EEG monitoring at home: the technical challenges

Bernard Grundlehner, Julien Penders, Maaike Op de Beeck, Firat Yazicioglu

Abstract—Taking EEG out of the traditional, clinical environment into people’s homes will require a paradigm shift, in which a set of technological challenges needs to be tackled, from electrodes and analog readout to application and headset design. In this work, the challenges associated to the electronic and mechanical aspects of a wearable EEG acquisition unit are summarized.

I. INTRODUCTION

In clinical settings, bio-potential signals such as Electroencephalogram (EEG) and Electrocardiogram (ECG) are measured as input for medical diagnosis. A new and evolving field is the continuous monitoring of bio-potential signals out of the hospital environment. Continuous monitoring could help in detecting early onsets of certain disorders, or to monitor recovery or disease progression. In some cases it can even be used as integral part of treatment of brain-related disorders. However, recording bio-potential signals in an uncontrolled environment comes with very challenging (technical) challenges.

II. REQUIREMENTS FOR HOME USE OF EEG EQUIPMENT

Requirements for the acquisition equipment for using at home are different from hospital equipment. Four key aspects are identified:

Ease of use / comfort: No skilled specialist, No contact gel (dry electrodes), Painless, Should give EEG signals instantly

Good signal quality: coping with dry electrodes, Low noise and low power-line interference, No (motion) artefacts

Easy integration in any headset: Small form factor, Small battery (low power consumption)

Robust application: Limited number of electrodes, Uncontrolled (daily life) activities, Headset design

III. WIRELESS EEG SYSTEM

These requirements can be translated into technical challenges, which are easiest explained by looking at the different components that make up the complete signal chain, as depicted in Fig. 1.

A. Dry electrodes

Dry electrodes are the preferred solution for home use of EEG. Electrodes with contact gel (or other liquids) are not suited for long-term use, because evaporation will reduce contact properties over time. Moreover, the gel cannot be removed from the hair without washing, creating discomfort for the patient. For EEG, a structure that penetrates the hair to (almost) touch the surface of the skin is typically required. Several studies report the use of dry electrodes in EEG or ECG recordings, such as [1], [2], [3].

B. Analog Readout Circuit

Several challenges are associated to the analog readout circuit. Several sources of interferences will lower the signal quality [4], which becomes even more challenging with the use of dry electrodes. Careful amplifier design and the use of active electrodes or active shielding will overcome some of these problems.

C. Digital Signal Processing

In medical applications, the patient can be asked to sit quietly, and to limit eye movement and blinking as much as possible. If the patient is monitored in his daily life environment, several artefacts will contaminate the EEG signal. When using dry electrodes, we will see an increase in the severity of motion artefacts, on top of the biological artefacts (EOG, EMG). Digital signal processing algorithms, such as ICA, are widely used to attenuate these artefacts.

D. Headset design

Some (mechanical) challenges will have to be addressed in the headset design, in which aesthetics, comfort and pressure [1] on the electrodes are key for a successful application. Different application paradigms will typically come with a unique set of requirements (such as sensor positions), and hence it is likely that headset designs will be application-specific.

REFERENCES