Advances in circuits and algorithms for high-quality EEG recording in non-controlled environments
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Abstract— Home monitoring of scalp EEG is highly desirable for a number of medical conditions. This work reviews current state-of-the-art EEG hardware for home and portable monitoring and motivates key future directions.

I. INTRODUCTION

The scalp electroencephalogram (EEG) is an essential tool for high time resolution, non-invasive, and portable monitoring of the brain. Its use in home epilepsy monitoring and sleep disorder diagnosis has been well established [1], and it is now finding increasing use in home stroke rehabilitation applications [2].

Although both have seen considerable progress in recent years, the two main obstacles to high quality EEG recording in non-controlled environments are well known, and remain to be, power consumption and dry electrodes. This work presents a review of recent developments in these areas, highlighting areas that are promising for future development. We give particular focus to circuits and algorithms for the online analysis of EEG data in EEG recorders.

II. STATE-OF-THE-ART REVIEW

Since our 2010 article [1] there has been much work toward realizing truly wearable EEG. Minimally-cumbersome wet electrodes have been created [3], and dry recording electrodes are now available commercially from a number of companies. In addition, the concept of in-ear EEG recording has been proposed [4]. In this, EEG electrodes are placed in the ear canal as part of a standard hearing aid. A limited number of channels and locations are available, but this recording modality can offer EEG-type signals using electrodes that are non-invasive, socially acceptable and intrinsically held in place by the recording set up.

Power consumption has also seen many improvements and there are now several commercially available units that can offer a day or more of wireless recording time. This is likely sufficient for any single recording where generally one day (which can capture a complete sleep-wake cycle) is a sufficient starting point. However this duration still falls far short of pick up and use devices that are reliable and can be easily reused without having to worry about battery life. For further power consumption improvements, on-board signal processing for the first level analysis of the EEG data (Fig. 1) is essential [1]. However, implementing complete and accurate algorithms within the limited power budget available remains a major challenge.

Recently such algorithms have started to emerge for seizure detection applications [5, 6]. Nevertheless much work on the trade-off between circuit power consumption and algorithm accuracy, and techniques for improving this trade-off, is still required. In addition, hardware implemented algorithms for other EEG applications are less well developed. Compressive sensing [7, 8] is a popular emerging technique that can be used across EEG applications. Whilst promising — our work demonstrates that acceptable average compressive sensing performance can be obtained — a critical challenge remains in obtaining acceptable performance variance over time.

![Figure 1](image)

Figure 1. The addition of low power online signal analysis remains a major challenge in improving the performance of EEG systems.

REFERENCES