International
Journal
Of Advanced Research in Engineering & Management (IJAREM)
ISSN: 2456-2033 || PP. 65-67

Control of Power Assisted Upper Limb Exoskeleton Using EMG

Shali.S.S[1], Aksa Anna Vinoy[2], Shahin.P[3], Priya Ajayaghosh[4]
(Department of Biomedical Engineering, TKM Institute of Technology, Kerala, India,
Email: [1]shaliss05@outlook.com, [2]aksa.vinoy@gmail.com, [3]shahinavala@gmail.com, [4]priyuag@gmail.com)

Abstract: Upper limb exoskeleton is a collaborative robotic external artificial hand exoskeleton that supports and protects the human body. It complements the existing human skeleton by sharing the load (in part or full) along with augmenting the human body's torque with that of the exoskeleton. This device is a powered exoskeleton which is a wearable robot that can be driven by a system of electric motors, pneumatics, levers and hydraulics or a combination of technologies that allow for limb movement, endurance and strength. Electromyography signals play a pivotal role in controlling powered exoskeletons. Existing methods introduce bulky wheelchairs, crutches etc. for movement of paralyzed patients where they move as a whole. The device here permits the movement of individual body parts such as upper limb which is driven using a linear actuator whose motion is controlled using EMG signals obtained from the subject's limb.
Keywords: Exoskeleton, EMG, Actuator, Processor, Sensor

1. INTRODUCTION

The world population is aging rapidly, more and more elders suffering from old age disorders [1] and neuromuscular diseases [2] involving disability of upper limb. Exoskeletons have potential applications in the medical field which include helping people who are unable to maintain their balance on their own or cannot move their limbs or suffering from neuromuscular disorders. The assistance provided by exoskeleton can be exploited in a myriad of ways including augmentation, enhancement of strength or to restore normal abilities in patients affected by movement disorders such tremor, hemiplegia, paraplegia or for neuro- muscular rehabilitation.

Forearm pronation/supination motion and elbow flexion/extension motion have been assisted by exoskeletons using EMG and Neuro fuzzy logic [3].A 3 DOF mobile robotic exoskeleton have been designed for rehabilitation which is controlled by a proportional controller [4]. Exoskeletons which are directed using intention uses force sensing resistors (FSRs) and a concept called "intentional reaching direction" (IRD) [5]. Powered exoskeletons can be driven by an EMG- proportional controller [6].

In this paper we explore algorithm based EMG control of an upper limb exoskeleton. EMG signals are picked from the body using electrodes, which are processed using a sensor. The PC interface and processor drives the actuator that regulates the exoskeleton movement. EMG is diagnostic technique for recording and assessing the electrical activity of skeletal muscles. EMG electrodes detect the electric potential generated by muscle cells when these cells are electrically or neurologically stimulated. Detection of medical abnormalities, activation level and the biomechanical motion analysis of human or animals is possible by evaluation of EMG signals.

2. MODELLING

2.1 The ENERGIA platform

The Energia is the software prototyping platform. This open source and community-driven integrated development environment (IDE) software brings the wiring and Arduino framework to Texas Instruments MSP, TM and CC based LaunchPads. It is operating system independent. Launchpad develops interactive objects with Energia which are stand alone or can communicate with software running on Host PC. Communication can be enabled by addition of wireless modules.

2.2 Controller

The controller is a 32 bit ARM Cortex M4 [7] based microcontroller. It is integrated with DSP, SMID, and MAC instructions. Cortex M4 by ARM has three stage pipeline architecture with branch speculations. It has saturation arithmetic support and integrated sleep modes.

2.3 Sensor

The sensor acquires electric signals from muscles using electrodes which consist of two active types and one reference. It processes and conditions the electromyography signals. The muscle activity is measured in terms of analog voltage through a microcontroller board with an ADC input which is then filtered and rectified.

2.4 Actuator

The actuator is a type of electric motor that converts energy into torque which then directs the operation of the incorporated system. The shaft of linear actuator creates motion in straight line as opposed to the circular motion of a normal motor.

2.5 Exoskeleton Design

The external skeletal framework supports and manoeuvres the upper limb. It is subject specific i.e. designed specifically for each subject. The linear actuator is placed along with the framework and attached to it to facilitate its movement as shown in Fig.1. The device is controlled by the subject's intention to move the limb.

Figure 1: Exoskeleton framework with linear actuator.

3. EXPERIMENTAL PROCEDURE

After setting up the EMG device, the subjects wore this exoskeleton on the right hand. The framework holds the actuator which supports the upper limb. The working is as per the architecture depicted in Fig.2. The sensor threshold values for which the skeleton movement happens is identified and is fed into PC interface through the sensor. The controlling is done by the processor which manoeuvres the actuator which in turn moves the framework.

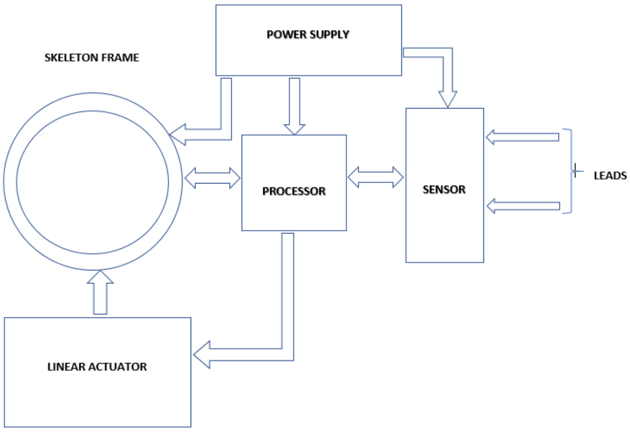

Figure 2: The system architecture

4. RESULTS

The sensor value is obtained and limb augmentation is done for three subjects. The subject includes healthy male, healthy female and an old aged adult. Table I depicts the sensor threshold values. The inference drawn is that EMG signals can be easily picked from a healthy male than a healthy female, thus the augmentation of exoskeleton is more prominent in male than in female. The EMG of an old aged adult is of low amplitude, thus the sensor requires a low threshold. Table I depicts sensor threshold values of various subjects.

Table I: Threshold Values For Various Subjects

Subjects	Sensor Threshold Values (mV)
Healthy Male	600-2000
Healthy Female	500-1300
Old Aged	100-150

5. CONCLUSION & FUTURE WORKS

This work uses EMG obtained directly from the subjects for the flexion and extension movements of the exoskeleton framework. This EMG signals can be obtained on the same upper limb as where the skeleton is placed in case of partially paralyzed patients. In case of fully paralyzed patients EMG signals can be obtained from any of the limbs which can generate EMG.

Acknowledgements

Authors would like to thank Mr. Sarath Raj S, Mr. James Clinton, and Mr. Nibu Mathew for their valuable support. This project was supported by Electronics Corporation of India Ltd., Hyderabad, India.

REFERENCES

[1] L.Pratali *.et.al*, “Motor Activity in Aging : An Integrated Approach for Better Quality of Life” ,*ISRN, vol.2014*, pp. 1-9,Nov,2014.

[2] Reeves A.G, Swenson R.S, “Neuromuscular system disorders”, in *Disorders of the Nervous System : A Primer*, Hanover, New Hampshire, USA: Dartmouth Medical School, 2008, ch. *21*, sec.3 [Online]. Available: https://www.dartmouth.edu/~dons/.

[3] K.Kiguchi,R. Esaki,T. Tsuruta, K.Watanabe, T. Fukuda, “An Exoskeleton for Human Elbow and Forearm Motion Assist”, *IEEE International Conference on Intelligent Robots and Systems,*pp.3599-3605,2003.

[4] M.H Rahman,K.Kiguchi,M.M Rahman,M.Sasaki, “Robotic Exoskeleton for Rehablitation and Motion Assist”, *ICIIS International conference on Industrial and Information Systems,*pp.241- 246,2006.

[5] W. Huo,J.Huang,Y.Wang, J.Wu,L.Cheng, “ Control of Upper-Limb Power-Assist Exoskeleton Based on Motion Intention Recognition”, *IEEE International Conference on Robotics and Automation,* pp.2243-2248, 2011.

[6] T.Lenzi,S.M.M. De Rossi,N. Vitiello, M.C Carrozza , “Proportional EMG Control for Upper-limb Powered Exoskeletons”, *IEEE EMBS Annual International Conference,* pp. 628-631,2011.

[7] Joseph Yiu, “ Technical Overview”, in *The Definitive Guide to ARM® Cortex® - M3 amd Cortex® - M4 Processors,* 3rd ed.,Kidlington,Oxford,UK : Elsevier , 2014,ch.3, pp. 57-73.