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A REVIEW ON EMBEDDED CONTROL OF ANIMATRONIC PROSTHETIC HAND

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Abstract: this paper is a review of different prosthesis hands that are commercially available. Prosthesis is a functional replacement for an amputated or congenitally malformed or missing limb. Such prosthesis are been developed commercially, such as smart prosthesis hands, micro controller prosthesis hands, fluidic prosthesis hands, cosmetic prosthesis hands and industrial prosthesis hands but which are still are not providing higher level DOF's and flexibility. This paper describes that advantage of building an embedded based prosthetic hand which can be controlled by a combination of inputs from several sensors.
Index Terms: Prosthesis, DOF, amputated, cosmetic, fluidic.

I. INTRODUCTION

The prosthesis [1] is the artificial machine that can replace the missing part of the body. Prosthesis need to be designed and placed according to the patient's appearance and functional needs as natural. Robots are generally used to perform unsafe, hazardous, highly repetitive, and unpleasant tasks. Here by Embedded Systems are influencing all tasks of life and development in the field of embedded systems and VLSI technology has brought a revolutionary change in the field of medical science. The development of electrical prosthesis is getting more and more advanced with advancement in embedded technology. Replacing an amputated arm with a prosthesis that has the functionality of the human arm have been tried innumerable times. Embedded technology makes it a reality to build a prosthetic limb with several degrees of freedom. The improvement of animatronics provides useful technology for the transhumeral prosthesis. Transhumeral prosthesis can be said to be prosthesis designed for AE amputees. In order for the prosthetic part to work, there should have several components need to be integrated into the body's function. Sensors detect the signals from the human nerve or muscle, limbs [2]…etc, Then this information is carried to the micro controller and processes feedback from the limb and then to the actuator and sends it to the controller. The controller is responsible for the monitoring and control of the movements of the device. In this paper, the review of the different prosthesis hands are discussed, an actuator mimics [1] the action of the muscle in producing force and movement, some prosthesis include a motor that aids. Recently, robotic limbs have improved in their ability to take signals from human brain and translate those signals into motions in the artificial limb. Advancements in the processors used in myoelectric arms have allowed developers to make gains in fine tuned control of the prosthetic. Cosmetic prosthesis [11] [14] has long been used to disguise injuries and disfigurements. With advances in modern technology cosmetics, the creation of lifelike limbs made from silicone or PVC has been made possible. Such prosthetics, such as artificial hands, can now be made to mimic the appearance of real hands, complete with freckles, veins, fingerprints. Custom-made cosmeses are generally more expensive, while standard cosmeses come ready-made in various sizes, although they are often not as realistic as their custom-made counterparts. Another option is the custom-made silicone cover, which can be made to match a person's skin tone but not details such as freckles or wrinkles. Cosmeses are attached to the body in any number of ways, using an adhesive, suction, form-fitting, stretchable skin, or a skin sleeve. The paper analyses the control of a prosthetic arm with several degrees of freedom [2] [3] in different methods, based on the anatomical and biomechanical features and functions of the hand to perform grasping movements performed by the fingers and movement of the elbow and the wrist.

II. PROSTHETIC HANDS

A. ISSUES RELATED TO CURRENT PROSTHETIC HANDS

Currently, commercial prosthesis available on the market but provides a lesser DOF. Some of prosthesis provides elbow tighten-expansion motion. Along with the elbow motion, some prosthesis provides forearm supine-prone motion and a 1 or 2 DOF. Commercially available prosthesis which is cosmetic provides more natural appearance and simple control. But their efficiency is poor compared to the human hand. To improve the quality of life of AE amputees and to expand their ability in daily life activities, several DOF powered prosthesis is reviewed in this paper.

B. CURRENT PROSTHETIC HANDS

1. Space robotic hands

Prosthetic Hand [1] [11] [15] is one of the under development for space use and the compact in size and capability to a suited astronaut's hand. The hand and wrist parts are made fairly large to replicate the required strength needs. Parts of the hand is made of distinct substances are tolerance to perform functionality under the heavy temperature variations. Motors are used to provide long life in a vacuum. All parts are designed to use validate space lubricants. Robotic Hand has a total of several degrees of freedom. It consists of a forearm which houses the motors and drive electronics, a two degree of freedom wrist, and a

five finger, twelve degree of freedom hand. Robonaut hand [1] is the one having the forearm, which measures four inches in diameter at its base and is approximately eight inches long, houses all fourteen motors, 12 separate circuit boards, and all of the wiring for the hand. The prosthetic hand itself is divided into two sections: a masterly work set which is used for manipulation, and a grasping set which allows hand to keep in a balanced grasp while manipulating or actuating an object. This will be the basic feature for tool use. The fingers are mounted into the palm. Prosthetic hand [1] [10] can be designed with the tendon operated multiple-degree-of-freedom dexterous hand (DH) with multichannel touch-sensing capability is developed. The prosthetic hand [1] [10] [13] will be having the same dimension as the human hand. It can have five fingers, they are four fingers and a thumb arranged in a very anthropomorphic configuration. Each finger can have four degrees of freedom and can operate at five times of human's finger speed, along with handshake. Their bending and prolongation are controlled by wire operated by pneumatic pistons; this is adopted in the hand. By using the finger motion of forces the grasp can react, to some degree, to the object being grasped. We can use 4 types of sensors on the hand, motor position sensors, joint position sensors, tendon tension sensors and tactile array sensors. According to the signals detected movement of the hand is performed.

2. Micro controller Animatronic hand

This is an animatronics hand [1] [10] [13], the palm; the fingers and the forearm can be fully made of wood or rubber material. There are sensors to sense and there are motors to actuate. The motion of the hand is sensed by the sensors mounted on the fingers and palm. That information is processed by the micro controller, which is capable of controlling motors. The fingers are arranged by tenders pulled by motors. Motors are controlled with a micro controller. This prototype can perform a good amount of different grips and take or pinch. The hand is of more strength in which the even parts are made of wood. It's strong and very compact.

3. Industrial robotic hand

Industrial robots [7] are available commercially in a wide range of sizes, shapes etc. they designed and fabricated with different design configurations and different number of axes or degrees of freedom. The configurations are of servo and non servo controlled. Servo robots are controlled by sensors that continually monitor the robot's axes and associated components for position and velocity. This information is stored in robot's memory via feedback. Nonservo robots do not have feedback capacity, and their axes are controlled through a system of mechanical stops and limit switches. The teach mode will be responsible for the movement of the arm i.e, the control state that allows the generation and storage of positional data points effected by moving the robot arm through a path of motions.

4. European robotic hand

European robotic hand [8] is a robotic arm to be attached to Russian segment of the international space station. ERA has two limbs: symmetrical arm sections made of carbon fiber, approximately 5 mts long, two identical gripper mechanisms also capable of transferring data, power actuation to payloads, two wrists with three joints each, one elbow joint, one central control computer within the arm. Have four camera and lighting units. ERA has features such as ability to 'walk' around the exterior of the Russian segments of the station under its own control, moving hand-over-hand between prefixed base points, and ability to perform many tasks automatically, results in freeing its operators to do other work.

5. Optoelectronic hand

Optoelectronic [9] is based flexible contact sensor for Prosthetic hand. The optical fibers are placed on the fingers. The light rays always given as input to fiber. The sensors that could be used for the detection of variations in the human muscle depending on the intensity variations in the light rays in optical fiber, which is used as the input for operation of prosthesis. The optoelectronic sensor placed on the robotic finger, which could able to recognize the variation on the infrared light. They specified the advantage of optoelectronic material is flexible, reduced resistance, negligible hysteresis. The optoelectronic signals are utilized for the operation of the robotic hand. But the optical materials faces issued such as stretching, termination, splicing, and critical angle when the fiber bends.

6. The cosmetic prosthetic hand

The cosmetic prosthetic hand [10] [14] design (fingers and palm) made of soft material by single production process, which produces actuation. This prosthetic hand functions by EMG control, which is simple and of low cost design. The hand structure molded on as soft polymeric part alone. The mould is made by rigid polyurethane. The hand operation could be EMG signal control of DC motor attached to it, which defines its movement. The operation of the prosthetic hand is said to be cables fixed to the fingers and to the pulley in complaint joints, where DC motor is used to pull the cable. This approach is having only one DOF's, and produces only 100N, important property that cosmetic hand uses EMG signals for its operation, EMG signal sensors must have higher accuracy to operate. The above statement can be considered as requirement and drawback of cosmetic prosthetic hand for AE amputee. The multifunctional cosmetic prosthetic hand is a fluidic hand [10] [14] is operated by an electronic module that transmits human arm variables from computer to the micro controller in wireless method. The fluidic hand type of prosthetic hand containing viscous oil liquid in the fingers and forearm, the liquid in the arm is responsible for movement of the hand. The fluidic hand uses DC motor to drive the hydraulic pump attached in the palm of the hand. The 5 valves, which are independent functions [2] [3] as artificial fingers, could be able to transmit pressure to bag bellows at the joints. A single motor

connected to a hydraulic pump, which pumps viscose liquid into the joints of the fingers. The pumped force in terms of analog voltage values are evaluated by micro controller. Such changing in physical state of human arm carries and have reliable change in prosthesis hand. Resulting in respective fingers bends up to 900. Human hand produces average of 95.6N maximum up to 400N. To do daily activities 68N is needed normally. Fluidic hand produces maximum of 100N.Fluidic hand have 5 grasping patterns such as index position, tripod pulpa grasp, cylinder grasp for complete hand and hook grasp.

III. METHODOLOGY

The prosthesis which is to design to generate elbow flexion-extension, forearm supination-pronation, wrist flexion-extension and radial-ulnar deviation, and hand cylindrical grasp-release motion. Currently, no commercial prosthesis provides wrist flexion-extension and radial-ulnar deviation motion, which have importance to perform daily life activities. A number of prosthesis capable of generating multi-DOF motion has been proposed for upper limb amputees. However, none of these provides a combination of forearm and 2 DOF wrist motion except the prosthesis designed for above wrist amputees. To imitate human arm function during prosthesis design, it is essential to use flexible actuators that can act like human muscles. In this study, traditional rotary DC electric motors are used to generate the required motions. Moreover, placing the hand motor in the forearm part reduces the inertia effect and provides sufficient grasping area in the palm. In commercial and current prosthesis, the terminal device is mounted on a circular rotating unit to provide forearm supination-pronation motion, which is different from their biological counterpart. In human arm, the radius and ulna bone of the forearm are almost parallel to each other in supinated forearm position and the radius bone crosses over the ulna bone in pronated Position. A joint and wire tension mechanism is used in the wrist part to accomplish two DOF wrist motions. The prosthesis provides sufficient joint torque compare to normal human arm, and the weight and length of the prosthesis are kept similar to normal human arm. The present prosthesis hands produce certain functions (motions) such as elbow motion and forearm motion.

A. Elbow Motion

The elbow joint [5] of the prosthesis which needs permit maximum flexion. One of the main features of the designed prosthesis is that the elbow motor is placed on the point of attachment of the forearm which provides sufficient space in the amputee arm holder. Rotation of the elbow motor will cause the whole forearm part to rotate relative to the arm holder part, like human elbow joint.

B. Forearm Motion

The designed prosthesis must provide 60o-70° [5] forearm supination-pronation motion [2] [3]. In normal human elbow complex, the radius bone of the human forearm crosses over the ulna bone during pronation motion whereas during supination motion they lie just about parallel in position. The prosthesis provides more freedom and flexible on movement.

C. Wrist Motions

The wrist joint of the prosthesis must permit two DOF motions [2] [3], and the allowable range of motion is 50° for both of flexion and extension motion and that of for radial and ulnar deviation is kept 30° for both. This fundamental concept is implemented to position the wrist motors on the forearm. The motor to provide wrist flexion-extension motion. The part of wrist motor holders also act as a mechanical stopper during forearm motion. When the motor rotates, the tangential force of the pulley is transmitted to the wrist joint by the movement. The movement of the inner cable is used to generate pulling force at the wrist joint to provide required motions.

IV. CONCLUSION

This paper is a review of the different prosthetic hand designs and detailed content about DOF, flexibility, material used for current commercial prosthesis, present prosthetic hands are still need to upgrade for providing the function of elbow movement, but if the prosthesis hand can mimic of human hand where sensors placed, provides elbow movement and cylindrical grasp-release motion, in real time system which provides higher torque is very useful and built at lower costs. The current commercial prosthesis which uses (electromyographic) EMG (electroneurographic) ENG signals to actuate the prosthesis, but it may cause biological issues with the hand. This concludes that compared to all other prosthesis the animatronics prosthesis is benefit.

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