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Brain Computer Interfacing using Electroencephalography and Convolutional Neural Networks

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ABSTRACT
A brain-computer interface (BCI) is a communication system that interprets brain activity into commands for a computer or other devices .This technology is the emphasis of a rapidly growing research and development initiative that is greatly exciting experts, and the public in general. Today, humans can use the electrical signals from brain activity to interrelate with, influence, or change their surroundings. The evolving field of BCI technology may allow persons in capable of speaking and/or use their limbs to yet again interconnect or operate assistive devices for walking and functional objects. In other words, a BCI permits users to act on their environment by using only brain activity, without using outlying nerves and muscles. In this paper we give an overview to some of the aspects of BCI research mentioned above, present a tangible example of a BCI system, and highlight recent progresses and open complications.

KEYWORDS: *BRAIN INTERFACING, ELECTRO-ENCHEPHALOGRAPHY, CONVOLUTIONAL NEURAL NETWORKS*

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1. INTRODUCTION

A BCI uses brain signals to control a device or to regulate the communication between user and device[1].Brain-Computer Interface (BCI) technology is a theoretically powerful communication and control option in the communication between users and systems and is by definition interaction beyond the keyboard. According to the original definition [1], a BCI is a communication and control system that does not depend in any way on the brain's normal neuromuscular output channels. BCI's convey with them the expectation of the future. Medical BCIs are slowly budding, but non-medical BCIs can still be considered an embryonic technology .Besides the transfer of knowledge from assistive technology, there are several crucial issues that are not within the scope of medical BCIs or the impact of which is much less critical in medical BCIs. User state monitoring is a typical example of an application relevant for non-medical users but that is outside the scope and definition of medical BCIs. BCIs have a wide range of applications that can be beneficial for users who do not necessarily have a medical indication to use one. One of the dynamic forces behind the growth of BCIs was the aspiration to provide users who lack full control of their limbs access to devices and communication systems. A bidirectional brain-computer interface (BBCI) can both record signals from the brain and send figures back to the brain through stimulation.

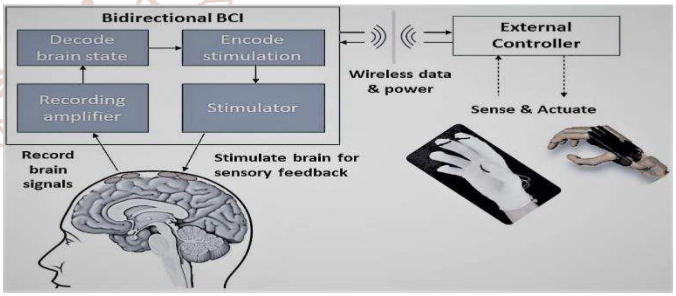

FIGURE 1 – WORKING OF BRAIN COMPUTER INTERFACE

2. ELECTROENCEPHALOGRAPHY (EEG)

An electroencephalogram (EEG) is a test that senses electrical commotion in your brain using small, metallic discs (electrodes) attached to your scalp[2]. Your brain cells communicate through electrical instincts and are active all the time, even when you're insensible. This action shows up as wavy outlines on an EEG recording. An EEG can define changes in brain activity that might be useful in diagnosing brain syndromes, specifically epilepsy or another seizure disorder. An EEG might also be helpful for detecting or treating the disorders such as Brain tumour etc.

The EEG of a normal adult in a completely conscious but relaxed state is made up of frequently repetitive oscillating waves known as alpha waves. When a person is excited or startled, the alpha waves are substituted by low-voltage rapid irregular waves. During sleep, the brain waves become tremendously slow. Other abnormal circumstances are connected with certain EEG configurations. For example, irregular slow waves known as delta waves arise from the vicinity of a localized area of brain impairment [3]. Some of the techniques [4] used in Electroencephalography in brain computer interface are discussed below.

FIGURE 2- ELECTROENCHEPHALOGRAPH

A. Slow Cortical Potential

Slow Cortical Potentials (SCPs) are based on electrical movement in the brain usually less than 1Hz. The SCPs are produced by several mechanisms. These comprise (a) slow graded post-synaptic potentials of the giant pyramidal cells in the cortex (usually going down to around 0.5Hz)- these are usually oscillating signals. (b) The major source of SCPs is the glial cells that support and regulate the neurons and are thoroughly related to brain instigation and brain constancy [4].

Positive SCPs specify decrease of cortical excitation of the original neural structures.

B. Sensorimotor Rhythms

The sensorimotor rhythm (SMR) is a brain wave. It is an oscillatory idle measure of coordinated electric brain SMR characteristically decreases in amplitude when the equivalent sensory or motor areas are stimulated, e.g. during motor tasks and even during motor imagery .Theoretically, SMR is occasionally varied up with alpha waves of occipital origin, the strongest source of neural signs in the EEG. One reason might be, that without appropriate spatial clarifying the SMR is very inspiring to detect since it is usually flooded by the stronger occipital alpha waves. The feline SMR has been noted as being analogous to the human mu rhythm activity. For most persons, the rate of the SMR is in the range of 13 to 15 Hz [5].

C. Evoked Potentials

An evoked potential is an electrical potential in a certain form detailed from a exact portion of the nervous system, specifically the brain, of a human or other creatures following demonstration of a stimulus. Different categories of potentials result from stimuli of different modalities and types [6].

EPs have the benefits of being objective, frequently more sensitive than inclusive neurological inspection, and they can be recorded in patients who are sedated or comatose. The concluding fact, along with enhancements in recording equipment, has led to innovative applications in the operating theatre and intensive care unit (ICU)—at a time when the role of EPs in the valuation of multiple sclerosis has largely been exchanged by magnetic resonance imaging (MRI) [7].

3. CONVOLUTIONAL NEURAL NETWORKS

A classifier based on a CNN seems to be a good method for EEG organization as the signal to detect comprises a lot of differences over time and persons. For such a variable signal, constructions based on local kernels can be inefficient at representing functions that must be tolerant to many variations[8].A convolutional neural network (CNN) classification algorithm is executed to categorize the motor imagery (MI) experiment using novel feature 3-dimension input.

There are various architectures of CNNs existing which have been key in constructing algorithms which power and shall power AI as a whole in the predictable future. Some of them have been listed below[11]:

- LeNet
- AlexNet
- VGGNet
- GoogLeNet
- ResNet
- ZFNet

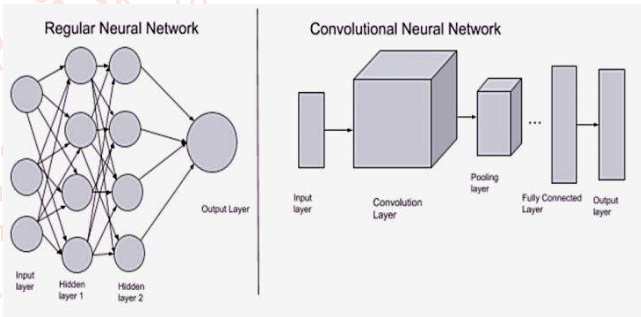

FIGURE 3- CONVOLUTIONAL NEURAL NETWORKS

4. BENEFITS AND RISKS IN BC

Though constant research has led to the progress of several applications of Brain Computer Interface (BCI) technology and its benefits in various fields, there are a little risks related with brain computer interface, which can be a remarkable limitation to technological development[12].

4.1. BENEFITS

A. Technology that is 'smart'

One of the biggest reasons why BCI is deemed as advanced technology is because it can make formerly passive strategies into 'smart' and lively ones. An illustration of such devices is prosthetics[12].

B. Telepresence

Telepresence is a knowledge that gives the capability to someone to make their presence felt, at a remote location, with the help of telerobotics. Telepresence, with the integration of BCI, can give military personnel the ability to keep an eye on any apprehensive activity that might take place at the border. Telepresence can thus detect any suspicious activity and help fight it[12].

C. Fewer accidents

Car-related accidents are one of the most severe reasons of death worldwide. A BCI-enabled car can thus avert any such occurrence from occurring by distinguishing what is going on in the driver's mind and by taking the choice in just a matter of seconds. Automobile manufacturer Nissan has revealed that it is leading research on a BCI-enabled car control scheme that will allow the system to slow the vehicle or turn the steering wheel faster than the driver himself. This technical invention can potentially be a major breakthrough in the automobile production[12].

Even progressive BCIs that could perceive neural activity associating with complex semantic processing might not be adequate to show that the subject had the intellectual and passionate capacity to make an informed and autonomous decision about life-sustaining treatment. Some form of behavioural interaction may be essential to check that the subject had this capacity. Medical specialists and caregivers must be careful not to read too much into BCI-enabled responses and understand them as having a denotation they lack [13].

4.2. RISKS

One of the basic restrictions of BCI is that the signals acknowledged from the brain are prone to intrusion. Additionally, legal and ethical apprehensions such as the risk of infection or haemorrhage harm caused when a patient's aim to control an external device fails as well as privacy and privacy of patients' data are some of the challenges confronted by BCI in healthcare. Nevertheless, important attention has not been paid to the challenges that delay the enactment of BCI in healthcare [14] .

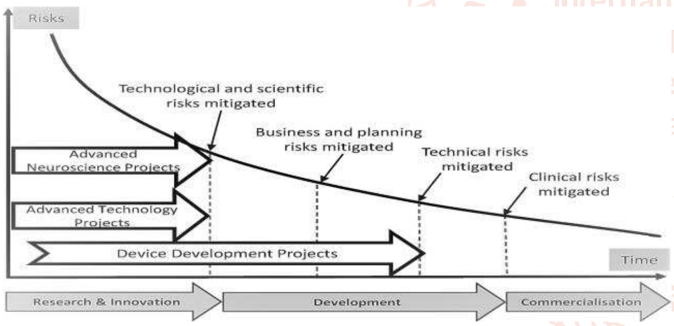

FIGURE 4 – TECHNOLOGICAL RISKS IN BCI

5. CONCLUSION

The potentials of BCI technology are nowhere near fatigued. The rise of non-invasive BCI devices — based off an EEG — is symbolic of future mainstream approachability of BCI technology. For example, BCI technology can allow users to create music with their views. The specific device for this is called an encephalophone, which is measured by the pictorial or motor cortex. The device mechanisms by receiving input from cortical signals such as the posterior dominant rhythm (PDR) from the visual cortex or else the mu signal from the motor cortex. This technology can be used by persons who suffer from neurodegenerative circumstances, but most likely will also become a typical product.

In conclusion, BCI has increasingly attained several monumental milestones. The forth coming influence of BCI in terms of patient care is slowly beginning to come into focus. It is important to think of that the generation of surgeons that we belong to will be in charge of knowing and assimilating new technology, to deliver better care to our patients [15].

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