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Original Research Article

An Overview of the Study Using Biosignals Generated During Thinking a Particular Alphabet

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Abstract

The paper is enclosed with the idea of helping people who are not capable of operating their limbs due to any accidents occurred in their past life. It implies theoretically, knowledge gained out of studying our field related articles. Mind readings as well as remote communication have their unique fingerprint in various fields such as educational, self-regulation, production, marketing, security, games and also in entertainment. It enables a mutual understanding between the user and the surrounding systems. Here in this paper we discuss about brain waves (Biosignals) which are recorded using Electrode Encephalography (EEG), and the brain computer interface process used in gaming are the two valuable sources to create our typing using the Biosignals generated during thinking particular alphabets. We hope that this paper will be much helpful to the people who are physically challenged with writing disabilities can put up their words comfortably using this idea.
Keywords: EEG (Electroencephalography), BCI (Brain Computer Interface), Writing disabilities, Thought process, Interaction.

INTRODUCTION

Brain Computer Interface (BCI) technology is a very powerful communication tool between users and systems. It doesn't require any external devices or muscle intervention for it to issue commands and to complete the interaction [1]. The brain activity may be a wide used one to investigatory neurobiology and rehabilitation engineering. The analysis community has ab initio developed BCIs with medical specialty applications in mind, resulting in the generation of helpful devices [2]. The promising future predicted for BCI has encouraged research community to study the involvement of BCI in the life of non-paralyzed humans through medical applications. They have expedited restoring the movement ability for physically challenged or locked-in users and substitution of the lost motor practicality [3].

The brain-computer interface (BCI) is a very powerful technique that has become a major tool which provides a direct communication pathway between the brain and to the external world by translating signals from the brain activities into machine codes or commands. The acquisition of brain activities by BCIs can be divided into two different categories: invasive BCI and non-invasive BCIs

Non-invasive BCIs have become another major BCI research direction. These non-invasive devices are worn on the outside of the head and are removable. Recently, electroencephalogram (EEG)-based BCIs have been shown to provide a feasible and non-invasive method to communicate between the human brain and external devices. An invasive BCI is implanted directly into the grey matter of the brain to obtain the highest quality of brain activity signals or to send external signals into the brain [4].

However, invasive BCIs rely on surgical techniques and are probably risky because of the interaction between the device and brain tissues if used in the long term. Use of Encephalogram signals has become the foremost common approach for BCIs due to their usability and powerful reliability. In recent years, the advanced styles of the sensors and system techniques have created it possible to integrate the sensors into transportable acquisition devices to measure a vast and wide variety of physiological signals. Therefore, non-invasive BCIs have become another major BCI research direction. These non-invasive devices are wearable on the outside of the head and are also removable. Recently, electroencephalogram (EEG) based BCIs have been shown to provide a feasible and non-invasive method to communicate between the human brain and external devices [5, 6]. A BCI system that's supported steady state visual-evoked potentials (SSVEPs) has been usually used for dominant practical neuroprostheses. BCI system that was based on SSVEPs combined with a functional electrical stimulation (FES) system to allow the user to control stimulation settings and parameters [7-10]. EG-based BCIs provide a reliable, fast, and efficient solution for the communication between humans and computers. However, almost all of the above-mentioned BCIs focus on feasible applications by using their general systems or sensors. Measuring the EEG signals with a portable BCI device in a reliable manner during daily life is still an important issue which requires further study [11].

The BCI has many applications particularly for disabled persons like [12] (1) New ways for the gamers to play games using their heads (2) Social interactions enabling the social applications to interact and capture feelings as well as emotions (3) Serving partially or absolutely disabled people to interact with totally different computational devices and (4) Helping people to understand more about brain activities and human brain neural networks. These applications rely on the fundamental understanding of how the brain works.

MATERIALS AND METHODS

Design of the dry EEG sensors

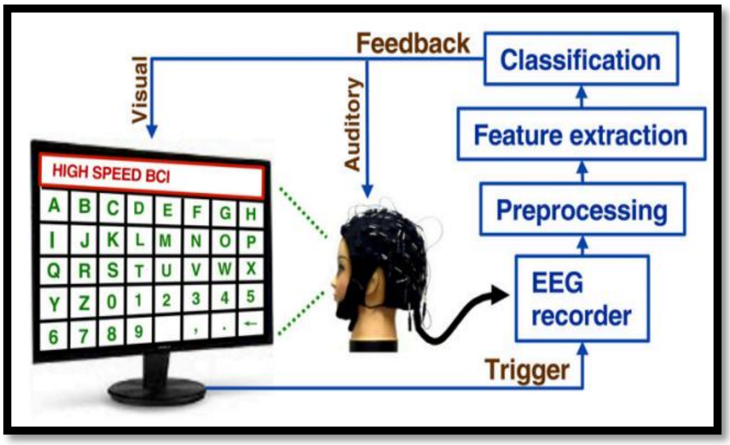
The dry foam electrode is the one fabricated by electrically conductive polymer foam coated with conductive fabric and can also be used to measure bio-potentials without the outer skin preparation or conduction gel. Moreover, the foam substrate of the dry electrode allows a high geometric conformity between the electrode and irregular scalp surface to maintain low skin-electrode impedance, even under motion. The proposed dry foam-based EEG sensor device is specific one designed to contact the skin of the forehead with the utilization of a conductive polymer foam product made of a urethane material with a compression set of about 5-10%. The conductive foam was covered with a 0.2-mm-thick taffeta cloth material that was made of from an electrically conductive chemical polymer fabric material (conductivity of approximately about 0.07 ohm/cm^2) and was coated with Ni/Cu on all of its surfaces to ascertain an electrical contact that was same as that of silver EEG sensors. A 0.2-mm layer of copper was used as an gummy layer that was then connected to the wireless EEG acquisition module. The proposed dry foam EEG sensors were 20 × 20 × 9 mm^3 [13].

Wireless EEG acquisition module

The wireless EEG acquisition module receives EEG signals from the dry EEG sensor and it has the following components such as a microprocessor component, an acquisition component, and a wireless transmission component. To intensify the signals and filter the EEG signals, a band-pass filter (0.5-50 Hz), a pre-amplifier and an analog-to-digital converter (ADC) were implanted into the circuit board as a bio-signal amplifier and acquisition component modules.

A wireless noninvasive signal capturing device
Picture source: Rabie A. Ramadan, *et al.*, [14]

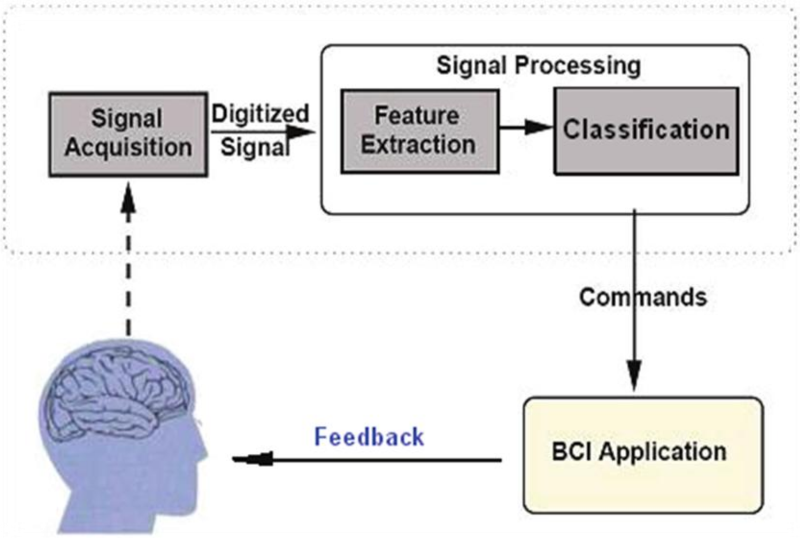
The gain of the amplifier and also acquisition component was set to a level approximately 5500. An Assisted Device Circuit (ADC) with 12-bit resolution was cast off to digitize the EEG signals, with a proposed sampling rate of 256 Hz for the filtered and amplified EEG signals. In the microprocessor component, the EEG signals which were probed using an ADC which were digitally stored. With a moving average filter having the frequency at 60 Hz was then applied externally to dismiss any power-line interference preceding the wireless transmission. A Bluetooth module has to be included in the wireless transmission part of the circuit. It is quite important to note that the module was fully adaptable with the specifications of a Bluetooth with v2.0+ EDR and includes a Printed Circuit Board (PCB) with antenna. Moreover, the size of the proposed wireless EEG component module was approximately 4.5 × 3 × 0.6 cm^3, and to include this module into the mechanism of wearable EEG-based BCI device. This wearable module was operated at 31.58 mA with a 3.7-V DC power supply. Most importantly, this module was able to operate continuously for a period of 23 hours using the commercially available 750 mAh Li-ion battery.



BCI Signal Processing
Picture Source: Christopher Packham [15]

The mechanism of the wearable REEG-based BCI device

The quick-placement mechanism for the proposed EEG based BCI device was designed to let the dry EEG sensors attach to the user's forehead easily and quickly. This device contains three dry foam sensors and a wireless Electroencephalogram acquisition module which has a battery inside. An elastic band was adjustable to fit the users' head sizes. This mechanism was also used to maximize the skin-sensor contact area to maintain low impedance while probing the EEG signals using the dry EEG sensors [16]. This mechanism did not cause any permanent or detrimental effects to the forehead skin. It was clearly noted that each one of the channels of proposed devices used the dry foam-based electrodes. The uses of the wearable EEG acquisition device allowed the users to monitor their EEG signals much more conveniently and comfortably.



Picture Source: Marcin Kołodziej [17]

Features

- Rejection of the artifact signals,
- Extraction of the focusing feature.

First, preprocessing of the initial original EEG signals was performed to reject the noise signals. It is well known that the mentally focused state is highly associated with the alpha rhythm (8-12 Hz) of an EEG in the forehead region, and the noise artifacts were located in the frequency regions that were totally different from the alpha rhythm of brain wave frequency range. Consequently, to reject the artifacts, a fast Fourier Transform was performed to get the EEG power spectrum patterns of the signals, and signals among the alpha band were retained.

Secondly, extraction of the focus feature was carried out on the power spectrum within the alpha band of brain wave. Previous studies have shown that the power of the alpha rhythm of an EEG grows as the user's mental state changes from focused to unfocused cognitive states. Therefore, the alpha band is the main frequency band that we used to indicate the user's focused state in the present study, and the 8-12 Hz frequency band of first original EEG signals was chosen for the FL detection algorithm.

Suggestion

In future the dry EEG sensor can be replaced with MEMS electrodes. These bioelectrical signals are a typically transduced one with either external or internal electrodes. With the usage of MEMS technology, many electrodes can be cofabricated onto one substrate so that both of the precise temporal and spatial information can be obtained. MEMS technology also can be used to shape the form of substrate into either arrays of microprobes capable of penetrating the neural tissue or into a perforated membrane through that the regenerating neural tissue can grow and then it can be monitored.

Neuroscientists are now doing a great job by realistically envision sensing devices that enable real-time measurements at the cellular level. The information from such sensors may well be monitored, analyzed, and used as a basis of experimental or medical intervention, again at the cellular level. Another example is to use the micro machined neural sensors and the stimulators to control prosthetic limbs using processed signals recorded from the brain wave or spinal column.

Applications

Brain computer interfaces have contributed in numerous fields of research. Such as medical, neuroergonomics, a smart environment, neuromarketing, advertisement, academic and self-regulation fields, games, recreation, Security and authentication fields.

Medical Applications

Healthcare field includes a number of applications that might take advantage of brain signals in all the associated phases like prevention, detection, diagnosis, rehabilitation and restoration [18].

Neuroergonomics, Smart Environment

Smart environments such as smart houses, workplaces or transportations could also exploit brain computer interfaces in offering further safety, luxury and physiological control to human's daily life. They are also expected to witness cooperation between Internet Of Things (IOT) and BCI technologies [19].

Games and Entertainment

Entertainment and gaming applications have opened the marketplace for nonmedical brain computer interfaces. Various games are presented like in [20] where helicopters are made to fly to any point in either a 2D or 3D virtual world. Combining the features of existing games with brain controlling capabilities has been subject to many researches such as [21] which tend to provide a multi-brain entertainment experience.

Security and Authentication

Cognitive Biometrics or electrophysiology, where only modalities using biosignals (such as brain signals) are used as sources of identity information, gives a solution for those vulnerabilities [22, 23]. They also can be of great value for disabled patients or users missing the associated physical trait [24]. This makes such signals difficult to synthesize and therefore improves the resistance of biometric systems to spoofing attacks. Besides electroencephalogram (EEG), as a biometric modality, could be used to send covert warning when the authorized user is under external forcing conditions, as implemented in [25].

Present

- Gaming using BCI
- Computer and medical interfacing like EEG, EMG, EEG, ERG using MEMS and BCI technology.

Future

- Rehabilitation engineering
- Medical prostheses like hand, limbs.

Above applications can be done by both BCI and MEMS.

CONCLUSIONS

In the present study, we proposed a wearable EEG based BCI device with dry EEG sensors for typing the letter. The use of dry EEG sensors provides several advantages: 1) In contrast to conventional EEG sensors, the dry foam-based sensors can be used without conductive gel; 2) the elasticity of the substrate of the dry EEG sensors allows them to adapt to irregular skin surfaces to maintain low sensor-skin impedance; and (3) the fabrication process is inexpensive, comparing with other types of dry sensors. Moreover, a portable, wireless and low-power consumption EEG acquisition module was successfully used for long-term EEG monitoring. The dry EEG sensors and the wireless EEG acquisition module were embedded into a wearable EEG acquisition device. Using our wearable EEG-based BCI device without conductive gel will allow users to monitor their EEG states more comfortably during daily life. A cognitive application of EEG-based letter typing was also demonstrated in this study using this portable device. A personal computer was used as the platform to run a real-time focused feature detection algorithm and an EEG monitoring program, which were used to monitor the user's cognitive state. Our data indicate that this wearable EEG-based BCI device and the corresponding algorithm can be reliably used to control outside-world applications for general users or researchers. This device complements other existing BCI approaches for investigating the human cognitive states of neuronal activation and behavioural responses in daily life.

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