

Dry Contact and Non-contact EEG Sensors for Mobile Wireless Brain-Computer Interfaces

Brain-computer interfaces (BCI) translate electroencephalogram (EEG) signals from the human brain into device commands. BCI systems often require extensive subject preparation, including scalp abrasion, gels and a multitude of wired electrodes. In real-life applications, BCI systems should not use bulky, expensive, wired EEG acquisition device and signal processing platforms.

This study aims to explore the feasibility of using a truly mobile and wireless dry-electrode based EEG system to implement a steady-state visual evoked potential (SSVEP) BCI. The SSVEP is characterized by an increase in amplitude at the stimulus frequency. The EEG system consists of a three-channel bio-signal acquisition/amplification module, a wireless transmission module and a Bluetooth-enabled cell phone. The performance of using three different types of electrodes was demonstrated in a case study in which wearers' EEG was used to directly dial 10-digit numbers.

For the electrodes, the first is a simple active electrode built from standard off-the-shelf electronic components. Spring-loaded fingers provide for electrical connection to the scalp by pushing through the strands of hair without the need for scalp preparation or conductive media. High contact impedances from the absence of gel and the small contact surface are mitigated with the use of an onboard buffer. The second design is a high-impedance, non-contact electrode design based on a custom integrated analog front-end. Real-time EEG data processing, Fast Fourier Transform (FFT) and Canonical Correlation Analysis (CCA) were carried out on the cell phone.

A comparative experiment was devised and performed on ten healthy subjects. Each subject gazed at a single SSVEP target stimulus, displayed on a CRT monitor, and the three sensors were arrayed in a triad over the occipital region as closely together as possible. The averaged correlation between the signals acquired by the wet and dry contact electrodes was 0.912 ± 0.068 , while the correlation between the signals from wet and non-contact electrodes was 0.797 ± 0.108 . These tests demonstrated the feasibility of using dry electrodes to assess weak SSVEP signals. Results of online SSVEP BCI showed that information transfer rates (ITR) with the dry contact electrode were comparable to that of wet electrodes. In addition, although data from the non-contact electrode showed some degradation signal quality, they remained useful for online SSVEP BCI. This study demonstrated that both dry and non-contact electrodes might become a viable tool for both future mobile BCI and general EEG applications.