MULTI-REFERENCE ADAPTIVE NOISE CANCELLATION IN THE EEG

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INTRODUCTION: The electroencephalogram (EEG) records patterns of brain activity and provides a great deal of diagnostic information. For example, these recordings can help detect epileptic patients, brain tumors, or even psychiatric disorders. Recently, aided by the miniaturization and reduced cost of headsets, a strong interest in real-time EEG signal analysis for classification and prediction has emerged, in domains such as gaming, and security at work. Research, lead at the New Zealand brain Research Institute and University of Canterbury, targets the development of an EEG headset for the detection of microsleeps.

One of the first steps in detecting microsleeps is the preprocessing of EEG signals to eliminate artefacts contained within the EEG such as eye-blinks or activity of muscles. An approach called multi-reference adaptive noise cancellation (MRANC) in the EEG was successfully used in [1], and has now been implemented in a field programmable gate array (FPGA) for the elimination of artefacts in real-time.

METHODS: Multi-reference adaptive noise cancellation is an approach intended to adaptably cancel out the noise (present in the primary input of the canceller) thanks to correlated versions of it (present in reference inputs). In MRANC, an adaptive filter, in the form of a multilayer perceptron (MLP), changes its internal weights so as to produce an output signal, which is as close as possible to the noise contaminating the primary input.

The multilayer perceptron is a type of neural network that can easily learn to detect artefacts online using the back-propagation algorithm and update its internal weights based on the error function. The integrality of the MRANC is implemented on an FPGA using a Zynq platform (ZedBoard) and the resulting module is replicated to provide multichannel reduction of artefacts.

RESULTS: A system that accepts raw EEG data and performs real-time filtering using MRANC on an FPGA has been developed. Early observations of real time filtering among several subjects suggest a reduction of the artefact power in the EEG.

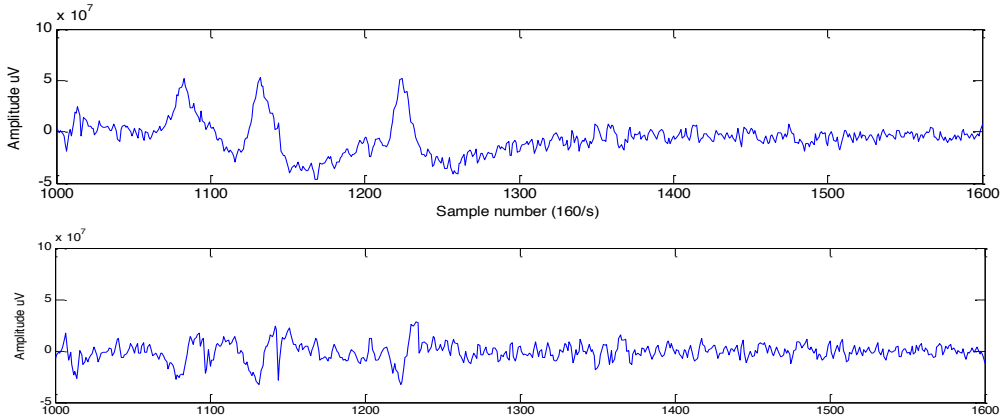

Fig. 1: Top: Contaminated EEG raw signals (Before). Bottom: EEG filtered in real-time (After).

DISCUSSION & CONCLUSIONS: This project can serve as a proof of concept for a more developed and online adaptive filter that effectively removes artefacts contaminating the EEG. Further research is continuing to ensure the best elimination possible using MRANC.

REFERENCES:

[1] C. James, M.T. Hagan, R.D. Jones, P.J. Bones, G.J. Carroll (1997), "Multi-reference adaptive noise cancelling applied to the EEG", *Transactions on Biomedical Engineering. IEEE*