Real-time rejection of gradient and pulse related artefact (GRA and PRA) from electroencephalographic signals recorded during functional magnetic resonance imaging (fMRI)

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Electroencephalography (EEG) and functional magnetic resonance imaging (fMRI) are two imaging techniques used to study the dynamical activity of the human brain. Although complementary, i.e. EEG has a high temporal resolution while fMRI provides precise volumic information, the simultaneous use of both techniques introduces large artefacts in the EEG recordings. These artefacts are consequences of the Faraday's induction law. Indeed, EEG wires constitutes loop and during fMRI acquisition the magnetic field within the MR scanner changes continuously and abruptly causing the "gradient related artefact" (GRA). Similarly, at each heartbeat, the blood passing through the arteries make the scalp surface pulse slightly, and the entire human body moves slightly causing the "pulse related artefact" (PRA). Online access to EEG data during fMRI acquisition would allow real time monitoring of the subject's consciousness state, and possibly neuro-feedback.

The method proposed by Allen et al. (1998) efficiently rejects the GRA artefact. Methods for PRA rejection are based on various mathematical techniques such as "Average Artefact Subtraction" (AAS, Allen et al. 1998), "Principal Component Analysis" (PCA, Niazy et al. 2005) or "Independent Compenent Analysis" (ICA, Srivastava et al. 2005) and its derivative. All these algorithms work with various efficiency depending on the type of data they are applied on, and are designed for offline EEG correction. We propose an algorithm, cfr Fig. A, based on an optimized version of an offline "constrained ICA" (cICA) method (Leclercq et al. 2008, which proved equally or more efficient than any other method) to suppress the PRA in real time, the GRA being rejected online with Allen's method.

We present here preliminary results of our algorithm applied on the recording of an awake subject with closed eyes. There is no visible decrease of EEG signal quality when comparing the proposed online ICA correction with the offline one, cfr. Fig. B. Moreover, when the power spectrum of the signal corrected online and offline are compared, cfr. Fig. C, a peak corresponding to the alpha activity is properly retrieved with both methods.

<u>References:</u>

Allen et al., *NeuroImage*, 8(3) 229–239, 1998
Leclercq et al. *NeuroImage*, in press, 2008
Niazy et al., *Neuroimage*, 28(3), 720–737, 2005
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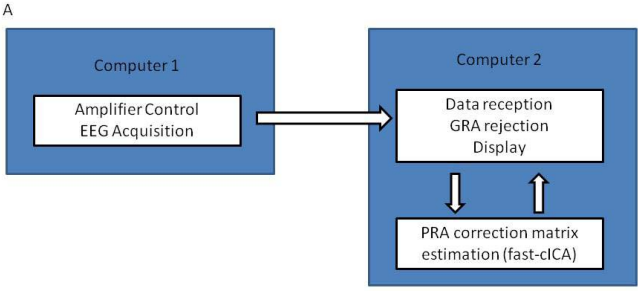

Fig : A : Block diagram of our algorithm, B : PRA rejection offline (bottom), online (middle) plus the data corrected only for GRA (top). The PRA correction starts after a short while as it takes some time to estimate the correction matrix, C: Power spectra between 1 and 20Hz of the above mentioned signals.