Artificial Intelligence Arm- Review

N.D.Jadhav[1], Bipin Diwakar[2]

[1]Assistant Professor, Mechanical Department, Ashokrao Mane Group Of Institutions, Vatahar, Kolhapur,India.
[2]Student, KLE DR. M. S Sheshgiri college of engineering and Technology, Belagavi, India

---***---

***Abstract*:-**The introduction of information technology to prosthetics has allowed bionic limbs to emerge and change the way we were thinking about prosthetic limbs. The ability to easily connect the prosthetic to a person's brain or muscular system for movement has been made simpler by neural signal. With developments in information technology, the way in which bionic limbs are connected to a person can advance. The modern prosthetic hand has been designed to closely approximate the natural limb in both form and function. Despite the fact that the bionic hand was recently hailed as a triumph of engineering excellence it remains an inferior replacement to the real thing and consequently there are a number of barriers to its uptake amongst the upper limb amputee population. These prevent the prosthetic hand from achieving the ultimate goal of any prosthesis: 100% acceptance by its users. If a body part is missing, an artificial device (prosthesis) is often recommended to replace that part. At a minimum, a prosthesis should enable the user to perform daily activities (such as walking, eating, and dressing) independently and comfortably, as well as affordability and personalization. However, a prosthesis may also enable the user to function as well or nearly as well as before the amputation. As prosthetic limbs become more and more advanced, the my electric receptors used in the device become more advanced as well. Rather than just relying on an on/off electrical impulse to open and close the hand, researchers have been able to use the electrical signals from the nervous system to detect and simulate movement in the elbow, wrist, and fingers. As Courtney Moran of the Johns Hopkins Applied Physics Lab said, "Right now, the gap between man and machine integration has been narrowed to the smallest it has ever been."

Keywords : *Prosthetic Hand , Orthotic devices, EMG electrodes*

Introduction:-

The human hand is able to perform a complex repertoire of sophisticated movements that enables us to interact with our environment and communicate with one another. The opposable thumb, a rarity in nature, has helped us achieve high levels of dexterity allowing our evolution to proceed rapidly over other creatures to perform complex hand movements we need to synthesize an enormous amount of so esthetic information about our environment including fine touch, vibration, pain, temperature and proprioception.

The sensory and motor cortices span large, complex areas of the brain and are devoted to interpreting the vast sensory input and using it to fine-tune the motor control of over forty. The practice of upper-limb prosthetics is much different than that for the lower limb. There is often a lot of customizing, adjusting, tweaking, problem-solving, and trial and error. Done right, it requires more time and can be frustrating. Patients unhappy with the fit or function of their prosthesis will likely just not wear it. They don't "need" to after all; they have another hand.

However, a large percentage of patients end up with overuse injuries of their sound arm. And, of course, there are many things it is helpful to have 2 "hands" for. People with bilateral amputations (both sides) who rely on their prosthetic arms exclusively would especially benefit from working with a practitioner with extensive experience. It may also be that such practitioners are more familiar with and adept at dealing with insurance companies with regard to obtaining authorization and coverage for upper-limb prostheses.

In addition, the use of myoelectrics is extremely complicated and unique. There are specialized computer programs, electrodes, microprocessors, and wires that must be connected correctly, programmed, and maintained. Many practitioners unfamiliar with the technology may be reluctant to attempt it and rather go with what they know--the standard body-powered hook--, even though it may not be the best choice for that particular patient. It is difficult to figure out whom to go to for upper-limb prosthetic care. Within the field, there are professional organizations for practitioners interested in that area, but that information is not readily available to prospective patients.

Fig1: Upper-limb prosthetics

[1]Craig Sherstan, Towards Prosthetic Arms as Wearable Intelligent Robots, studied pneumatic hand. At the beginning of the 20th century, soon followed by the first electric-powered hand. In end of the Second World War, early concepts of myoelectric prostheses were introduced. These devices, which linearly translated the electrical activity of the residual muscles of the stump into the velocity of closing and opening of gripers, started to be used in research laboratories and to be sold on the market in the late 1950s. The concept of direct proportional control is still present in current commercially available systems, due to its simplicity and robustness.

By the late 1960s, pneumatic prostheses were able to drive and control several joints and grip types. However, the control was inefficient and not robust enough, requiring specific anatomical features, dexterity, and cognitive effort of the patient. Myoelectric systems have tried to face these issues with state-based control. Accordingly, the patient would control the prosthesis using two control sites, as in the single degree of freedom (DoF) case. When there was the need to control a different joint or grip type, a co-contraction of the muscles under the two recording sites changed the control state of the prosthesis. This quite cognitively demanding sys-tem is still dominant on the market of dexterous prosthetics, mostly due to its robustness.

Numerous studies have been conducted in the past two decades, still indicating high rejection rates of all types of upper limb prosthetic devices across a variety of users. Depending on the study population, rejection rates vary from 25% to 50% for myolelectric and up to 35% for body-powered devices. However, these figures have leveled off with respect to previous periods, mainly due to modern technology. However, it is possible that the trend will eventually reverse. Hand transplantation is an alternative to the prosthetic devices, offering functionality, superior visual appeal, and integrated sensory function. However, it is associated with the lifelong immunosuppressant therapy, lengthy rehabilitation, loss of grip force, and high risk of complications, leading to the possible rejection. These issues are then combined with very high costs.

Advances in micromachining and material design have enabled construction of versatile lightweight prosthetic hands and wrists. These market products, in combination with precise, small-sized, low-consumption electromotor, corresponded to highly actuated systems. Development of high-speed processing units with the top-end battery -management and large memories in small housing propelled the research into more advanced and intuitive control systems. Greater understanding of the human neuromuscular system yielded new surgical and reconstructive techniques, which now pro-vide access to high-quality and intuitive electromyography (EMG) sources even in high-level amputations. Socket design has also benefited from this rapid development of technology and now can offer solutions that are able to host multiple surface sensors, facilitate the use of implanted electrodes, and, in combination with surgical advancements, provide direct link with the skeletal system in the form of osseointegration. Finally, three-dimensional printing is quickly becoming a viable alternative for production of highly customizable products that are lightweight and inexpensive. Several open-source hand prosthetic projects are available for personal printing, and an ever growing number of companies are already using this method for building certain components of their own products.

What is Prosthetic Limbs?

[2] R.G.E. Clement , K.E. Bugler and C.W. Oliver, Bionic prosthetic hands: A review of present technology and future aspirations, studied review of prosthesis devices. In medicine, prosthesis is an artificial device that replaces a missing body part, which may be lost through trauma, disease, or congenital conditions. Prosthetic amputee rehabilitation is primarily coordinated by a prosthetics and an inter-disciplinary team of health care professionals including psychiatrists, surgeons, physical therapists, and occupational therapist,1 and mostly concerning this thesis, occupations such as engineers, program and software developers and finally the field of biomedicine.

A limb may be amputated or missing because of a blood vessel disorder (such as atherosclerosis or damage due to diabetes), cancer, an injury (as in a motor vehicle crash or during combat), or a birth defect. In the United States, slightly fewer than 0.5% of people have an amputation. However, the percentage is likely to increase in the coming years because of the rising rate of obesity, which increases the risk of atherosclerosis and diabetes. An entire limb or just part of one may be amputated. A lower-limb amputation may involve a toe, a foot, part of the leg below or above the knee, or an entire leg (at the hip). An amputation may even extend above the hip. An upper-limb amputation may involve one or more fingers, a hand, part of the arm below or above the elbow, or an entire arm (at the shoulder). If a body part is missing, an artificial device (prosthesis) is often recommended to replace that part. At a minimum, prosthesis should enable the user to perform daily activities (such as walking, eating, and dressing) independently and comfortably, as well as affordability and personalization. However, prosthesis may also enable the user to function as well or nearly as well as before the amputation.

Fig. 2 An illustration of the Limb hand as an example of a modern prosthetic hand demonstrating the modular assembly and aesthetic appearance of currently available prostheses

Hardware:-

[3]Dario Farina and Oskar C Aszmann, New developments in prosthetic arm systems, focused on hardware of gripper .The current market of actuated my electrically controlled upper limb prosthetic devices can roughly be divided into systems that address transradial/transcarpal, transhumeral, and shoulder disabilities. Each group features specific requirements, and, in general, the options for replacement are more advanced the more distal the level of impairment is. Transradial/transcarpal solutions Due to the complex anatomical nature of hands and yet crucial role in object handling and manipulation, their prosthetic counterparts have undergone an important evolution and functional advances in recent years. Although simple grippers are still dominant in the market, multi-actuated hands that provide several grip types or even fully controllable individual digits and finger joints are now common (Figure 2).

Some of the current common characteristics of the most promising commercial hand products – i-limb Quantum by Touch Bionics, RSL Steeper's Be Bionic v3, and Otto bock's

Figure 3 Examples of Otto bock prosthetic hands and cosmetics (from left to right): small System Inner Hand, small MyoHand VariPlus Speed, and medium Michelangelo hand.

Michelangelo – are presented in Table 1. For the sake of put-ting these products into perspective, the same table lists three different, already established, products aiming at children with hand disabilities, adult long stump cases, and usual transradial users – Centric Child Myoelectric Hand, Transcarpal-Hand by Ottobock Healthcare, and Select Electric Hand by Liberating Technologies, respectively .From Table 1, it is evident that the increase in functional-its did not significantly influence the size, the weight, and the power grasp force of prosthetic hands. Moreover, the listed products all offer certain wrist solutions, indicating an overall tendency of the market for further development of this joint. Besides the features listed, each of the hands in Table 1 is also equipped with a variety of product-specific features, mostly focusing on the different grasp types and safety measures (this is further discussed in the "Control strategies" section).Prosthetic hand devices developed by smaller companies or research laboratories include the world's first touch -sensing hand prosthesis from Vincent Systems, Evolution 2, and DARPA founded DEKA Arm RC. Evolution 2 combines the sensory feedback information with the individually motorized digits and fully actuated thumb in a compact and light package (400 g). The DEKA Arm RC is the heaviest of the products so far listed (1,270 g) and, in its third generation, offers highly actuated digits and thumb with an included compound wrist that can be actuated in three DoFs.

In order to provide a more natural object manipulation and therefore increase functional benefits to the users, modern prosthetic hand devices are frequently accompanied by an actively or passively controllable wrist joint. Passive versions of prosthetic wrists can be manually adjusted by the user in order to be in either compliant mode or to lock in one of the predefined positions in flexion/extension direction (Otto bock Axon Wrist, Touch Bionics Flexion Wrist, Be Bionic Flexion-Wrist) or along the rotation axis (Otto bock Axon Rotation, Touch Bionics QWD, Be Bionic Short Wrist).

Transhumeral and shoulder disarticulation solutions

The more proximal the upper limb impairment is, the greater the disability. In transhumeral amputations, the absence of an elbow requires an additional prosthetic joint to substitute the missing two DoFs. Even though the rotation of the forearm can be compensated using the wrist rotation unit, the major setback at this level of disability is the reduced number of sources and methods for controlling all the necessary prosthetic- components. As for the wrist, prosthetic elbows can be passive or active with several locking positions. Passive or body-powered elbows are dominant on the market, though several major vendors also provide electrically powered, myoelectrically controllable devices. Some representative products and their characteristics are listed in Table 2. The DEKA Arm HC offers a motorized elbow solution with a limited range of motion to prevent reaching the face for safety reasons. This characteristics and the absence of the free swing mode have not been well received by the users.

Even though improvements in academia have indicated possible solutions in designing elbow joints with anthromorphic characteristics, one of the current main challenges is the design of a device fully compliant with all the standards and yet lights enough to be suited for children and frail adults.

Socket technology:-

The amount of time a user wears a prosthesis mainly depends on the socket fit and its design. Inadequate prosthetic fit might lead to limited range of motion, discomfort, and general poor performance, usually resulting in the abandonment of the device.

After the development of the Otto Bock Muenster style socket in the 1960s and the Northwestern University socket in 1972, the transradial powered prosthesis socket design has not significantly changed. The introduction of flexible thermoplastics has indeed been the only major improvement. At the end of 1990s, silicon liners have been -introduced, and

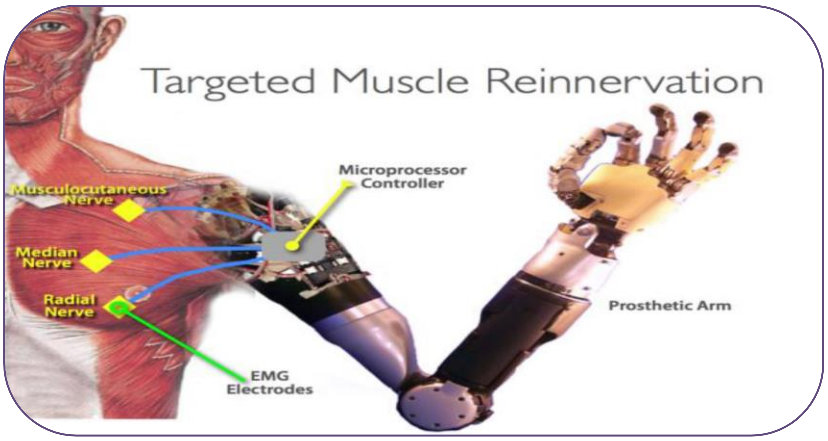
the transparent, moldable plastics allowed better analysis of the inside socket dynamics, resulting in a tighter contouring around the fitted stump (Figure 4). Nowadays, new textile materials allow better, more hygienic and less obstructing harnesses to be developed and custom fit to higher level upper limb amputees. The general tendency over the past few years, which was enabled through these novel materials, is the design of anatomically contoured sockets for all levels of amputation.

Based on the Osseo integration technique introduced 60 years ago, an advanced mounting concept of the upper limb prosthesis has been developed and applied. The main idea behind this technique is to exploit the direct structural and functional connection between the skeletal bone and the surface of the titanium implant, which would further be connected to an additional implant penetrating the skin. In this way, a point for a direct, rigid connection of the pros-thesis and the skeletal system is created. Osseo integration offers numerous advantages over the traditional sockets by providing a more intimate fit, increased range of motion, and oases perception. However, it also requires additional surgery and poses potential risks of infection, implant fracture, or incomplete integration requiring revision surgeries. The introduction of implantable sensing technologies for EMG detection and control of prosthetic devices such as implantable myoelectric sensor requires certain revisions of the standard sockets. Namely, implantable myoelectric sensor compatible shafts are equipped with transmitter/receiver coil capable of enclosing the stump and receiving the signal transmitted by the implanted EMG electrodes.

Figure 4 Example socket design with custom pattern, silicon liner, and Otto bock Energy Pack housing.

[4]David Harvey and Benjamin Longstaff, The Development OF A Prosthetic Arm studied new generation of prosthetic arms has a different set of software challenges and solutions. DEKA, the research firm founded by inventor (and 2009 PM Breakthrough Award winner) Dean Kamen, is developing the third generation of its bionic limb, known internally as Gen 3. It's backed by DARPA's Revolutionizing Prosthetics program—a $100 million effort to create devices that is roughly equivalent in function to biological arms. Now awaiting FDA approval, Gen 3 has 10 degrees of freedom (typical motorized arms have only two or three) and a range of algorithms that mimic the precise control of its flesh-and-blood counterpart. By moving his or her foot, which operates a wireless controller, the user can engage various preset grasping patterns. Previous upper-limb models have used foot switches but with nowhere near the number of grip options, nor the machine intelligence and the force sensors that guide the artificial fingers and determine how much power should drive them.

[5]Kyriazi Nefeli Evdokia,Master thesis on Artificial Intelligence[6] Jennifer E. Cheesborough, Lauren H. Smith, Todd A. Kuiken, and Gregory A. Dumanian, Targeted Muscle Reinnervation and Advanced Prosthetic Arms, The second arm funded by the Revolutionizing Prosthetics program, the Modular Prosthetic Limb (MPL), developed at Johns Hopkins University, may lead to what many believe is the endgame for bionics: direct neural control. By embedding electrodes into a subject's existing nerves, or going through the skull and implanting them directly onto his or her cortex, researchers have been able to turn thoughts into action. In a study conducted in 2010 at the University of Pittsburgh, a quadriplegic pressed the MPL's hand against his girlfriend's. Through trial and error, processors are taught to decrypt a user's thoughts and recognize a growing list of intentions. "The system's smart. It has to be," says Michael McLaughlin, Revolutionary Prosthetics' project manager at Johns Hopkins. "The algorithms interpret what the patient is trying to do, then do it." The MPL, in other words, isn't truly mind-controlled. The electrodes deliver orders, but it's the arm that decides how to carry them out. Or, rather, it's the network of machines—each jointed segment and finger with its own processor—that makes up the arm. The state of the art in powered prostheses is in some ways stranger than science fiction: a swarm of bots that obey the human mind, either through cables that snake out of the skull or by taking their best collective guess at those thoughts. Stranger still, this is just the beginning.



Conclusions:

Limb loss is one of the most physically and psychologically devastating events that can happen to a person. Thankfully, the technology has developed a lot the past decades, in order to serve people's needs. One of the main ways is the entrance of Artificial Intelligence in the field of Prosthetic limbs. The prosthetic hand of the middle ages was present merely as a prop. Today we have bionic hand prostheses that give much better functionality, are acceptable to more patients and are durable and comfortable. However these prostheses still have to overcome considerable hurdles in order to mimic or even improve upon the intrinsic hand and they carry significant economic implications. The advancements in this field of medicine are exponential and it is likely that within 10 years there will be commercially available limbs that provide both sensation and accurate motor control from day 1

The current bottleneck of the upper limb prosthetic development seems to be the control of the robotic limbs. The majority of commercially available devices are still relying on the cumbersome mode-switching approaches dating some decades ago, while novel techniques seem to continuously fail in making a stable transition into the market. There are new solutions that have recently emerged but that have not yet been tested clinically on a large scale. High prosthetic abandonment rates are still present, though they have been stagnating compared to the trends from about two decades ago

REFERANCES:

[1] Rhys Clement Chris, Oliver and Kate Ella Bubler Article in The surgeon: journal of the Royal Colleges of Surgeons of Edinburgh and Ireland · December 2011 DOI: 10.1016/j.surge.2011.06.001 BIONIC PROSTHETIC HANDS: A REVIEW OF PRESENT TECHNOLOGY AND FUTURE ASPIRATIONS.

[2] Ivan Vujakliia, Oskar Aszmann and Dario Farina. Article in Orthopedic Research and Reviews · July 2016DOI: 10.2147/ORR.S71468 NEW DEVELOPMENTS IN PROSTHETIC ARM SYSTEMS

[3] LINKING PROSTHETIC LIMBS TO THE BRAIN: AN EXAMINATION OF ACURRENT TECHNOLOGY IN ENGINEERING By Mathew Schleifer (mrs184@pitt.edu).

[4] David Harvey and Benjamin Longstaff Department of Mechanical Engineering, The University of Adelaide, Adelaide SA 5005,Australia THE DEVELOPMENT OF A PROSTHETIC ARM

[5] Kyriazi Nefeli Evdokia,Master thesis on Artificial Intelligence

[6]] Jennifer E. Cheesborough, Lauren H. Smith, Todd A. Kuiken, and Gregory A. Dumanian, Targeted Muscle Reinnervation and Advanced Prosthetic Arms

[7] W. J. Chen and M. Xie, "On the Design of a Novel Dexterous Hand", The 9th International Conference on Advanced Robotics, Tokyo/Japan (1999), 61-65

[8] G. K. Klute, J. M. Czerniecki and B. Hannaford, "McKibben Artificial Muscles: Pneumatic Actuators with Biomechanical Intelligence", [Online, accessed 26 March 2001] URL: http://brl.ee.washington.edu/BRL/devices/mckibben/aim99v6.pdf

[9] Nayim Ali Khan, Nagesh K, Rahul 'Bionic Arm'International Journal of Engineering Science Invention ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726 www.ijesi.org ||Volume 6 Issue 9|| September 2017 || PP. 41-45

[10] Chorge Nitish, Dhage Shantanu, Mane Abhijeet B.E Mechanical, Theem College Of Engineering, Boisar (E) BIONIC ARM International Journal of Recent Research in Civil and Mechanical Engineering (IJRRCME) Vol. 2, Issue 1, pp: (19-21), Month: April 2015 – September 2015, Available at: www.paperpublications.org