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Review Article

Advancement in Biomechanics: A Review

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ABSTRACT

This paper reviews the recent technology in the control of the bionics, advancement in the legs & arms prosthetics and its history. In this paper we are also focusing on how hand works and which are the key parts involved in it, future trends in this field, improvement required in available technology and what is the key knowledge required by the engineer to work in the field of biomechanics. In Advance we are also finding what are methods in controlling the prosthetics? How the signals from nerves is been extracted? How the pattern of signals is been recognized and then what are the various actuators used to control the prosthetics.

Keywords: Prosthetic Hand, Prosthetic Leg, Actuators, Biomechanics, Myoelectric signals, future of bionics, extraction of signals, etc.

INTRODUCTION

In the past decades, we have seen various developments in the field of biomechanics. The very first non-technological prosthetics were consists of the hook and was having a specific application. The first bionic arm was discovered in the year of 1993 by Robert Campbell Aird (UK). The first bionic arm was called as, the "Edinburgh Modular Arm System". This arm was equipped with the microchips, circuitry to operate this arm in a different place, it also comprises of the small gears, pulleys, and motors, all were embedded in the realistic artificial skin. The function of the new bionic arm was to rotate fully at the shoulder, wrist and elbow joint, while the fingers help him to grip the object. The prosthetic legs were called peg and were not controlled by the brain signal. Thus during the late 1500s French Army barber/surgeon Ambroise Paré developed the first bionic prosthetics thus he is also called as the father of the modern amputation surgery and prosthetic design. He invented an above-knee device that was called kneeling peg leg and foot prosthesis the features included in his design were consist of fixed position with adjustable harness and knee lock control and many more.

Day after day the technology evolved and then came the bionics which is controlled by the human brain. Thus there are various technics involved in the extraction of the mind signals to control the bionics. [1] Thanks to Dr. Todd Kuiken at North western University and Rehabilitation Institute of Chicago and Dr. Gregory Dumanian at

Northwestern University Division of Plastic Surgery who firstly developed the targeted muscle Reinnervation surgery to bring back the control of the motor nerves and sensory feedback from the different parts of the amputees. Now days this technology has become very cliché and used by various research laboratories. We can also say that disabilities played a very crucial role in human life in evolution and testing of the human intellectual power. The research of "targeted muscle Reinnervation" was just the start of the advanced technological era.

The hands and legs are used to perform various complex tasks. When we see the structure of the natural hand and legs we see that the thumb is having the special position and design. In our hand, we see the thumb is perpendicular to palm to do the proper gripping action and posture of the hand. Thus same as in the legs the thumb is at the top position and used to grip the ground and creates stability. To in perform in nature, we need various types of the information and certain set of ideas. The information such as, touch sensitivity, pain, etc. this all things are performed by arms and legs, in which certain naturally build sensors are equipped with sensory and motor nerves connection which act as a communication bus between the brain and sensory part. While designing the prosthetic arms and the legs the acceptance rate of the human is much important and need to be designed so.

1.1. WHAT IS BIOMECHANICS?

Biomechanics is the study of biological systems and utilizing there special skills in the engineering field. We can also say that study of mechanics of biological thing in engineering field. [5]

1.2. HOW HAND AND LEGS WORKS AND KEY PARTS INVOLVED IN THE ACTUATION

KEY PARTS INVOLVED IN THIS WORKING IS:

BONES:

As inside any of the mechanical structure chassis provides the function of the supporting element, this bones also act as supporting element of the body.

MUSCLES AND TENDONS:

Just like in our machine the actuator and joints are having specific function the muscles and the tendons provides does the same function. There are different types of the muscles they are generally categories in to 2 types voluntary and in voluntary muscles.

NERVE AND BLOOD SUPPLY:

The nerves play the important roles in transferring the signals from the body to the brain and from the brain to the body. Now we get feedback from the body and sensation of the environment. There are two types of the nerves involved in these they are motor nerves which carry the signals from the brain to the body and the sensory nerves which carries the signals from the body towards the brain. The body is completely depending upon this nerves thus plays a vital role in the functioning of the muscles contraction and relaxation. Blood has various types of the cells and have different types of function. The cell provides the oxygenated blood to the all parts of the body from the heart and carries the deoxygenated blood from all parts of the body to the heart. Thus by doing this we get the strength to work and our muscle won't get fatigue.

Thus we can say the functioning of the natural parts are the combine effort of all this things stated above.

1.3. WHAT DO YOU MEAN BY TARGETED MUSCLE REINNERVATION?

In Targeted Muscle Reinnervation technique the nerves are bring back to use for actuating of the bionic arm. [2] In this technique the nerves of the amputees are joint at the skin of the nearest part of the body from where the signals are accessed. Thus providing this we can control the actuating of the bionic arm just like our natural arm. The nerves which is brought in

to action are mainly motor nerves. Thus brings out all the voluntary action. [3]

1.4. WHAT DO YOU MEAN BY TARGETED SENSORY REINNERVATION?

In Targeted Sensory Reinnervation technique the nerves are bring back to use for feedback from bionic arm. [2] In this technique the nerves of the amputees are joint at the skin of the nearest part of the body from where the signals is accessed. [1] Providing these we get the feedback from the bionic arm just like our natural arm. These brings sensation of touch and feel, etc. from the body to the brain. The nerves which are brought in to action are mainly sensory nerves. Thus brings out all the sensation action. [4]

1.5. HOW MUCH BIOLOGY DOES THE ENGINEERS NEED?

The need of the biomechanics or bio-engineering is increasing day by day. Thus it becomes important for an engineer point view to know basics of the biology. The biomechanics is nothing but learning from the nature and develop something which has been inspired by the biological term. The engineer should know how to pose questions to biology and how to control the process of analyses and syntheses from the beginning. Thus at these we can say that the need for basic understanding and basic knowledge in the following fields of biological sciences (Botany, Zoology) (Comparative) (functional) anatomy, Developmental biology, Taxonomy, Physiology, Biochemistry, Genetics and molecular biology, Ecology, Strategies and methods of bionic inspiration. [5]

2. EMG PATTERN RECOGNITION AND DATA EXTRACTION TECHNIQUES WITH THE REAL TIME PROBLEMS FACED IN EXTRACTION OF THE SIGNALS AND THE VARIATION OF SIGNALS PERSON TO PERSON

Various methods are there to extract the peripheral information which used to the control the bionic. These information we get it from the different techniques. These techniques which are used by some researchers are discussed below:

The signals from the brain carry away from the nerves and then to the actuators muscles, etc. and are having different methods for extraction, if the information extracted from the nerves they called it as the electroneurographic signals. If they extract it from muscles then they called it as electromyographic signals. [2]

First method is electroneurographic signals second one is surface electromyographic signals and the third one is intramuscular electromyographic signals. [2] The second and third is categories in to one categories but in these review we are going to discuss them as a separate categories.

2.1. ELECTRONEUROGRAPHIC SIGNALS

The electroneurographic signals extracted from the nerves of the body that are still there even after the removal of the part. Thus after the Targeted Muscle Reinnervation surgery these nerves brought in to use. [1] Thus these signals are first been used for controlling of the body parts at first but now they are not of any use thus they can brought into action even after the year of removal of the part. [6]

2.2. SURFACE ELECTROMYOGRAPHIC SIGNALS:

These types of signals recorded from the surface of the skin. Whereas it represent the non-invasive method to measure the electrical activity generated by active muscle fibers. [2,7] "Either as a sensor of the electrical activity of a muscle or as a transducer of the ionic current, flowing in the tissue, into the electronic current, flowing in the metal wires." [8]

2.3. INTRAMUSCULAR

ELECTROMYOGRAPHIC SIGNALS

These signals as the name only suggest that these signals being extracted from the inside of our body were as by using needles, wires, etc. These needles inserted into only selected muscles for extraction of the data. [2]

The various extraction of the signals processes is carry away by many researchers but only some of them discussed below based on the methods they used to recognize the pattern the nerves and the muscles creates. [2] First method is Artificial Intelligence Based Technology. In this technology of electromyography signals are recognized by evidence accumulation procedure using distance measured with reference parameter based on the artificial intelligence with multiple parameters. A fuzzy mapping function is designed to transform the distance factor for the evidence accumulation procedure. During this method the various parameters are drawn for the calculation and recognition of the pattern that are Integrated Absolute Value (IAV), Difference Absolute Mean Value (DAMV), Variance (VAR), AR Model Coefficients (ARC), Linear Cepstrum Coefficients (LCC), Adaptive Cepstrum Vector (ACV), thus finding all this parameters the required for the evidence accumulation technique and fuzzy mapping the pattern is been recognized. [9,10] In this way the EMG pattern is recognized, but these technology uses the AI based system which is undesirable and difficult to use thus in order to simplify these defects the another thing which is been used is DIRECT NEURAL SENSORY FEEDBACK In this process it is possible that by injecting the special electrode in to the body of person who has disability in to the fascicles of the peripheral nerves of the bottom part of the part from which the rest of the part is cut down, thus process say that by embedding this electrodes in to body brings out the sensation of touch, or we can say movement created by the amputee's hand and thus by recording this motor neuron processing during of controlling this limbs. Thus data obtain can be used for the further processing to control of the bionics. Process says that by using this techniques the amputees can set the grip force required and the joint position of the bionics and thus providing the substrate for the implementing the artificial limbs into amputees body. [11] The above technique focuses on the direct injection of the electrode in to substrates body which is dangerous and are requires the special skills and even we have to go for the surgery. Thus to overcome this problem without injecting something in to the substrates body we should do something which is not very dangerous and does not requires any skills sets. Thus the technology of the Surface Electromyographic Signals came into existence. In this technique the electrodes are placed on to the surface of the skin to measure the signals and record it for the pattern recognition of the signals process. [12] In this technique the major parameters involve is selection of the electrode. Since the amplitude of the signals obtain from the skin are very low and these leads to capture this in precise manner, amplifies it and process it. [2] In this technique the two different surfaces are used to detect the two different signals from the body and by using the differential configuration technique, these signals are subtracted from each other in order to get amplified signals. In this differential configuration principal, the shape and area of the detection surfaces and the distance between the detection surfaces are important aspects because they affect the amplitude and frequency content of the signal. Thus in this way the signals from the nerves are extracted and evaluated without an injecting the electrodes. This technique widely used throughout the world and is most convenient technique. [13-15]

One of the examples stated below is using the Surface Electromyography pattern recognition system for control of a wrist. [15] This technique uses the recollected data from four muscles of the forearm and wrist torque from the experiments conducted from the trial and error basis. The signals

from the experiments contain the root mean square (rms) EMG amplitude, autoregressive (AR) model coefficients and waveform length. In order to extract this different force intensity signals from the sEMG signals the Support Vector Machines (SVM) was employed. Thus in this technique the control of the wrist is been carried out with the help of the surface electromyography signals. [16] One of the methods introduced in the surface myoelectric pattern recognition is the anticipatory pattern recognition method to control the hand. To detect humans' motor nerves signals as fast as possible, this technique focuses on the transient state of the EMG signals. The EMG signals are taken from the forearm, and remove a feature vector every 50 ms. [17] At each time channel, pattern discriminator determines the state of the EMG signals that if the state is transient or not. When we consider the transient state, participants of displaced prosthetic hand patterns were constrained by some protocol related to a transition chances among the hand patterns. Thus the suitable hand pattern can be selected; else an ongoing hand pattern was maintained. In this way the anticipatory pattern recognition method used. [18] There are various techniques to improve the pattern recognition thus different technique having different approach to solve the problem. Thus the motion discrimination methods using the conical models are one of the techniques to improve the EMG pattern recognition. In this technique, they increase discrimination accuracy of motion discrimination using conic model, they uses the extraction method using quadratic polynomials. Thus many prosthetic hands using motion discrimination have constant motion speed that can't be controlled these method uses an angular velocity generation method using multiple regression models.

There are various processes made in the clinical application of electromyography (EMG) pattern recognition for purposes. [16] Thus Making this technology practically possible and available to user is very difficult as the defects in the motor neurons, such as for the physically and physiologically change person. It is very difficult because the result of the changes in EMG signals and systems that are unreliable for period of time. Thus in order to nullify these challenges the investigation of the stability of time-domain Electomyographic features during changes in the EMG signals ARE BEEN CARRIED OUT. Also to identify the technique in which we get the most robust EMG pattern recognition. [16] Thus in order to overcome this problem various experiments are been taken which states the following: there are main three things which affects or creates the disturbances that commonly affect EMG signals that are (1) EMG electrode location shift (2) variation in muscle contraction effort, (3) muscle fatigue. Thus as these features was recorded they claimed that impact of these disturbances on individual features and combined feature sets was quantified by changes in classification performance. Again in order to check the robustness of signals they was evaluated by stability index developed program. Thus the results were no different than expected firstly they evaluated that (1) Muscle fatigue had the smallest effect on the EMG pattern recognition, whereas the electrode location shift and varying effort level combine reduced the classification accuracy for most of the time. Thus after detailed study they brought out one conclusion that EMG auto regression coefficients and cepstrum coefficients showed the most robust classification performance of all studied time-domain features.

3. ACTUATORS USED

The actuators used are having specific criteria based on that criteria we have to select the actuator. The criteria such as:

3.1. EASY TO CONTROL

As the name only suggests that the actuators and the system should be the easy to control. i.e. its speed should be easily controllable and does not require any

alternative system for its control, which ultimately increase the expenditure. [19]

3.2. LESS BULK

The system should not be bulky since all the load of the hand has to be carry by the user itself. And also the thing is hand should lift the weight more than its own weight. Thus the weight to power ratio should be as good as possible. The main thing is the actuator we are using should be light weight. Thus along with the actuator the frame work we are going to use should use the material light weight. [19]

3.3. COMPACT

The space available inside the hand is very less. And thus if we select the actuators which are large in dimension then our hand becomes larger. And as the hand is larger, ultimately the system becomes bulky. And also the advantages of the compact sizes are proper gripping and accurate movement. [19]

3.4. LITTLE MAINTENANCE WORK

Here in this system little maintenance means no maintenance. As the maintenance is less the operating cost is also less. And hence the system becomes convenient to use. And it's very important to work this arm without any maintenance because it is directly connected to the human body.

3.5. LESS POWER CONSUMPTION

As the hand is controlled electrically thus the power consumption is also very more as we use more than 5 motors at a time. Thus if the power consumption is also more we need to carry more number of batteries and thus increase the weight of the system. The main reason behind control in the power consumption is that after usage of the motors the motors become hot and can also affect the user. Thus we need to control the power consumption and allow them to use it as less as possible.

3.6. EASY TO INSTALL

If the system is complicated in installation then if by mistakenly then user broken down one of the part, then we need to remove or open all the parts to repair that one part. This ultimately increases the operational cost. If the assembly is complicated then ultimately increase the manufacturing cost. And the cost of the system also increase which does not sell our product more easily.

3.7. INSTANT ACTUATION TIME

The human reflex action works with in an impulse so it need to get the signal and process it and then produces the movement should be done within that impulse. If the movement is taken into with a specific delay then the actuators, controller and the sensors are not selected properly. Another thing included in this is actuators should be easily controllable. [19]

3.8. ONE ACTUATOR FOR MULTIPURPOSE USE

The actuators should use which produce the more movement or the system should use which are used to control many applications.

3.9. COST EFFECTIVE

The factor which affects most of the design are the cost of the products. This hand should be in inexpensive and should be as low as possible because the customer will only chose the material which is affordable. In our design we are using the BLDC Servos, micro controller, tactile sensors, and the fabrication material thus all the material should be selected on this parameters also. [19] Some components are not commercially available such as the finger and thumb shells as well as the palm of the hand. These components were designed to be easily prototyped using a 3-D printer to eliminate the need for expensive, labor-intensive fabrication processes.

4. ACTUATOR BASICALLY USED

4.1. MOTORS

There are different kinds of motors based of the limitation the motor are been selected and thus as per requirement the control action also changes. Thus some portion requires the servo control whereas the some portion requires the direct use without servo control. But most of the times the user only requires servo control in order

to precision control, where the control of the rotation of the arm is been done in degrees of rotation. [20] The motors used generally are as follows with advantages and disadvantages:

4.2. BRUSHED DC SERVO MOTOR

In brushed DC servo motor the encoder are used to control the angle of the rotation. There are many types of Brushed DC motors the typically used DC motors are

4.3. PALNETARY DC GEARED MOTOR WITH ENCODER

This motor rotates in the all 360 degrees with number of turns with precision control and then the position is control with the help of the encoders based on the PPR the control is depends. Thus we can say that the maximum PPR more is the control accuracy and less PPR then less control accuracy. Instead of accuracy we can say the resolution of the motor. With the help of the planetary geared box the torque multiplication of the motor is more in compact space. Where the disadvantages of this motor is heavy weight and less speed of base motor (generally). There are so many gear drives used in the motor but the generally used gear drive is planetary gear drive. [21] There is another gear drive which is even useful in the prosthetics that is the helical gear drive. This gear drive is most widely used in the field of the automobile because of the less noisy and high efficiency of this gears is also very high as compared to other. Thus most of the gear drive is manufactured from this gears.

4.4. DC DIGITAL/ANALOG SERVO MOTOR

This motors are used to control when the rotation of the axis is required to be in the only in the range of 0 to 360 degree. [23] This motor is having in build quadrature rotary encoder with a resolution of per degree rotation. Thus we can stop this motor at any angle we want. The dis advantages of this motor is it could rotate only one rotation in forward and reverse direction. It is easier to control than that of the planetary dc geared motor with encoder. [22]

4.5. BLDC SERVOS

As the name only suggest that this motor is brushless motor thus the speed of this motor is incredible and are of different types and shapes easy to control and require less programming to operate. Thus as this motor comes into various sizes and shapes, it is very flexible motor to use at any place and can be controlled using the encoder attached to control the direction and angle of rotation. [24] The torque can be multiple by using the planetary gear box. Thus it is a best example of control of the arm using simplicity, compactness and accuracy. [25]

4.6. HYDRAULICS & PNEUMATICS

The system made by this is powerful but the main disadvantages are the system is bulky and requires lots of power to actuate. [26] Continuous fluid supply is required to operate the system. The system is very risky also since the actuation of the system is at high pressure thus if the system is exploded then the user may be in danger. [26] Thus another disadvantage is, if there is leakage in the fluid either it will spill on the user by which the user may get infected or any other problems may affect the user, so it very important for the users safety first. But then also there are some actuator which are used based on the pneumatics not on hydraulics because we can operate the pneumatics in less weight but can't operate the hydraulics in less weight.

Additionally, new series elastic actuators and other deformable actuators are being proposed for use in robotic exoskeletons based on the ideas of control of stiffness in human limbs. [28]

FIGURE 1: PNEUMATIC AIR MUSCLE [28]

Pneumatic artificial muscles are a new technology in pneumatic actuators.[30] In this actuator, the volume of the cylinder changes, aiding performance according to thermodynamic principles. [28]

FIGURE 2: ARTIFICIAL PNEUMATIC MUSCLE [28]

A similar artificial muscle is the air muscle, also known as the Braided Pneumatic Actuator, a lightweight and very flexible design that is more powerful than any other type of pneumatic actuator. [28-30]

5. ADVANCE TECHNOLOGY IN THE ARM AND LEGS WITH CERTAIN EXAMPLES

5.1. MOTOR BASED

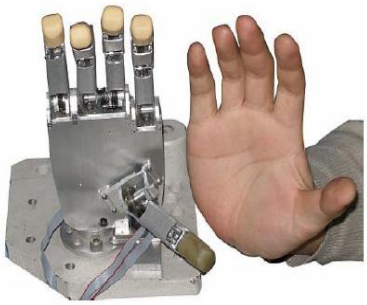

FIGURE 3: FIVE FINGURE HAND WITH UNDER ACTUATED MECHANISM REAL MODEL [31]

Motor based under actuated mechanism arm: The system is completely based on the under-actuated mechanism and coupling principle, this hand is equipped with the five-fingers, and with multiple-sensors thus to control the bionic hand. The system is composed of the multiple degree of freedom having the nearly around 13 joints and is controlled by 3 motors. Specially designed thumb which could rotate in the conical manner and actuated by only one motor, the transmission of the motion is been carried out by springs, to control the mid finger, the ring finger and the little finger thus by providing the motion the hand can cover the object. The hand is been controlled by the Bluetooth control protocol and also the hand can be controlled by the voice signals, it can also be controlled by Electromyography (EMG) signal like most of the prosthetic hand. The advantages of the hand is the strong capability of self-adaptation grasp and can accomplish precise and power grasp.[31]

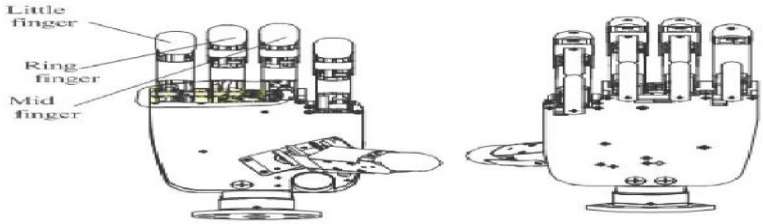

FIGURE 4: FIVE FINGURE HAND WITH UNDER ACTUATED MECHANISM 2D DRAWING [31]

The system based on the 6 degree of freedom with motor as actuator is been stated below. In this prosthetic hand the motor is used as a prime actuator and the specially designed BLDC is been used where the one finger consist of the one individual motor and the thumb is been designed according to natural thumb but consist of the two motors and are used to control of the thumb independently at both the joints. The upper joint of the regular fingers are been controlled with the timing belt and timing pulley mechanism. The whole hand is been manufactured by the 3D printing. Figure below shows the mechanism used and arrangement of the motors in order to achieve the proper grip and are used to produce the desired posture. The transmission is done through gear mechanism for which bevel gear is used in order to achieve the perpendicular transmission. [31]

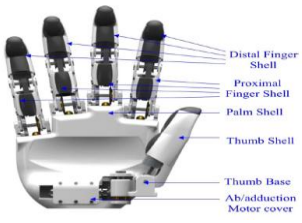

Figure 5: Five Finger Hand With Under Actuated Mechanism Labeled Drawing [31]

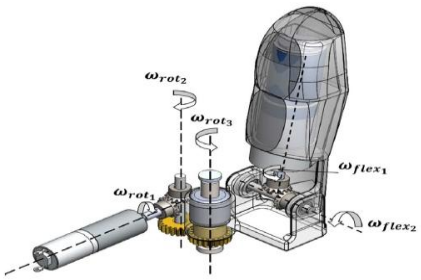

Figure 6: Thumb Mechanism With Actuator Used [31]

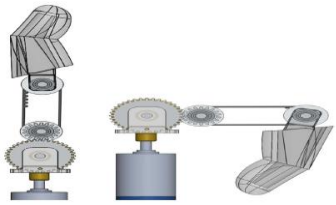

Figure 7: Finger Mechanism With Actuator Used And Its Flexibility [31]

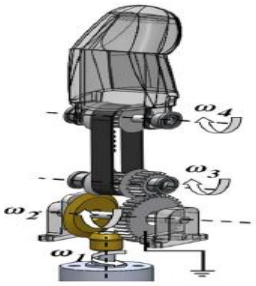

Figure 8: Finger Mechanism With Actuatorand Drive Used [31]

The below figure shows the hybrid prosthetic hand, this prosthetics hand is having 24 degree of freedom (DOF).theses structure is been actuated by the Brushless DC motors along with Shape Memory Alloy (SMA). These hand is been controlled by the human impulse using the 8 channel EMG used to detect 7 basic hand gestures. Thus the properties of the SMA, that when they are heated to certain temperature they changes there shape and when they are cooled then they regains its original shapeis been used in combine with the small and high torque BLDC motor. [25,33]

FIGURE 9: COMPLETE HAND DESIGN WITH 24 DEGREE OF FREEDOM [25]

These system given below is another example of the prosthetic hand these prosthetic hand is been used for the grasping the objects. Amazing thing about this mechanism is that the actuators are been arranged at the back side of the person. The transmission of the motion is been done through the cables and thus we can say that the system is less bulky at the hand whereas bulky at the back of the person. The system comprises of the pulley type of the mechanism and uses large amount of motors. The complexity in the compact design is been eliminated by fixing the motors outside the system. [22]

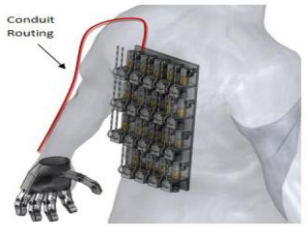

FIGURE 10: CONDUIT LAYOUT [22]

5.2. PNEUMATIC BASED

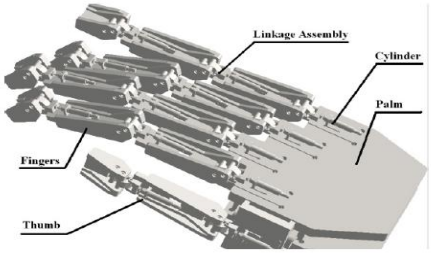

FIGURE 11: PNEUMATIC HAND WITH 24 DEGREE OF FREEDOM [26]

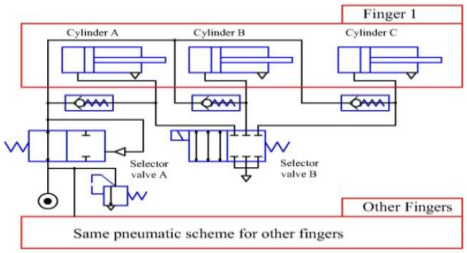

FIGURE 12: PNEUMATIC HAND CIRCUIT DIAGRAM [26]

The hand is based on the pneumatic principle with the under actuated mechanism. The hand comprises of the 5 finger just like the natural hand. The hand is been designed with the help of the micro specially designed pneumatic cylinder and

are arranged in the parallel manner. The knuckle joint is used to control the angle this angle is totally decided by the shape of the grasped object. The force calculation of the grasping is been calculated by the static and kinematic calculations. The bionic hand with strong stability and control with the perfect grasping pattern is achieved by this mechanism. As this system is controlled by the pneumatics the circuit diagram is been mentioned above. [26]

The below figure shows another pneumatic mechanism used for the walking robot. These leg is having four-DOF designed, build and controlled on McKibben artificial muscles. The stiffness of the legs are controlled independently at each joint. The stable movement of the walking robot is brought out by the tunable passive stiffness properties of the actuators. This leg is capable enough of walking on a horizontal plane with its control valves off 90% of the time. Thus these robot is robust enough to control in any environment and are used for generally walking. These passive joint build gives the high energy efficiency. [34]

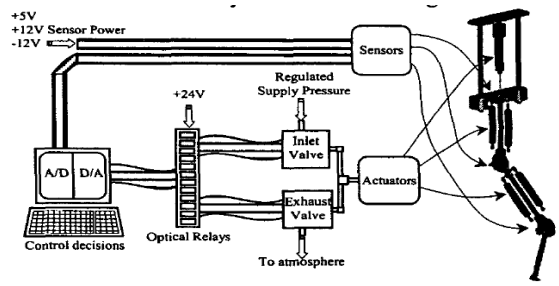

FIGURE 13: MCKIBBEN PNEUMATIC CONTROLLED LEG WITH SYSTEM LABELED DIAGRAM [34]

5.3. ACTUATOR USED IN PROSTHETIC LEGS WITH POWER CONTROL TECHNIQUE

POWERED PROSTHETIC LEG Recently developed bionic legs are been controlled complexly just by individually controlled joints and with the large processing speed but this result in the difficult to controlled or tune according to the need. This challenge is been completed by this virtual constrain control of a powered prosthetic leg by, derives exact and approximate control laws for a partial feedback linearization to enforce virtual constraints on a prosthetic leg. Thus in this method human inspired invariance property called effective shape into virtual constraints for the stance period. The figure below shows the different parts used in order to produce this prosthetics legs. There two motors are used to control the knee joint and the ankle joint. The prosthetic foot ac as the suspension element and then the load cell is used to measure the force acting on the system. The battery is located in the knee section and the whole system is been controlled using microcontroller [22]

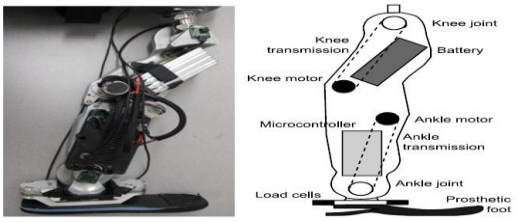

FIGURE 14: TORQUE CONTROL LEG WITH LABELED DIAGRAM [35]

PROSTHETIC KNEE USING 5 BAR MECHANISM as the name only suggest the whole mechanism is based on the basic geared five-bar mechanism. Thus there are 4 as well as the 6 bar mechanism which are not much more adaptive and flexible. Compared with the basic 4 bar and 6 bar mechanism their 5 bar geared mechanism is much more effective in bringing the flexibility in diverse movement and is easy to control. The control on the motion is such that mechanism is capable enough to precisely control the angle and trajectory of the ankle joint. The centroid of this prosthetic knee is been designed according to the centroid of the human knee which is been mechanically optimized. Thus in addition, the stability control of this prosthetic knee joint during the swing and stance phase is achieved by a motor. By adjusting the gear ratio this stability isbeen achieved. [36]

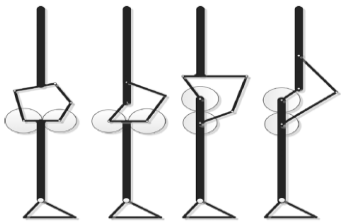

FIGURE 15: KNEE WITH 5 BAR MECHANISM WITH DIFFERENT POSITION [36]

During sit to stand position we generally uses the large torque to move our body. It becomes very important during the sit and stand position to control the torque either to increase to certain level or to degrease the over torque applied. Thus to control this torque a specialized technique is been utilized to control this torque by using the lead screw mechanism this function is brought into existence. Thus during the sit to stand position we require extra torque at our lower limb, by which we stand up. Thus one of the system developed is shown in above figure. The sit to stand laps are been marked with the help of the weight bearing between the paretic and unaffected legs. Thus this problem is been solved by the knee extension torque by powered exoskeleton. This mechanism is capable enough to produce the toque up to 80 Nm and at the speed of 3 rad/s. The transmission system used here is with the help of the series of fiberglass beam spring which his used to control the torque and also used to reduce the output impedance. Thus in this way the high level sit to stand torque controller is been designed. The controller could rotate up to 120 degree. The position of this lever is been measured by the rotary encoder and are been controlled precisely. Whereas the linear encoder is been used to measure the linear displacement of the linear guide from the original position in order to control the position of the knee. In this way the control of the torque is been carried out with accuracy. [37]

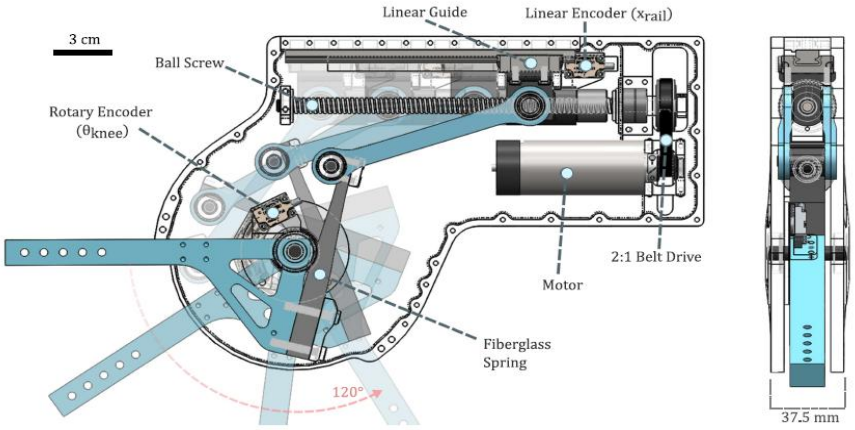

FIGURE 16: ACTUATOR DESIGNED WITH TRANSMISSION COMPONENT LABELED [37]

5.4. LEGS BASED ON DAMPING features

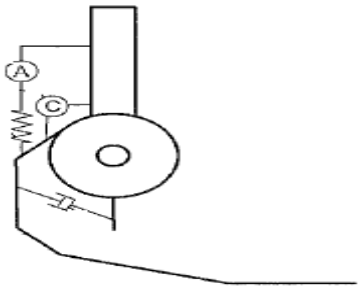

FIGURE 17: SPRING MASS DAMPING SYSTEM [38]

In this technique there the artificial foot and ankle is been created with the spring and damper system. This spring is of special type as we see in the trucks and other commercial vehicle the spring is of special shape which is also called as leaf spring, this spring is used in this artificial foot and leg joint. The shape of the spring is curved in shape as shown above and the one end is connected to the ankle joint while other end is free which touches the ground. This spring is elastic in nature where it acts just like a heel and used for the rotation of the ankle joint. The actuator is used in this invention is motor which applies the torque

to the ankle joint to bring the foot in to alignment when the foot is not touching the ground where as the spring is cantilever type supported this spring act as store house of the potential energy and the energy is also stored inside of the catapult mechanism or spring. This catapult spring is brought into action when the energy from the leaf spring is release into kinetic energy form to allow the user to move or propel forward. The limited restriction is been given to the foot to not to allow it to rotate the foot in circular manner this restriction is brought out by the specialized clutch named ribbon clutch as, as soon as the foot tries to the move beyond the certain limit this clutch activates and stops the foot. During the travelling we run, jumps, climb the stairs, play sports there the vibration are generated. Our foot naturally consist of the damping system preinstalled but we designed the artificial foot large amount of the vibration is been developed which is been needed to control. Thus due to this reason the damper is employed to absorb vibration as a form of mechanical energy. Whereas the other uses of this damper is to lock the ankle joint. The controller with the help of the sensing devices or in general we call it as the sensor. Is used to control the motor and the damper system at the time of the walking, running, playing climbing stairs, etc. thus another methods which uses the springs, and variable-damper elements is discussed below. [38]

The legs damping system shown below prosthetics uses the electromotor for Supplying kinetic energy and in return gets the stored potential energy from an artificial joint, as well as system uses shock absorbing element such as springs, and controllable variable damper components, for secondary storing and releasing energy and providing adaptive stiffness to achieve level ground walking as well as movement on stairs and Surfaces having different slopes. [39]

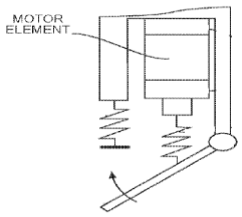

FIGURE 18: ELECTRO MOTOR DAMPING SYSTEM WITH SPRING AND DAMPER SYSTEM [39]

When we say damping the magnetic damping is one of the methods used to control the vibration and shocks. Thus based on this damping another technique used to control the the prosthetic legs are discussed. [40] In this technique the major problem associated with vibration is solved with the help of the specific apparatus and its system along with the method utilizing the electro-magnetically damped joint for prosthetics or orthotics. The system is controlled in such a manner that the change in the resistive nature of the electric circuit in which the braking or damping mechanism is sufficiently added which results into the biomechanical movement. This can be only brought into the use by using the advance electronic circuitry means only, or through the use of intelligent control through a microprocessor and dynamic ambulation replication algorithms.

Not just electro-magnetic damping the hydraulic damping is also used to control the vibration. These technique is stated as, in these technique the spring mass damper system is been used to control the vibrations for controlling of the swing-phase damping in an above-knee. The linear spring and damper model is used to locate the properties of the damper. Thus due these model three control parameters that drives the damping force and displacement of the damper have been located. The parameters of the damper are obtained from the prosthesis knee angle with a desired knee angle trajectory. [26]

5.5. BASED ON EXTERNAL SENSORS CONTROL OF THE HAND

TONGUE CONTROL ROBOT

The system comprises of the inductive tongue control system (ITCS) for controlling bionic hands and arms. This

system is the combination of the electromyogram and the inductive tongue controlled system. This system is been used for the control of the multi grasp robotic hand. The control system is been implemented on the IH1 Azzurra robotic hand thus in this system after lots of research it is found that the conventional EMG control system works slower than the ITCS based system. Thus approximately the conventional EMG system is 1.15 seconds slower than the ITCS based system. Thus by implementing this system we get the 35.4 % reduction in the actuation time. Thus results also indicates that the ITCS control system is much faster and convenient to use. [41]

5.6. BASED OF ACCLEROMETRIC SENSORS

The Accelerometers sensors are specially designed sensor used to measure the alignment of the alignment of an object. Thus can tell us the proper orientation of the object and need to improve the level where ever required. In this system the prosthetics hand is been controlled by this sensors. Thus sensors which are used here plays the role for measuring the orientation of the limbs and used to control the torque required to move the limbs from one place to another. This system has to perform 3 application, in controlling the power wrist and power arm. By addition of sensors to the arm the input from the user made simple to operate the bionic. There is no need to correct the orientation of body as they move as the accelerometers sensors already detects the motion and orientation. [42] The controller for all uses is a distributed set of microcontrollers, one node for each joint, linked with the control area network bus. In this control form, the user gives simpler input commands and leaves the detailed control of the arm to the controller. [42]

5.7. SLIPPAGE AND DEFORMATION PREVENTIVE CONTROL OF BIONIC PROSTHETIC HANDS

When we say the bionic hand, firstly things came into our minds are mechanical linkages with certain sort of the actuators and sensors working together to control one prosthetic hand. Thus there are lots of parameters which are involved in the control of the bionic hand. Thus they are control of the hand position to a certain level and sensory feedback, control of the torque at specific area, etc. Thus when we say the torque controlled at certain area then and the there are certain areas where we need to apply the specific amount of torque, which is at the gripping section. There are various object which are very delicate to operate where if we increase the toque by a certain limit then the object may get deform and then at certain cases if we apply less torque then even the object will get slip from the hand. By our natural hand we could recognized the stiffness of the object and apply the force accordingly. Thus in the prosthetics there are lack of the sensory feedback. Thus in order to control the torque of the gripping force many system is been develop one of them is discussed below:

The system comprises of the bionic reflex control system designed to perform the reflex control function for a prosthetic hand. The Lagrange method is used to obtain dynamic model of under actuated tendon-driven prosthetic hand. Then the force sensor is been used to sense the slippage of the grasp object based on the empirical mode decomposition. Then, a polyvinylidene fluoride sensor is used to find out the stiffness of an object, by applying the grasping force to avoid deformation. [43]

5.8. BASED ON FEEDBACK

5.8.1. ELECTRO-TACTILE FEEDBACK SYSTEM FOR A PROSTHETIC HAND

THE AMPUTEES still disable if they won't have the sense of touch, thus it become very difficult for the amputees with prosthetic hands to apply the necessary amount of the force to an object where the amputee if does not have this sense the nit become very difficult to control the arm. Thus thanks to the targeted sensory Reinnervation technology (TSR) this defect is been solved by applying the some sort of the tactile sensor on to the substrates body the sensation of touch and position of the

arm, etc. is brought out. Although some sort of force sensors and implanted electrodes, brings this sensation signals to the brain. But by using these systems which is expensive, surgically invasive and can represent an infection risk where cables emerge through the skin which is very risky. To solve this problem the said system comprises of an electro-tactile feedback system for prosthetic hands. This system is based on force sensors that can be placed almost anywhere on a prosthetic hand, and TENS electrodes that can be placed on the wearer's arm. This system is inexpensive, multi-channel and easily fitted to existing prosthetic hands. [44]

5.8.2. FUTURE TRENDS AND INPROVEMENT REQUIRE FOR DEVELOPING THIS TECHNIQUE

Up till now we have seen various types of improvement in the terms of the physical disability such as the hand and leg amputee. Thus we need to move forward towards the next and most complicated disability such as the spinal cord injury, spondylitis, thus by focusing on this kind of disabilities we will move more forward and will really develop the society where the persons with this kind of disability will be helped. There must be a technology which are developed by combining all the developed technology and extract all there advantages combine together and produce such a hand which will be feasible for the replacement of the original hand same goes for legs also.

Many system are been developed by the people but only few are brought in to existence. Thus due to cost and many problems many didn't receives this technology thus someone should take the responsibilities and brought this technology into the market. Thus various types of the physical disabilities which we should be focus on are mentioned below:

6. TYPES OF PHYSICAL DISABILITIES

There are two major categories under the Physical Disability Group, they are:

6.1. MUSCULO SKELETAL DISABILITY

It is defined as the inability to carry out distinctive activities associated with movements of the body parts due to muscular or bony deformities, diseases or degeneration. The disabilities grouped under musculo skeletal disability are:

1. Loss or Deformity of Limbs
2. OsteogensisImperfecta
3. Muscular Dystrophy [45]

6.2. NEURO MUSCULO DISABILITY

It is defined as the inability to perform controlled movements of affected body parts due to diseases, degeneration or disorder of the nervous system. The categories are:

1. Cerebral Palsy
2. Spina Bifida
3. Poliomyelitis
4. Stroke
5. Head Injury
6. Spinal Cord Injury [45]

CONCLUSION

Thus by this we can say that during the medieval period the prosthetics were not fully developed and are having large constrains. But as the time passes the method of controlling improved and types of actuators and different kinds of mechanism came into existence. The precision and control of the bionics developed and the feedback system for the brain is also developed. We can also say that for controlling the same prosthetic many researchers have made their research with different kinds of mechanism.

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