A Practical Mobile Dry EEG System for Human Computer Interfaces

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Abstract. A complete mobile electroencephalogram (EEG) system based on a novel, flexible dry electrode is presented. The wireless device features 32-channels in a soft, adjustable headset. Integrated electronics enable high resolution (24-bit, 250 samples/sec) acquisition electronics and can acquire operate for more than four hours on a single AAA battery. The system weighs only 140 g and is specifically optimized for ease of use. After training users can self-don the headset in around three minutes. Test data on multiple subjects with simultaneously acquired EEGs from a traditional wet, wired system show a very high degree of signal correlation in AEP and P300 tasks.

1 Introduction

Portable electroencephalogram (EEG) based systems have long been explored as a tool for implementing brain- computer interfaces (BCI) [1,2,3,4]. Despite the many advancements in signal processing and algorithms towards realizing a useful system, the EEG headset itself has remained a critical barrier against a practical device. Conventional EEG systems are cumbersome, requiring extensive subject preparation. Recently, dry electrode EEG systems have been explored as an alternative. However, dry headsets still suffer from numerous issues relating to comfort (e.g., hard metal pins) and signal quality. This paper aims to present a new, wireless dry EEG headset that specifically addresses the need for a complete, mobile system and will cover both the design and experimental validation.

2 Sensor Design

Mobile EEG systems have focused heavily on the use of dry electrodes with mixed results. In principle, dry electrodes are attractive due to the lack of scalp preparation. In practice, they have multiple issues relating to signal quality, usability and comfort. Current dry electrodes mostly utilize the straight metal spring-pins structure [5] to push through the hair. Pin based designs introduce significant discomfort and in military or ambulatory applications, pose an injury hazard [4]. Spring loaded sensors are also too intricate and complex to produce

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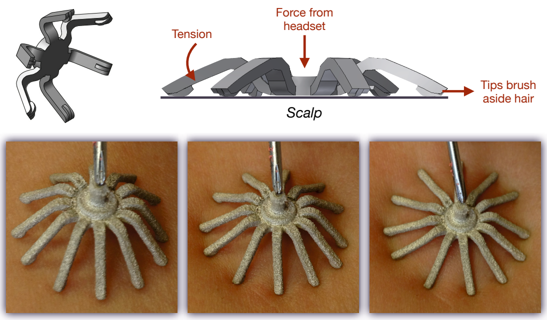

Fig. 1. Cognionics patent-pending flexible dry electrodes. The design consists of angled legs that can deform under pressure enabling penetration of hair without discomfort or risk of injury to the scalp.

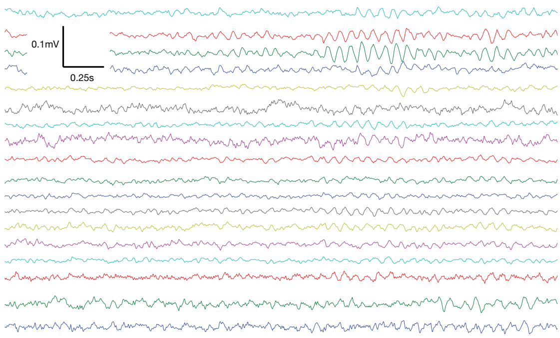

Fig. 2. An 18 channel raw data segment collected by the Cognionics headset using the flexible dry electrodes. The top traces clearly show alpha burst activity and demonstrates the high signal quality of the flexible dry electrode.

inexpensively. Other dry electrode designs exist, primarily based on conductive fabrics [6] or conductive brushes [7]. However, such approaches do not readily penetrate all types of hair and have issues with cost and longevity. Finally, many dry electrode systems also require significant fiddling of both the sensor and cap to generate sufficient pressure, eliminating many of their convenience advantages.

To address the performance and form-factor limitations with conventional dry EEG electrodes (e.g., hard metal pins), Cognionics, has developed a patent-pending, flexible dry electrode (Fig. 1) specifically designed to easily penetrate layers of hair while remaining safe, even under hard pressure. The new dry electrodes utilize a set of angled legs rather than straight pins. The electrode is made from a nylon material (3-D printed) that permits the legs to bend and flex outward under pressure. The flexing action helps push aside strands of hair for better scalp contact with minimal adjustment. Under hard pressure, the entire structure simply deforms and flattens to remain safe. For conductivity, the sensors are coated with metallized paint.