Controlling Exoskeleton Via EMG

Basic Biomedical Engineering Term Paper Report

Submitted By:

Name: **Hari Om Mishra**

Roll No: **21111020**

Section: **A**

Branch: Biomedical Engineering

1st Semester (2021-22)

Email ID: jitendranathm3@gmail.com

Submitted To:

Prof. Dr. Saurabh Gupta Sir

Department of Bio Medical Engineering

NIT Raipur, Chhattisgarh

India, 492013

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"It is not possible to prepare a project report without the assistance & encouragement of other people. This one is certainly no exception."

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Hari Om Mishra

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1 ABSTRACT

Exoskeleton robots are mechanical constructions attached to human body parts, containing actuators for influencing human motion. One important application area for exoskeletons is human motion support, for example, for disabled people, including rehabilitation training, and for force enhancement in healthy subjects. This report discusses the uses, working and the benifits of EMG controlled exoskeleton.The report begins with the small description of EMG i.e, electromyography. It discusses the design and the procedure involved in the sEMG aquiring system. A brief description of acquiring signals, and sending it to actuators have also been given. The different sEMG signals for different body parts motion have also been discussed. At last the process for determining the intensity with which the frame of exoskeleton should move have been given. The report end with the discussion and conclusion part.

2 INTRODUCTION

The requirements on a social, well-functioning, and modern health care system including elderly care—are demanding: it must be flexible enough to encounter the increasing process of change and the related challenges. These changes and challenges are triggered, among other things, by the demographic changes, the increase in chronic diseases, the rising costs, and the impending skills shortage.
Nowadays, robotic systems are used in various medical disciplines and different highly specialized applications, for example, in the field of minimally invasive surgery. Furthermore, technical therapy approaches in physiotherapy and occupational therapy are given more and more importance.
In this project report particular assistance and training devices are in the center of interest. These could be system like powered exoskeletons, active orthoses, or special end-effector-based therapy robots. On the one hand, these systems could provide important support in medical rehabilitation for the therapist and patient and, on the other hand, they could be a help in everyday activities for the elderly or motor-impaired people in their home environment.
Due to the aging society and probably significant increase in chronic diseases of the musculoskeletal and the nervous system, the need for innovation in assistive technologies for everyday activities and rehabilitation is

judged as very high. In general, independent living and acting are strongly connected with the motor skills of the individual. The proper function of the arm and hand in everyday activities—at work or at home—are of vital importance.
Surface electromyography (sEMG) is a widely used technology in rehabilitation research and provides quantifiable information on the myoelectric output of a muscle.

3 What is EMG ?

Electromyography (EMG) is a technique for evaluating and recording the electrical activity produced by skeletal muscles. EMG is performed using an instrument called an electromyograph to produce a record called an electromyogram. An electromyograph detects the electric potential generated by muscle cells when these cells are electrically or neurologically activated. The signals can be analyzed to detect abnormalities, activation level, or recruitment order, or to analyze the biomechanics of human or animal movement. Surface EMG is a non-medical procedure used to assess muscle activation by several professionals, including physiotherapists, kinesiologists and biomedical engineers.

4 Design of Exoskeleton based on EMG signals

Exoskeletons are wearable robots exhibiting a close physical and cognitive interaction with the human users.Over the last years, several exoskeletons have been developed for different purposes, such as augmenting human strength , rehabilitating neurologically impaired individuals or assisting people affected by many neuromusculoskeletal disorders in activities of daily life. For all these applications, the design of cognitive HumanRobot Interfaces (cHRIs) is paramount; indeed, understanding the users' intention allows to control the device with the final goal to facilitate the execution of the intended movement. The flow of information from the human user to the robot control unit is particularly crucial when exoskeletons are used to assist people with compromised movement capabilities (e.g. post-stroke or spinal-cord-injured people), by amplifying their movements with the goal to restore functions. In recent years, different approaches have been pursued to design cHRIs, based on invasive and non-invasive approaches. Implantable electrodes, placed directly into the brain or other electrically excitable tissues, record signals directly from the peripheral or central nervous system or muscles, with high resolution and high precision. Non-invasive approaches exploit different bio-signals:some examples are electroencephalography (EEG), electrooculography (EOG), and brain-machine interfaces (BMI) combining the two of them . In addition, a well-consolidated non-invasive approach is based on surface electromyography (sEMG),which has been successfully used for controlling robotic prostheses and exoskeletons due to their inherent intuitiveness and effectiveness.

It mainly involves the use of actuators and signal gaining devices. These are briefly described below.

4.1 ACQUIRING SIGNAL FROM MUSCLES :

Collecting electromyographic (EMG) signals emanated from the human body using electrodes has become a routine procedure both in rehabilitation engineering and medical research. Nowadays , different types of assistive devices such as externally powered prostheses and electrically powered wheelchairs are controlled using EMG signals. EMG signal is fairly weak and with the unwanted noises. It has to be carefully processed before using it for any health care applications. Signal amplification and filtering

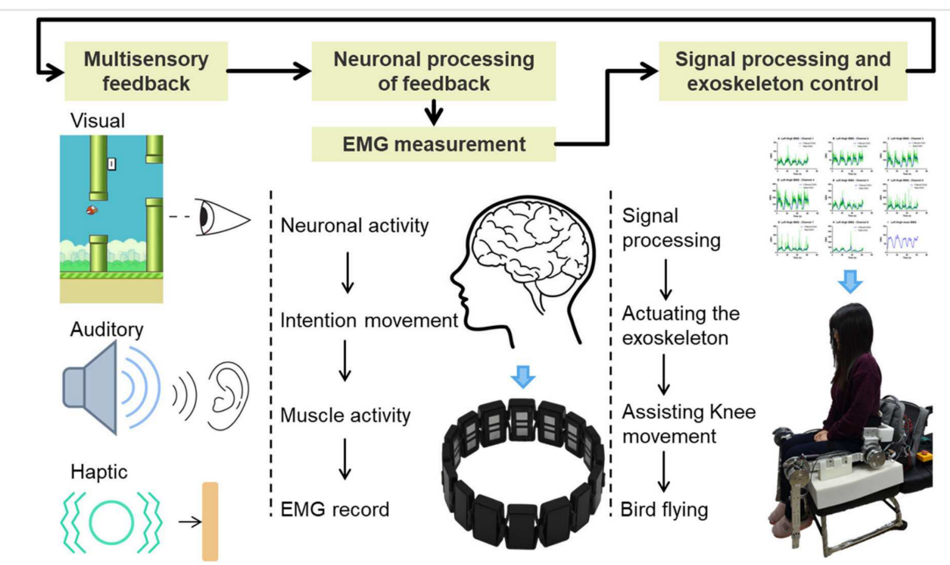


Figure 1: <u>PROCEDURE OF EXOSKELETON RESPONSE TO EMG SIGNAL</u>

plays a critical role in EMG practical application systems. The process is

expected to remain as much information from the physiological EMG signals as possible while it minimises the noise components. The two major functions of amplification and filtering process are the maximisation of the signal to noise ratio and the minimisation of the distortion of the signal. Although there have been many reports and approaches about the design of amplifiers and filters for EMG signal acquisition, better circuit structure and optimised design are still the focus of further research for accurate and reliable EMG signal driven systems.
The signals are acquired from the surface of the body by the built in electrodes in the form of strap or other wearables which act as sensors and they acquire the signals in real time. These signals are filtered and amplified by amplifiers which are then send to the actuators via machine learning algorithms.

4.2 SENDING SIGNALS TO ACTUATOR

An actuator is a device that produces a motion by converting energy and signals going into the system. The motion it produces can be either rotary or linear. An actuator is a device that produces a motion by converting energy and signals going into the system. The motion it produces can be either rotary or linear. An ideal actuator for the exoskeleton should be

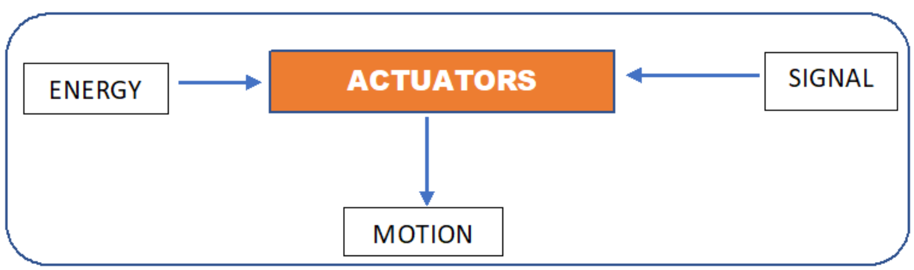


Figure 2: ACTUATORS USES ENERGY & SIGNAL TO PRODUCE MOTION

small and durable but equally efficient.

4.3 ALGORITHM

There are various open source algorithms for the processing of the EMG signals but those are preferred which are simple and have less time complexity.
Many of these algorithms are present on github for controlling exoskeleton.

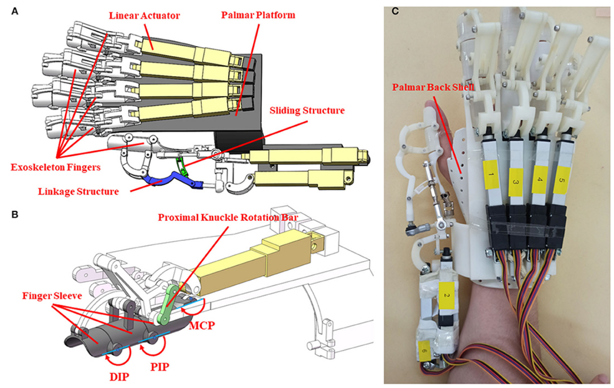


Figure 3: AN EXOSKELETON WITH ACTUATORS

5 Different EMG signals for different motions of Hand

The human upper limb is able to perform sophisticated movements as it has multiple degrees of freedom. However, up until now, it is still a challenge for researchers to model and control human hand movement. In most cases, only certain hand gestures are studied. Similar signals can

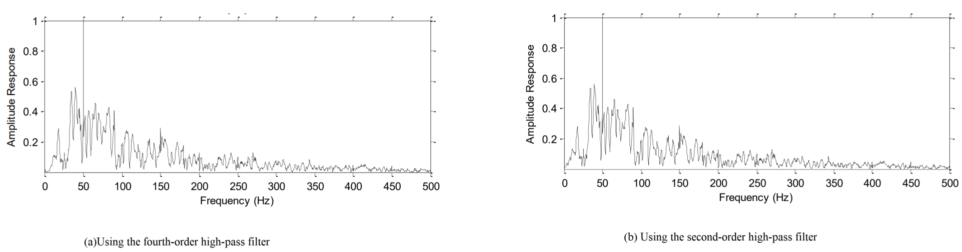
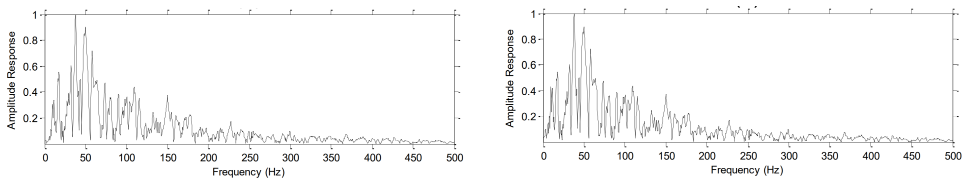


Figure 4: The amplitude response of the EMG Signal of ball squeezing (0-500 Hz)

be found in different parts of the body which are then processed by the required algorithm to send messages to the filter for amplification and removing noise and subsequently send to the actuators.

6 Estimation of Different Intention

While designing an EMG controlled exoskeleton it is very important to determine what the intention of the user that is to determine the action



(a)Using the fourth-order high-pass filter

(b)Using the second-order high-pass filter

Figure 5: The amplitude response of the EMG Signal of forearm flexion (0-500 Hz)

which user wants to perform. The steps involving the same has been discussed in he figure here with reference to upper limb exoskeleton:

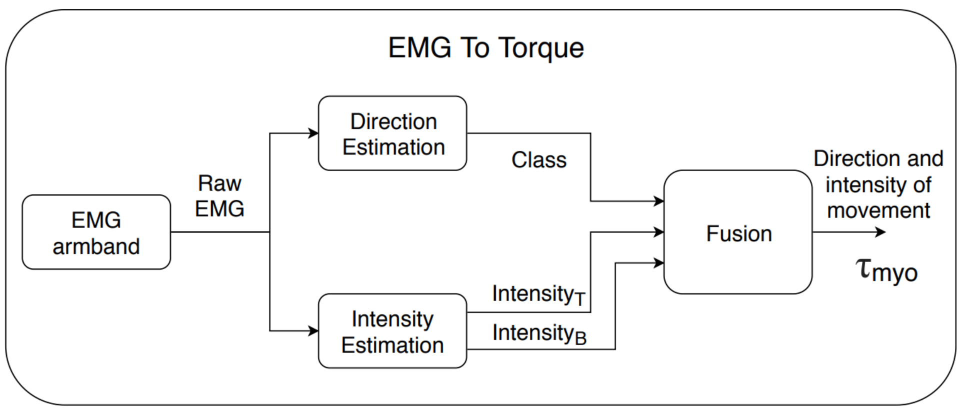


Figure 6: Estimation of the user's intention (IntensityB and IntensityT correspond respectively to the intensity of the Biceps activation and Triceps activation)

Basically in all the myoelectric exoskeletons the signals are processed to find intended direction of motion and the intensity of the same.These two are then processed to give a cumulative output in the form of torque.

7 DISCUSSION AND CONCLUSION

In this work I tried to present the working of the exoskeleton via myoelctric signals.The application of EMG signals can improve control schemes for exoskeleton robots based on force sensor measurements.It involve many steps as a result it can be cumbersome to be handeled by a patient in many situations. So the need of the present is to design made light weight

exoskeletons that are highly efficient and work on better and fast algorithms.If there some problem in the aforesaid algorithm it can result in the wrong message send to the exoskeleton thus it will not allow the person to perform thet intended task.
These EMG based exoskeleton might not only be used in healthcare it can find immense applications in the real life. It can be used by the workers were works demands high physical strength as it will help them to get extra power to do the same task thus making there work easy. These exoskeletons can also be used by the security personnels to perform highly covert operations which demands extraordinary strength.
Thus the use and benifits of myoelectric exoskeletons are immense and rigorous research in this field can reap lot of benifits.

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