Review on Prosthetic Limbs & Exoskeleton Case Study in India for Specially Challenged Peoples by Using ECG-Based Neural Interface

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Abstract: In today's world we have many people who have some body parts missing or they are disabled with arms or legs. Cause of the missing limbs is from their birth or due to any accidental factor. An accident can happen anywhere mostly talking to the India we have accidents relating to the sectors industries as industrial accident and road accident, railways accident and during the case of the war i.e. Army fighting at border. Most of the people lost their limbs during these accidents or happening. The purpose of this paper is to review recent developments in exoskeletons and robotic prosthetics. ECG-Based neural interface with the help of decoding algorithm is help in solving the problem [3].

Keywords— Prosthetic Limbs, Exoskeleton, Neural Interface, EMG, ENG, Machine Learning

I. INTRODUCTION

A prosthetic limb is defined as a mechanical device that is used to replace a missing human limb. The device is designed to help the user coordinate better control of an amputated limp as a result of motor control loss by a traumatic event, a congenital-related defect, or dyvascular- related. According to statistics by Ziegler-Graham, et al (2008), an estimated 1.6 million civilians were living with the loss of a limb. This research also revealed that approximately 38% of these people suffered an amputation of a limb as a secondary consequence to a dyvascular disease. Shockingly, it has been predicted that this statistic is likely to double to 3.6 million by the year 2050. Artificial, or prosthetic, limbs are considered a key element in the rehabilitation of both people with acquired limb loss and congenital limb deficiency. These technological aids are often able to restore some of the functions, as well as offering some aesthetic approximation, of an anatomical limb. [1]

An Introduction to the Biomechanics of Prosthetics [1]

Introduction to Exoskeleton

BCI-based systems can be used to support several different clinical rehabilitation processes. People with degenerative muscle diseases such as sarcopenia can be sup-ported with robotic exoskeletons that receive movement information from SEMG electrodes. Such systems are able to support activities of daily living (ADL) and can be used to help retrain muscles by regulating support strength, similar to an electric bicycle [5].

Robotic exoskeletons are the topic of a major research effort, much being funded by the US military, and aims to impart superhuman strength to the wearer. Japanese research is also well advanced and concerns a range of non-military applications, including strength enhancement and medical rehabilitation [6]. Some products have recently been commercialized. There has also been significant progress in the development of robotic prosthetic limbs, a topic which is also attracting support from the US military. A key aim is the development of thought-controlled prosthetics which will arise from advances in BCI technology.

II. PROPOSED WORK

Artificial prosthetic limbs Problems and solutions for connecting brains and robots Current motorized limb prostheses provide rudimentary functionality for the application in everyday life. Together with poor cosmetic appearance this is the reason why a large percentage of amputees do not use their prosthetic device regularly. This works seeks to present an overview of current state of the art research on neural interfaces. The focus lies on non-invasive recording with EMG and especially High

Density EMG sensors [3]. Additionally, different machine learning and pattern recognition algorithms for the decoding of the recorded signals are discussed. Finally, promising research directions for advanced prosthesis control brain-computer-interfaces and robotic limb prostheses.

BCI Input Technologies:

There is a multitude of methods for interfacing brains and computers that have special strengths and weaknesses and are thus used for many different applications.

Fig.1: *The Brain Gate neural interface*

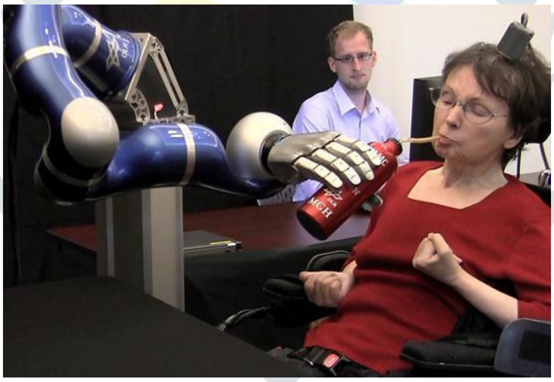

Fig.2: A tetra pelagic BrainGate2 clinical trial participant drinking from a bottle.

Noninvasive Brain Recording

Functional magnetic resonance imaging *(FMRI):*

Functional Magnetic Resonance Imaging (FMRI) is used as diagnostic tool in hospitals and research. It is a variation of MRI and utilizes echo-planar imaging for fast scanning of the whole brain by means of several cross section images

Indirect Brain Recording:

Interfacing technology that doesn't involve the central nervous system directly has several advantages regarding prosthetic applications [2].

Electromyography (EMG):

Instead of directly recording the neural activity of the brain, one can instead record the amplified electrical activity produced by muscle cells. This method is called electromyography (EMG) [3].

Electro-urography (ENG):

In recent studies, more direct means of control and feedback have been the focus of research. While recording muscle activity is a convenient and reliable way of accessing nerve signals [3].

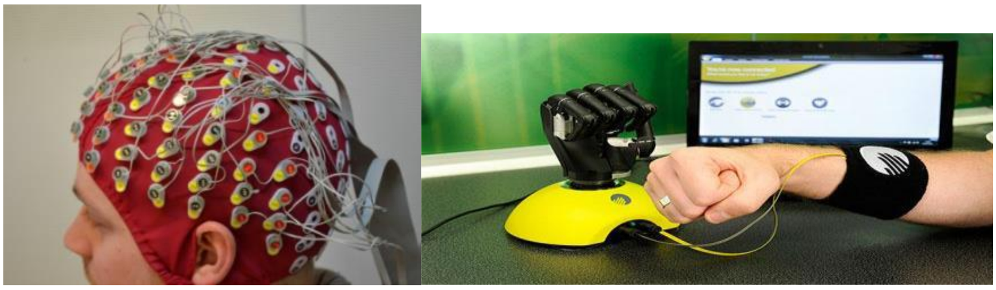

Fig. 3: Illustrating the recording of the nerve signals.

Robotic Arms

Intuitively teleported robot arms are useful, when the controlling person isn't able to use direct manipulation. This, among others, is the case for robot-assisted surgery, paralyzed patients or manipulation tasks in remote hazardous environments [6].

EMG Method

EMG recording is the most widely used non-invasive recording technique for the control of powered prostheses.

Signal source

To extract information from muscle activity, one has to understand the basic concepts behind the signal generation. The basic functional element of a muscle is called the motor unit

Electrodes

Electrodes used in SEMG recordings can be differentiated into dry and wet, polarizable and non-polarizable as well as single- and multichannel electrodes [3].

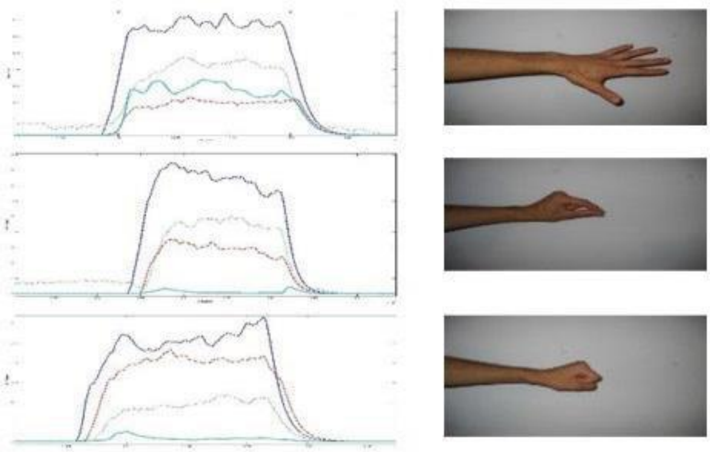

Fig. 4: Distinct SEMG amplitude relations for selected gestures recorded by 4 electrodes placed around the forearm.

Signal contamination:

To get clean and repeatable measurements, one has to factor in several possible error sources during recording sessions.

High density EMG:

Current research heralds High Density (HD) EMG as the next step in signal recording, made possible by improvement in grid electrode technology and the development of more powerful microprocessors [2].

Decoding Algorithms EMG-based Prostheses:

For the decoding of the EMG signals, different classes corresponding to different arm movements are trained by machine learning algorithms [5].

1. Pre-processing
2. Feature Extraction
3. Feature Classification

Decoding Algorithms for EMG-based prostheses:

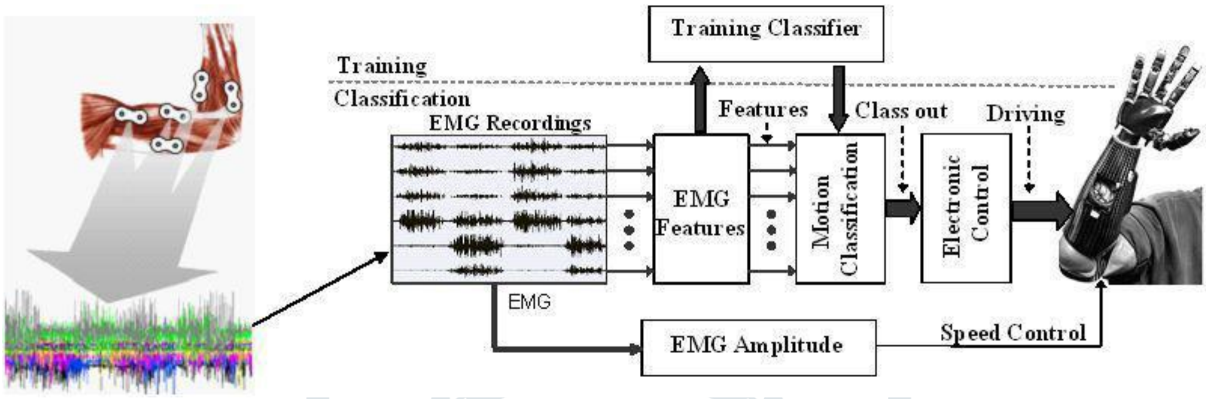

Fig. 5: EMG-based Neural Interface

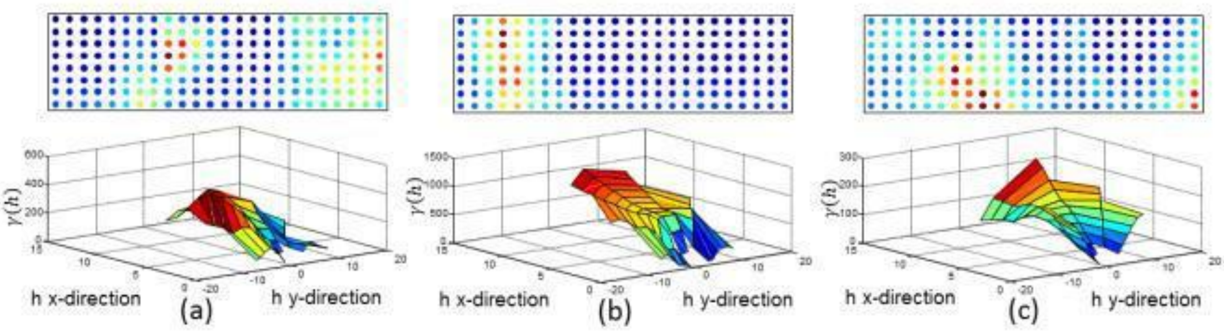

Fig.6: Matrix of EMG RMS values and the corresponding experimental various-programs

Machine learning approaches Standard Algorithms

Support Vector Machine - SVM

The most commonly used machine learning algorithm for the computation of the classifier for EMG data is the Support Vector.

Linear Discriminate Analysis - LDA

The Linear Discriminate Analysis (LDA) is a machine learning algorithm which can be used to end a linear classier by constructing a linear combination of features.

Neuro-inspired Algorithms - Neural Networks

Inspired by biological neural networks, artificial neural networks are one of the most powerful machine learning algorithms [1].

Pattern Recognition

While the training phase can easily be done through, the recognition of new motion commands via EMG signals have to be online and ideally in real-time [1].

Summary and Outlook:

Advances and Problems

The research in electric prostheses has come a long way. Until then, there do remain hurdles to be overcome. Algorithms have to be optimized for high dimensional inputs; embedded controllers have to meet rising computational demands. SEMG signal based control has to become more users' friendly [5].

Promising research in Area of Deep learning:

Deep learning is very new area of the study which has gained significantly popularity last year's [4].

Bidirectional closed-loop neuroprostheses:

Current prostheses rely solely on vision feedback to control grip strength and timing. This concept requires close attention in all grasping tasks and causes problems with choosing the right grip strength [2].

Multi-modal Approaches

The concurrent use of HD EMG sensors, EEG sensors and supplementary systems like eye tracking can help to increase precision and robustness, especially for ambiguous sensor data and in cases where single electrodes are malfunctioning.

Semi-Autonomous Control

As discussed in we believe that the use of advanced robotic control methods like impedance control can help to increase the performance of the neural interfaces. Semi-autonomous control also reduces the cognitive load of the subject. So, these are the recent development and the development going on the prosthetic limbs in the world. But in our India the case are different.

Let's take case study of Shiva who is resident of Kashmiri Gate, New Delhi; he is a disabled student with inborn disabilities of limbs.

In India the case are different just take a look on his problems, he is facing problem in automatic movements of limbs and he has to carry the supporting structure within him to walk and he uses his hand to move the supporting structure.

Fig. 7 (a) Showing the Shiva who is disabled with leg **Fig. 7 (b)** Showing the structure which are provided by the government of India which are of traditional in nature , which are not of autonomous type , and needs to do some up gradation.

Our aim is to build the exoskeleton for these types of people, we are analysing that we fit the motors and sensors with raspberry pie module help him in movement. For the better accuracy and fit we design the 3d printed leg with space for motor fitting and raspberry pie module, this is our future work. The disabilities like him will be reducing from the country.

CONCLUSION

As we talking about the prosthetic limbs there are many causes of the accident that can leads into the loss of limbs. Such as road accident, railways accident, industrial accidents and during the case of the war and also the loss of the limbs are not limited up to the accidents only they are even case of inborn babies who come with loss of limbs from birth and also they the limbs disabilities occurs in case of some diseases and age old . in the case of not having the limbs then they have the prosthetic limbs which is artificial limbs which provide them to walk in case of loss of legs and in case of arms loss they can do the usual things which they would do if they the normal limbs . In case of old people and disabilities either case of inborn or accidental then they can use exoskeleton which helps them to do their normal works.

But in the today world the prosthetic limbs are not limited up to the normal works they are more advanced than the earlier which the combinations of technologies

For example a normal prosthetic eye can able to see but with the advancement in the technology they can acts as danger detection as locations finder, they aware of the danger through their prosthetic limbs, which is camera which can give access to the physical world through the cyber space. Now they can access the things such as locations, time etc. easily. For examples prosthetics arm can do the extraordinary things that cannot be done by the normal hand , they are capable of fighting like a combat , in army they can be turned on into weapons which helps the army persons , during the case of war.

So there are lots of the features that yet to be discovered and the advancement is going on through the neural networks and artificial intelligence applications on those prosthetic and exoskeleton. In near future we will see the more advancement with the use of nanotechnology and genetic engineering. Which will in the near future make the prosthetic limbs same or we can say the exact replica of the human limbs in seeing but in the features they are more advance then the normal one.

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