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A Novel Detection Method for mTBI

Early Detection of Mild TBI

Introduction

Mild Traumatic Brain Injury (mTBI) is a significant emotional and financial burden on families and society. Common in both the country's deployed service members and civilians, these traumatic events can cause lifelong symptoms if left untreated. While traumatic events themselves are difficult to prevent, the early detection of mTBI would allow for mitigation of further brain trauma. Studies have shown that there is a significant alteration of brain activity when a traumatic event occurs, which can be detected using an electroencephalogram (EEG). This paper is a review of EEG technology that is commercially available for use in detecting mTBI.

Commercial Applications of EEGs

Current commercial applications of EEGs do not have any focus towards brain trauma, as they appear to be geared towards detection of focus levels and facial expressions [1]. These products are not advertised for any medical use and are simply sold for research application and personal use. Although only providing 5 channels, the EMOTIV Mobile Brainwear provides a relatively affordable price of $299, as well as a friendly API for both hobbyist and research use [1, 2]. Although this product is not used to detect any trauma to the brain, the inclusion of motion sensors and brainwave detection mechanisms could provide some insight into changes in brain activity after a traumatic event. This product also foregoes the need for direct contact with the skin, as it can still be used to detect brain waves through hair [1]. This prevents the need for a professional application and would significantly reduce the time needed to equip the device itself.

Another product in commercial EEG product-space is the WaveGuard Connect, which is a cap with pre-installed electrode cups rather than an actual measuring device. While this cap would require the purchase of a separate EEG device on top of the $399 purchase price of the cap itself [3], the benefit comes from the ease of use. By having pre-installed electrode cups throughout the cap, the user can forego the need for a professional application. However, this presents a different problem, as these electrodes require the use of EEG gel when equipping the cap, and the electrodes themselves require direct contact with skin. This deducts drastically from the general purpose and field useability of the device, as the need for gel application and skin contact would become a hinderance in both military and civilian use. Although more tedious to apply, the comfortable form factor of the cap could become the main selling point, as a cap can easily be worn under other equipment such as military and sports helmets.

Technology of EEGs

Data Acquisition

The first problem of brainwave detection is the acquisition of the data itself. While invasive electrodes would provide the most accurate results due to being closest to the source, it is not practical in applications where long setup times are not possible. An invasive approach would also hinder the use in general purpose cases, as the need for a professional would drastically increase the cost and reduce the ease of use of the EEG. The two noninvasive approaches are the dry EEG system used in the EMOTIVE Mobile Brainwear [1] and the wet EEG system used in the WaveGuard Connect [3]. The wet EEG approach uses EEG gel on the electrodes to make conductive contact with the skin, and the dry EEG approach is placed directly on the skin without any gel application, which typically results in larger impedances than the wet EEG approach. However, the dry EEG approach provide significant benefits in both ease of use and general-purpose useability, as the dry EEG system can be applied even through hair. While these commercial-grade products lack the accuracy of medical-grade instruments, careful use of consumer-grade EEGs can still yield useable data [6, 7].

Data Processing

The second problem of brainwave detection is the processing required once the data is acquired. Due to the complexity of the human brain, as well as various other signals traveling through the body, the data acquired from an EEG is very noisy. Because of this, the first step when processing EEG data would be the removal of EEG artifacts, most frequently done with independent component analysis and discrete wavelet transformation [5]. Another technique would be to focus on a limited bandwidth of the EEG to be analyzed. As studies have found specific frequencies of brainwaves linked with mTBI, a low pass filter can be used to focus the data. This is helpful in detecting early mTBI, as EEG data commonly show a reduction in alpha frequency and an increase in theta and delta frequencies immediately following a traumatic event [4].

Implementation of EEGs in mTBI Detection

Implementation of EEGs for early detection mTBI poses several challenges, especially using the more readily available commercial-grade products. While shown to be possible to yield useable data for the purpose of monitoring brain activity, these commercial-grade products require significant more work and careful measuring to yield data like those of medical-grade instruments [7]. However, the combination of these affordable EEGs with the knowledge of mTBI effects on the brain, the creation of a widely available method of mTBI detection seems not only feasible, but available in the near future.

[1] EMOTIV, Product Information. 2020. [Online] Available: https://www.emotiv.com/product/emotiv-insight-5-channel-mobile-eeg/. [Accessed: Oct. 9, 2020].

[2] EMOTIV, Cortex API. Sept. 9, 2020. [Online]. Available: https://emotiv.gitbook.io/cortex-api/. [Accessed: Oct. 9, 2020].

[3] bio-medical, WaveGuard Connect Product Information. 2019. [Online]. Available: https://bio-medical.com/waveguard-connect-19-channel-eeg-cap.html. [Accessed: Oct. 9, 2020].

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