Neuro technology with brain computer interfaces

[1]Aswin p.b,[2]Meenakshi v.s,[3]Bibitha baby

[1] BCA Student, [2] BCA Student, [3]Assistant Professor
Department of Computer Application
SNGIST ARTS AND SCIENCE college,
ManakkapadyKarumalloor (P.O) North Paravur, Ernakulam Kerala, India - 683511

Abstract: The term "neuro technology" describes a branch of science and engineering that focuses on creating tools that interact with the nervous system to improve or restore its function. The field draws on knowledge from neuroscience, computer science, engineering, and other related disciplines to develop devices and tools that can interface with the brain, spinal cord, and further portions of the nervous system.

Keywords: - Neuro technology, Brain–Computer Interfaces, Motor imagery,Deep brain stimulation (DBS),Electromyography (EMG).

1. INTRODUCTION

Neuro technology refers to the scientific advancements that aid in the understanding and manipulation of the nervous system. The use of neuro technology has increased in recent years, providing numerous benefits to society. However, the development of such technology has also raised ethical concerns, especially regarding privacy, autonomy, and responsibility. The field of brain-computer interface advancements has benefited greatly from neuro technology (BCIs). BCIs provide direct brain-to-external device connection, enabling paraplegic people to operate robotic limbs, for example. With advancements in this technology, people with disabilities can access opportunities and experiences that were previously inaccessible to them.

1.1Definition of Neuro technology with Brain Computer Interface

The goal of brain-computer interfaces (BCIs), a branch of neuro technology, is to establish direct communication channels between the brain and external gadgets like computers or prosthetic limbs. To enable humans to control these external devices using their thoughts, emotions, or other brain signals is the aim of neuro technology using BCIs.

A brain-computer interface (BCI) is a device that converts brain impulses into commands or outputs for computers and the other way around. BCIs can be invasive, such as when electrodes are surgically implanted into the brain tissue, or non-invasive, such when sensors are put on the scalp to monitor electrical activity in the brain.

Several aspects of human activity, including healthcare, education, entertainment, and military applications, might be transformed by neuro technology and BCIs. Neuro technology using BCIs can help people with disabilities reclaim their freedom and improve the quality of their lives by enabling direct brain-to-external device contact. It can also increase the capacities of healthy people.

1.2Scope of Neuro technology

The scope of neuro technology with brain-computer interfaces (BCIs) is vast and has the potential to impact different areas of human activity. Some main areas of scope for neuro technology with BCIs include:

- Healthcare: BCIs can be used to help patients with a variety of neurological conditions, including paralysis, stroke, and traumatic brain injuries. By allowing patients to control prosthetic limbs or other assistive devices with their thoughts, BCIs can help them regain sovereignty and enhance their quality of life.
- Education: BCIs can be used to create more immersive and interactive learning experiences, allowing students to control virtual environments using their thoughts and emotions.

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- Entertainment: BCIs can be used to create more engaging and immersive gaming experiences, allowing players to control game characters with their thoughts or emotions.
- Sports: BCIs can be used to help athletes improve their performance by monitoring their brain activity and providing real time feedback on their mental states.
- Business and productivity: BCIs can be used to help workers in high-pressure jobs monitor their stress levels and take breaks when necessary, or to control equipment using only their thoughts.
- Military and defense: BCIs can be used to enhance the capabilities of soldiers and pilots by allowing them to control drones and other equipment using only their thoughts.

Overall, the scope of neuro technology with BCIs is broad, and the potential applications are numerous. As the technology continues to advance, it is likely that new and innovative applications will emerge.

1.3Characteristics of Neuro technology with Brain-Computer Interfaces

Neuro technology with brain-computer interfaces (BCIs) has several characteristics that set it apart from other forms of technology. Some of the key characteristics of neuro technology with BCIs include:

- Direct communication with the brain: BCIs makes it possible for the brain to directly communicate with external gadgets, allowing users to command computers, prosthetic limbs, and other machinery with their thoughts or feelings.
- Non-invasive and invasive approaches: BCIs can be non-invasive, such as using sensors placed on the scalp to detect brain activity, or invasive, such as implanting electrodes directly into the brain tissue. Each approach has its advantages and constraints.
- Real-time feedback: BCIs can provide real-time feedback on brain activity, allowing users to monitor their mental states and adjust their behavior or environment accordingly.
- Personalized experience: BCIs can be personalized to the individual user, considering their unique brain activity patterns and preferences.
- Potential for neural plasticity: BCIs have the potential to promote neural plasticity, allowing the brain to adapt and reorganize in response to external stimuli.
- Interdisciplinary nature: Neuro technology with BCIs involves collaborations between scientists, engineers, clinicians, and other professionals from a range of disciplines, including neuroscience, computer science, and psychology.

Overall, neuro technology with BCIs is a cutting-edge field with many unique characteristics that have the potential to transform a range of industries and improve the quality of life for many people.

2. CUTTING EDGE RESEARCH ON BRAIN–COMPUTER INTERFACES

Brain-computer interfaces (BCIs) have the potential to revolutionize the field of neuro prosthetics by allowing individuals with compromised neural output pathways to control machines and produce specific behaviors. However, a lack of fundamental understanding of the mechanisms underlying behavior encoding has hindered progress in this field. Dr. Juan Alvaro Gallego, a bioengineering expert from Imperial College, proposes a novel approach to studying movement control that focuses on neural populations, which could lead to new insights and breakthroughs in the field of BCIs.

One of the primary challenges in neuro prosthetic research is the issue of neural turnover, which refers to the decline in the accuracy of the decoder over time due to the use of single-neuron coding. To address this issue, researchers have proposed a new theory that suggests that movement planning and execution occur through patterns of neuronal cluster activity called "neural modes." By identifying the neural modes that span the neural manifold, researchers may be able to decode intended movements with greater accuracy, even in the presence of neural turnover.

This technique has shown promise in animal studies and could have significant implications for the development of neuro prosthetics, particularly for individuals with locked-in syndrome. Furthermore, the formation of new neural modes could be involved in long-term motor learning, which could potentially lead to more effective neuro prosthetics in the future. Overall, the study of neural populations and neural modes offers a new perspective on movement control and has the potential to significantly advance the field of BCIs.

Patrick Kaifosh presented the work of CTRL-Labs, a company focused on reducing information loss and output latency in human computer interfaces. Using electromyography (EMG), CTRL-Labs researchers were able to directly Analyze signals sent to motor units and track wrist and finger movements with high accuracy, using dry electrodes to detect action potentials. This approach allows for subtle finger movements to control computer interfaces, representing a significant advancement in human-computer interaction.

To produce a more comprehensive virtual reality experience, CTRL-Labs and Facebook Reality Labs have united. The laboratory is now striving to enhance EMG signal identification and strengthen the system against possible wrist movement. One question that arises is how this approach differs from simply measuring muscle tension. However, researchers have shown that with another source of feedback about motor unit activity, it is possible to train an individual to control the activity of multiple motor neurons within a single muscle individually. This approach could potentially augment human output by enabling new ways of controlling information output.

In studying neural dynamics, it is not only important to understand them but also to have the means to influence them. Deep brain stimulation (DBS) is a highly effective technique used in clinical practice, but its invasive nature limits its accessibility a few medical institutions where neurosurgeons can collaborate with psychiatrists. Non-invasive technologies with simpler procedures are necessary to make the treatment of severe psychiatric conditions more affordable and accessible to patients. Transcranial electrical stimulation (TI) is a promising alternative to traditional brain stimulation techniques due to its non-invasiveness and potential for increased spatial and temporal precision. Dzialecka’s work highlights the importance of understanding the underlying biophysics of TI to optimize its effectiveness and safety. By manipulating the frequencies and strengths of the electric fields used in TI, researchers may be able to target specific neural populations and induce desired effects. Future research in this area could have important implications for the treatment of various neurological and psychiatric disorders.

3. MOTOR IMAGERY

The detection of event-related desynchronization/synchronization (ERD/ERS) in the sensorimotor cortex, which happens when the user imagines moving their right hand, left hand, or foot, is what motor imagery-based brain-computer interfaces (BCIs) rely on. Electrodes are implanted over the cortical areas to detect this activity, which the BCI system then analyses to determine the user's intent. Depending on the sort of electrodes utilized, motor imagery based BCIs come in a variety of forms. Both bipolar derivations over the motor cortex and a whole grid of electrodes over the sensorimotor cortex that are analyzed with similar spatial patterns are options for EEG-based systems (CSP). Research has shown that employing two bipolar derivations may attain 90% accuracy or better for roughly 6% of the population, but CSP-based systems have a grand average accuracy of around 80% after 20 minutes of training.

Grids of electrodes are placed across the sensorimotor cortex by a neurosurgeon for ECoG-based BCIs. A high-gamma functional mapping system or training a CSP filter to automatically weight each electrode in accordance with the BCI classification job can quickly identify the electrodes coding the essential information for an ECoG-based BCI system. Hence, the selected electrode or spatially filtered input may be used to directly control the motor movements of a virtual or robotic avatar. There are additional high-density grids with 256 channels and a center-to-center spacing of just a few millimeters that have a better resolution.

3.1 Advantages

Motor Imagery BCIs' Benefits for These Uses Compared to P300 or SSVEP based systems, motor imagery BCIs need greater training time but also provide excellent accuracy. They can be applied for motor movement detection or continuous control applications. This essay will discuss three applications: 1. the assessment of patients with awareness problems, 2.the recovery of motor function after a stroke, and 3.the use of avatar control to improve embodiment utilizing (for example) a humanoid avatar. To use an avatar or a functional electrical stimulator (FES) following movement photos for motor therapy, the system can instantaneously recognize brain-generated motor commands. This strategy ensures that the movement images and other system processes are closely related (Daly, 2013, Mrachacz-Kersting, 2013, Thompson, 2013). 3.2 motor imagery in future

Motor imagery, or the mental simulation of movement, has many potential applications in the future. Here are a few possibilities:

- Rehabilitation: Motor imagery can be used as a complementary technique for physical therapy in patients with neurological disorders such as stroke or spinal cord injuries. By visualizing movements, patients can activate the same brain regions that would be used during physical movement, potentially improving their motor function.
- Sports training: Motor imagery can be used to enhance sports performance. Athletes can mentally rehearse complex movements or routines, which can improve their confidence and performance in competition.
- Prosthetics: Motor imagery can be used to control prosthetic limbs. By imagining movements, patients can activate sensors that can interpret their intentions and control the prosthetic limb accordingly.
- Virtual reality: Motor imagery can be used in conjunction with virtual reality to create immersive experiences. By imagining movements, users can control avatars or interact with virtual environments.
- Motor imagery is a control signal that may be used to brain-computer interfaces (BCIs). To operate external equipment like prostheses or computers, BCIs can decipher the brain impulses connected to motor images.

Overall, motor imagery has the potential to play an important role in the future of rehabilitation, sports training, prosthetics, virtual reality, and brain-computer interfaces. Ongoing research in these areas will likely reveal even more applications and benefits.

4. CONCLUSION

These technologies—which have already demonstrated promise in helping people with disabilities—might become more generally accessible for a range of uses, from pleasure to learning. However, there are also significant ethical considerations to consider, such as the potential for invasions of privacy and the need to ensure that these technologies are accessible to all individuals, regardless of socioeconomic status. As we continue to explore the possibilities of neuro technology, it is essential that we remain mindful of both the potential benefits and the potential risks, and work to ensure that these technologies are developed and used in an ethical and responsible manner.

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