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Near Normal Control of Upper Limb Prosthesis to invoke Multiple Levels of Freedom for Above Elbow Amputees

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As technological development improves the lives and comfort level of human being in much aspect, the same is not achieved in upper arm Amputees cases. The existing prosthetic upper limb design suffers from a major disadvantage of lack of support of near normal control of prosthesis. In addition to myoelectric control, Proprioceptive feedback is obtained by magnetic field sensors through processing the variation due to the arm bone movement. In this paper, a method involves in implanting a small permanent magnet in the humerus bone of the AE amputees to provide feedback for near normal control of prosthesis.

Key words: Myoelectric, Prosthesis, Above Elbow amputees.

Even though technological advancement has eased the difficult of many physical challenged cases, the upper limb defectives are poorly served by rehabilitation services providers, this is due to the limited support & poor commercial services for the amputees. As a consequence most are patient are inaccessible to the solution or have to tolerate with the prosthesis or has to limits their lifestyle .In the last decade , an marvelous boost in the research of upper limb defectives have lead to vast acceptable performance. Myoelectric systems play a vital in the control of prosthetic devices designed for individuals with amputation or who have deficient upper limb right from birth. The system extracts the variation from myoelectric signal (MES) and operates with the obtained readings.

Myoelectric controller's posses a great effect on the life of limb deficient persons. Technological advances have led the research in myoelectric control of prosthesis by applying various techniques on electromyography (EMG) signal to improve the control strategies designed for artificial limb. The various control strategies for artificial upper limbs discussed in the literature have been implemented and tested on electronic systems designed by several researchers. Even though, the hardware designs were dependent of the available technologies at the time, they have set an important precedent for future versions. However, the control strategies discussed in the literature are having no access to the solution for near normal control. The major disadvantage of myoelectric prosthesis is lack near normal control of prosthesis. By exploiting the recent advances in the technology, a novel control strategy which is proposed to process EMG signal and also obtain feedback from the voluntary movements of distal end of the residual humerus of the amputee to achieve near normal control of prosthesis.

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Also, it is essential to have a common platform for evaluating the various control algorithms developed in past as well as future. Hence, an electronic test bed for evaluating the control algorithms developed by processing the EMG signals for artificial upper limb has been proposed.

MATERIALS AND METHODS

Factors like core diameter which fits the diameter of the magnets used and external issue give the layout idea to design the orthopedic screw. The conventional cylindrical neodymium magnets are used. These magnets have flux line same as bar magnet. The placement of magnet is done in such a way that it is parallel to the cross section of the arm. While considering the size of the magnet the average diameter of the humerus bone and orthopedic screw are consider.

Humerus bone can hold diameter ranges between 4.5mm to 6.5mm of orthopedic screw.since the humerus bone diameter ranges between 24mm-30mm in generally and intern is 23mm for male and 18mm for female, the magnet size should be between 2mm diameter to 6mm. The orthopedic screw length is around 20-46mm.the orthopedic screw must be a non-magnetic material ,so titanium is used ,which has a outer diameter of 6mm & inner core diameter of 3mm. Figure 1 shows magnet with dimensions and the screw model.

Depending on the variation of the magnetic field in the real time environment the evaluation are made. Majority there are three kinds

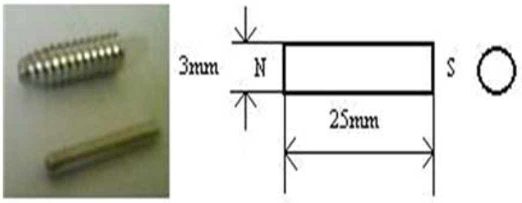

Fig. 1 :a) Screw model b)Magnet Dimensions

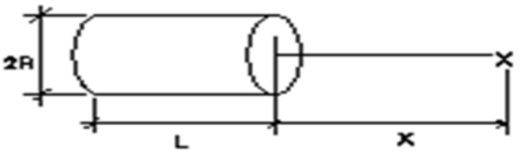

Fig. 2. Sensor Model

of variations that are considered:

- → Deviation from the center of the magnet depends on the humerus position in the socket.
- → Orientation decline in the magnet due to surgical implantation.
- → Displacement by the magnetic sensors while in usage

Flux variation

$$Bx = \frac{\mathrm{Br}}{2}\left(\frac{(\mathrm{L}+\mathrm{X})}{\sqrt{R^2+(L+X)^2}} - \frac{(\mathrm{X})}{\sqrt{R^2+(X)^2}}\right)$$

Length - L
Radius - R
X - from the pole surface
Br -residual magnetic flux density

Hall voltage

$$\mathrm{VH} = \frac{\mathrm{IB}}{\mathrm{ned}}$$

n = Density of mobile charges
e= Electron charges

(Figure 2) Magnetic field sensor- AH3503 accurately tracks changes in magnetic flux density. In the Initial teststhe following is inferred.

- → The output voltage is proportional to magnetic flux density. This sensor is extremely sensitive and operates at 4.5 to 6 V, with low-noise output.
- → Magnetic field density = 0 (Guass) is nominally half of the supply voltage. A south pole, presented to the Magnetic field sensor will drive the output higher than the null voltage level.
- → A north pole will drive the output below the null level. The output of the IC linearly changes with the magnetic flux density (input).

The two sensors S1and S2 are mounted on the two sides of the socket sothat it lies in the close proximity of the magnet as shown in Figure 3. For the null position of the humerus, the air gap is 25mm; above this distance the magnetic flux sensed by the Hall Effect sensor is zero.The difference in voltage from the two sensors S1 and S2is given to a comparator.

Simulation study is carried out with the help of ISIS Proteus software to test the feasibility of implementing the proposed work. The logic

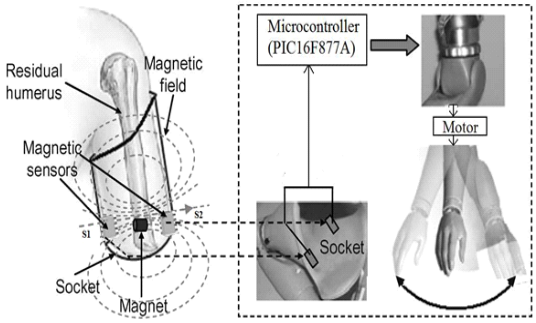

Fig. 3. Control system of Prosthesis Movement using Magnets

which helps the embedded controller to achieve near normal control (along with the myoelectric control) is obtained through simulations. The initial sample simulation results (sensor output voltage)are shown in Table 2.

The overall design of the proprioceptive feedback part of the work is shown in Figure 4 inthe form of block diagram.

Prosthetic hand fabrication

The socket dimension is made based on the stump (patient) measurement and the embedded control circuit. A cast is made of Plaster of Paris for the Patient stump and is coated with epoxy Resin for insulation of the circuits.The

Position	Sensor – Output Voltage: North Pole towards sensor (B.S.) Without Screw (V)	North Pole towards sensor (B.S.) With Screw (V)	South Pole towards sensor (B.S.) Without Screw (V)	South Pole towards sensor (B.S.) With Screw (V)
0 cm – Min	0.93	0.88	4.30	4.34
to	1.32	1.34	4.23	4.26
2.25 cm – Max	1.77	1.78	3.69	3.69
	2.22	2.25	3.23	3.25
	2.52	2.52	3.01	3.03
	2.58	2.59	2.88	2.88
	2.68	2.64	2.65	2.69

Comparator C1: $S_1(V_{in-})$	Comparator C1: $V_{ref}(V_{in+})$	Comparator C2: $S_2(V_{in-})$	Comparator C2: $V_{ref}(V_{in+})$	Output	Direction of the Motor
0.880	2.50	2.50	2.50	1 X	Right
2.50	2.50	4.340	2.50	X 0	Left
2.50	2.50	2.50	2.50	X X	No Operation

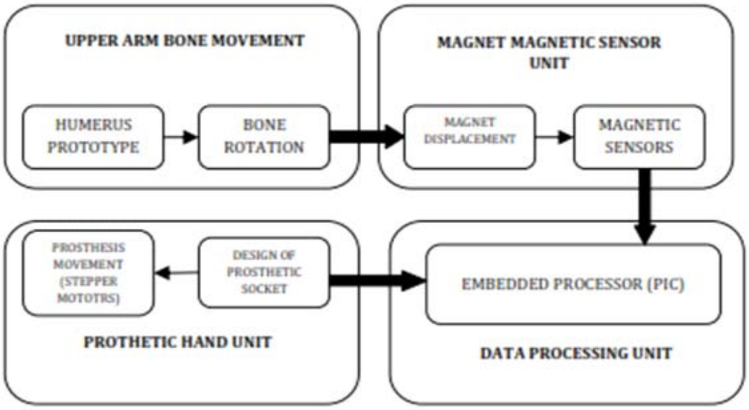

Fig. 4. Overall Block Diagram

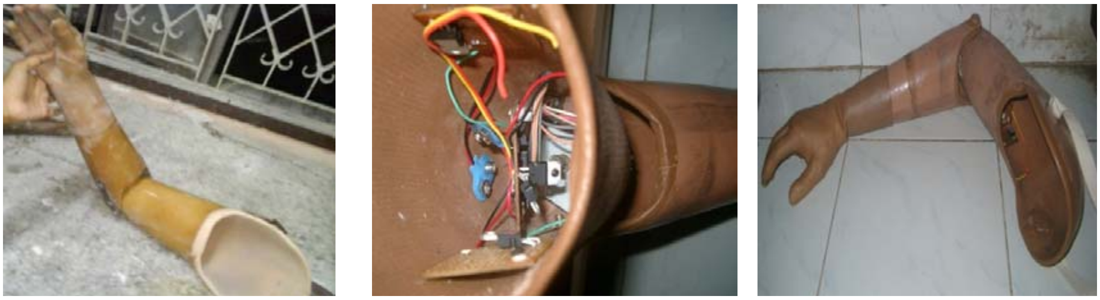

Fig. 5. Implementation Model

diameter of the socket is calculated to be 50mm. the length of the socket varies for patient to patient requirement. Thus a cosmetic hand is converted into a function hand.

CONCLUSION

The lack of proper feedback has restricted near to normal control, which intern affects use of prosthesis and reduces the functionalities. The proposed methodology uses a permanent magnet in the humerus bone helps in controlling the prosthesis movement. The proposed prostheses can be attached to the exterior of the body, in a non-permanent way.

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