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Brain-Computer Interface or Neuromorphic Computing

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Abstract: The Brain-Computer interface or neuromorphic computing is the technology that enables direct interaction between the brain and external devices like Robotics arms, Cursor etc. It developed rapidly in recent years but still have critical issues like accuracy and stability. The diversity of brains and machines hinders deep fusion between the two. Neuromorphic computing models, which mimic the structure and mechanism of biological nervous systems, present a promising approach to developing high-performance neuroprosthesis.

Keywords*:* Invasive, Partially invasive, Non-invasive, Energy efficiency, Real-time processing, Scalability.

I. INTRODUCTION

The Brain Computer Interface is also called as Brain-machine interface it is a direct communication link between the brain's electrical activity an external devices like computer or robotic limb. It is an Artificial intelligence framework that can perceives a specific arrangement of patterns in brain cues. A brain computer interface is a system that translates bio signals in commands that are then conveyed into an external devices such as computer software, musical instruments, prosthetics, military and aerospace applications, medical monitoring devices, robots and even exoskeletons. Neuromorphic computing is a concerned with processing information. Unlike its Programmed computing counterpart, a neurocomputing approach to information processing first involves a learning process within an artificial neural network (or neural network) architecture that adaptively responds to inputs according to a learning rule. It can be used to perform certain task depending on the particular applications.

II. RATIONALE

- **Flexibility and Accessibility**
- Flexible neural interfaces and devices is revolutionizing our ability to explore the neural foundations of consciousness, Intelligence, and behaviour.
- BCI technology has the potential to dramatically improve accessibility for people with severe physical or neurological disabilities.

- **Web Accessibility**
- BCI's present a unique method to interact with web and digital services. They could detour around traditional input method like keyboards and mice, which allows users with limited mobility to navigate online with ease, just as web accessibility overlays can help with other types of disabilities.

- **Education and Employment**
- BCI-powered interfaces could open doors to educational and employment opportunities for people with disabilities who were previously limited by physical constraints.

- **Mobility and Independence**
- Through the integration of BCI's with prosthetics and mobility aids, individuals with mobility challenges can regain their ability to navigate physical environments autonomously.
- It includes the operation of wheelchairs, prosthetics limbs, and other devices that facilitate movement and daily activities.

- **Communication**
- BCI's provide a new ways for people with communication disorders to express themselves, translating neural signals into word: speech or text. While this time the decoding is not perfect, it's relatively early in the technology mix of BCI and other recent innovations including AI and Machine learning, and we may expect great advances in the near future.

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- **Rehabilitation and Neurotherapy**
- BCI's are pivotal in the rehabilitation of patients with neurological disorders and injuries. They assist in the restoration of functions such as movement and speech by reinforcing neural pathways and substantially aiding in the recovery process through targeted brain exercises and feedback.

- **Environment Control**
- Already in existence in prototype form, BCI controls allows users to manage lights, thermostats, and other smart devices using only their thoughts.

III. OBJECTIVES

The objectives of this project is:

- The Brain- Computer interface are rapidly evolving, blurring the lines between human thought and digital actions. These interfaces hold immense potential for applications in medicine, rehabilitation, and even entertainment.
- As research continues, BCI's promise to revolutionize how we interact with the world around us, shaping a future where our thoughts have the power to directly influence technology.

IV. SCOPE

In Comparison to other technologies, The Neural networks have the ability to learn from their environment and to adapt to it in an interactive manner similar to their biological counterparts. Indeed, this is an exciting prospect because of the vast possibilities that exist for performing certain functions with artificial neural networks that can emulate (to a limited degree) the comparable biological functions. This can be applied to private as well as educational institutions, because it is about artificial neural networks.it may be utilized at anytime and anywhere.

V. LITERATURE REVIEW

- Brain computer interface (BCI) using Electroencephalogram signal

Published in: 2015 International Conference on Pervasive Computing (ICPC)

The system based on brain computer interface has been developed from past 30 years and now grown into the vast and diverse field. The first brain activity signal is recorded by Berger in year 1942.The control capability of this signal have been depend on the electrodes and the noise reduction technique used for preparing the system. Now a days the electrodes are getting better and have very large range of selection criteria depends on application such as the gel based electrodes are used to obtain the high sensitivity for better resolution

- Biologically-Inspired Technologies: Integrating Brain-Computer Interface and Neuromorphic Computing for Human Digital Twins

Chen Shang, Jiadong Yu, Dinh Thai Hoang

The integration of immersive communication into a human-centric ecosystem has intensified the demand for sophisticated Human Digital Twins (HDTs) driven by multifaceted human data. However, the effective construction of HDTs faces significant challenges due to the heterogeneity of data collection devices, the high energy demands associated with processing intricate data, and concerns over the privacy of sensitive information.

VI. NEED OF WORK

The primary need of work in Brain-computer Interface (BCI) technology is to develop systems that can directly translate brain signals in to commands to control external devices, essentially allowing peoples with severe disabilities like paralysis, to regain some levels of communication and movement by using their thoughts alone, thereby improving their quality of life and independence.

Specific areas where BCI research is needed:

- **Improving signal detection and interpretation:**
  Developing more accurate and robust algorithms to reliably translate complex brain signals into meaningful commands.

- **Developing Non-invasive and comfortable interfaces:**
  Creating wearable BCI Systems that can be easily used by a wider population without requiring invasive surgical procedures.

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- **Addressing ethical concerns:**

Developing guidelines for responsible use of BCI technology, including privacy, security, and potential for manipulation.

VII. PROPOSED METHODOLOGY

The brain computer interface, allows direct communication between one's central nervous system and a computer without any muscle movement hence by-passing the peripheral nervous system. They can restore disable people's ability to interact with their environment, e.g. Communication and wheelchair control.

To this day their performance is still hindered by the non-stationary of electron encephalo graphy (EEG) signals, As well their susceptibility to noise from the user's environment and from their own physiological activity. The result obtained on publicy available datasets show that the signature method is more robust to inter-user variability than classical ones, especially on noisy and low-quality data.

VIII. SYSTEM ARCHITECTURE

The coordinator, student, and administrator modules each have a portion of the architecture of BCI consists of three steps as described in fig.01.The first step is the acquisition of EEG data form human brain.In the second step feature extraction of the acquired signal takes place finally the output from the classification step generates the commands which are propagated to various devices in this paper a method to classify the EEG signal for BCI application has been described classification of signal and double blinking of eyes in the EEG data has been performed using various classification techniques. The output can be used to generate control commands for BCI application i.e. various device can be controlled like home appliances, robotic arm, or wheelchair movement .The methodology consist of data acquisition with the help of NeuroSky MindWave headset. Pre-processing and feature extraction are performed after the data acquisition step, and finally various classification methods are used to detect single and double blinks in the EEG signals.

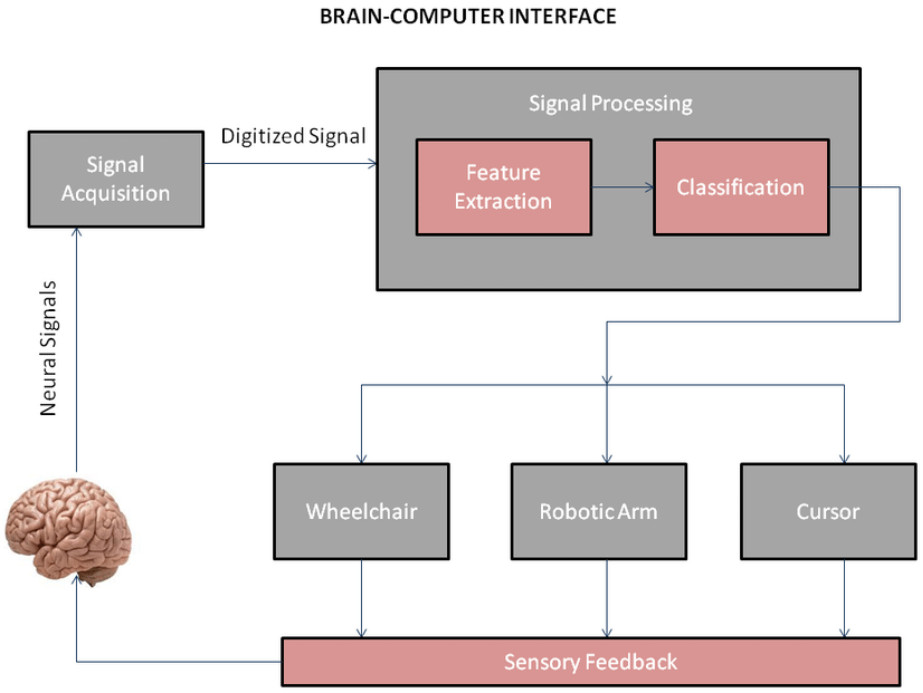

Fig.01. Brain Computer Interface

IX. CONCLUSION

The field of brain-computer interfacing has witnessed tremendous growth over the past decade. Invasive BCIs based on multielectrode arrays have allowed laboratory animals to precisely control the movement of robotic arms. Implants and semi-invasive BCIs have enabled human subjects to quickly acquire control of computer cursors and simple devices.

Noninvasive BCIs, particularly those based on EEG, have allowed humans to control cursors in multiple dimensions and issue commands to semi-autonomous robots. Commercially available BCIs such as cochlear implants and deep brain stimulators have helped improve the quality of life of hundreds of hearing-impaired individuals and patients suffering from debilitating neurological diseases.

X. FUTURE SCOPE

We live in an innovative and technologically advanced era when technology permeates every aspect of daily life. The future BCI's will provide more accurate and reliable performance, with faster and more efficient data processing, reducing the delay between input and output. BCI's will be used in a range of fields, such as gaming, entertainment, education, and sports. As we look towards the future, non-invasive BCI's are poised to dominate the market by 2029. These systems offer a safer and more accessible alternative to invasive methods, making them particularly attractive for widespread adoption.

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