Chapter 18
Brain-Machine Interface:
Human-Computer Interaction

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ABSTRACT

The brain-machine interface (BMI) is a very recent development in the area of the human machine interaction (HCI) and emerged as the sister technology of BCI. A physiological signal related to these electrical potentials in response of the mental thoughts is known as Electroencephalogram (EEG) signals. The BMI is most commonly known as the BCI because there is a direct communication between the brain and the external machine via a computer, which analyses and interprets the incoming physiological signals, which contain the shadow of the mental activity and the different types of artefacts. A multi-channel recording of the electromagnetic waves emerging from the neural currents in the brain generate a large amounts of the EEG data. The neural activity of the human brain recorded non-invasively is sufficient to control the external machine, if advanced methods of signal analysis and feature extraction are used in combination with the machine learning techniques either supervised or unsupervised.

INTRODUCTION

Many patients become afflicted with neurological conditions or neurodegenerative diseases (Wolpaw et. al., 2000) hat disrupt the normal information flow from the brain to the spinal cord, and eventually, to the targets of that information,(i.e., the muscles) which affect the person's intent. Amyotrophic lateral sclerosis (ALS also called Lou Gehrig's disease),spinal cord injury, strokes, and many other conditions can impair either the neural pathways controlling muscle's, or impair the muscles themselves. Individuals that are most affected may lose all their abilities to control their muscles. Thus, they lose all options to communicate and become completely locked inside their bodies. In absence of ways to reverse the effects of these disorders, there are three principal options for restoring function. The first option is to substitute the damaged neural pathways or muscles with pathways or muscles that are still functional. While

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this substitution is often limited, it can still be useful. For example, patients can use eye movements to communicate or hand movements to produce synthetic speech. The second option is to restore function by detecting nerve or muscle activity above the level of the injury. For example, freehand prosthesis is a method of restoring hand function to patients with spinal cord injuries. The third option for restoring function is to provide the brain with a new and non-muscular output channel, a brain–computer interface (BCI) (Wolpaw et.al., 2000), for conveying the user's intent to the external world.

The brain-machine interface (BMI) is a very recent development in the area of the human machine interaction (HCI) and emerged as the sister technology of BCI. However, there is not a clear cut difference between the BCI and the BMI. In fact, a computer is always between the brain and the machine for the interface. Different mental thoughts generate the electrical potentials over the surface of the scalp. These are recorded with sensors placed on the surface of the head. A form of physiological signals related to these electrical potentials of thoughts are known as Electro-encephalogram (EEG) (Carlson, 2007) signals. The BMI based on the EEG signals is called the EEG-based BMI (Carlson, 2007) system. The BMI pertains to the manipulation or operation of an external machine as per thoughts of a user, and such machine is called a though controlled machine. Thus, there is a direct communication between human and machine via a computer. The BMI is most commonly known as the BCI because there is a direct communication between the brain and the external machine via a computer, which analyses and interprets the incoming physiological signals (electroencephalograms), which contain the shadow of the mental activity and the different types of artifacts. A multi-channel recording of the electromagnetic waves emerging from the neural currents in the brain shows large amounts of EEG data. The neural activity of the human brain recorded non-invasively is sufficient to control the external machine, if advanced methods of signal analysis and feature extraction are used in combination with the machine learning techniques either supervised or unsupervised. A suitable feature extraction and classification methods are useful to generate a control command for controlling the external machine.

BCI provides a direct interface between the human brain and a computer. BCI is an emerging application of HCI. The first international BCI workshop was held in June 1999, in Rensselaerville, New York. More than twenty research groups from the different part of the world participated in that workshop. In it, a formal definition of the BCI was proposed (Wolpaw, 2000):

A brain-computer interface is a communication system that does not depend on the brain's normal output pathways of peripheral nerves and muscles.

BCI involves monitoring brain activity using brain pattern identification and analyzing the characteristics of the brain pattern using signal processing algorithms. In a BCI, system messages and commands generated to control any machine are nothing but the electrophysiological signals generated within the brain. The motivation that inspired to extend the research in the field of BCI is to develop an alternative way of the conventional communication system between the human and the computer. The BCI systems are bridging gap between the human and the machine used to interact with the world. BCI systems provide assistance to the human being with paralytic disability like Amyotrophic lateral sclerosis (ALS), Traumatic Brain Injury (TBI), Cerebral Palsy (CP), Spinal Cord Injury (SCI) etc.

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