Proceedings of the 2002 MyoElectric Controls/Powered Prosthetics Symposium, 2002.