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What is Minimal EEG? User centered and reliable EEG headsets for real-world applications

Alex Alda, Aitor Ortiz, Natalia Torreblanca, Luis Montesano, Javier Minguez

***Abstract*— It has long been well-known that EEG hardware is an obstacle to widespread adoption of brain-computer interface technologies in real-world applications. A new EEG family of technologies is reported herein. It combines high reliability with user-centered design, which is enabling the penetration of effective BCI applications in market and business applications.**

I. INTRODUCTION

Brain-computer interfaces (BCI) carry the promise to make an impact in real world applications, mainly as assistive devices but also as a powerful way to access the brain and enrich communication between humans and machines. Despite the steady progress regarding many technical challenges, most scientific studies are still carried out with medical/research-style technology and in well-controlled scenarios under the supervision of technical experts, such as laboratories or clinical settings. However, there are many BCI applications that display more friendly and wearable technology (e.g. neurorehabilitation, home based diagnosis of neurological disorders, neurofeedback). For BCI to penetrate the market effectively, EEG hardware must be easy to setup and use, for both the participant and operator. EEG hardware must also be comfortable to wear. The Minimal EEG family of devices developed by Bitbrain [1] is reported herein, which is mainly directed to **ease the penetration of BCIs in real-wold applications**.

II. THE MINIMAL EEG FAMILY

The main idea supporting the Minimal EEG family is the design reliable equipment with a minimal number of sensors that cover a given set of applications, with user- and application- centered design that favors usability and comfort in real-life settings. The rationale behind this approach is common to many research studies on the optimization of sensors for different BCIs (e.g. [2] for P300, [3] for SSVEPs, [4] for motor imagery, to name a few) .

The Minimal dry-EEG family is the result of combining two usually opposite driving forces in real-world applications: 1) **user-centered approach** that favours usability, ergonomics, and aesthetics to ensure user acceptance; and 2) **technical requirements** such the minimal number of sensors on a specific set of locations to measure EEG brain activity with the quality required by the final application.

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[1]All authors are with Bitbrain, Spain. alex.alda,aitor.ortiz,natalia.torreblanca@bitbrain.com

Fig. 1. BCI and FES motor neuro-rehabilitation (results from MoreGrasp H2020 EU project) with the Minimal EEG Hero.

A. An EEG technology per BCI application

We can basically divide BCI applications according to the location of measurements: (a) **frontal areas**, which capture pre-frontal and frontal alpha asymmetry (emotional states), frontal theta/beta ratio (memorization), frontal alpha sync (attention), and to some degree N400 for ErrPs and CVN. (b) **parietal and occipital areas**, which capture parietal alpha asymmetry (emotional states), alpha sync (for EEG baselines or meditation), visual P300, among others; and (c) **central areas**, which capture mu-ERD/ERS and MRCPs (movement intention), evoked sensory motor states, MNN and N400 for ErrPs, global alpha desync (workload), etc.

Minimal EEG family is composed by 4 devices (Fig 2):

1) Diadem: Wearable dry-EEG with 12 sensors over the pre-frontal, frontal, parietal and occipital brain areas.
2) Hero: Wearable dry-EEG with 12 sensors over the fronto-central, central and centro-parietal brain areas.
3) Air: Wearable dry-EEG with 12 sensors over the pre-frontal and occipital brain areas.
4) Inmmersive: Wearable dry-EEG seamlessly integrated with Oculus Rift and HTC Vive Pro, with the same sensor layout as Hero.

In terms of **usability**, all technologies are wearable dry-EEG devices designed to provide maximum freedom of movement and comfort to the user. All devices employ the same dry-sensor technology for a clean and easy setup. Operation is intuitive, with a setup time around 2 minutes, after a few minutes of training for the operator or the user (this last if the EEG setup is self-performed).

Regarding **signal quality** of dry-EEG technology, firstly there is mechanical stability. To guarantee that sensors are correctly placed on the scalp (under hair) with stable contact