ELECTRODE SELECTION FOR NON-INVASIVE FETAL ELECTROCARDIOGRAM EXTRACTION USING MUTUAL INFORMATION CRITERIA

Frédéric Vrins[1], Reza Sameni[2], Fabienne Parmentier[1], Christophe Hérail[3], Vincent Vigneron[3], Michel Verleysen[1], Christian Jutten[2]
(1) UCL, Louvain-La-Neuve, Belgium
(2) LIS, Grenoble, France
(3) LSC, Evry, France
(e-mail: vrins@dice.ucl.ac.be, www.dice.ucl.ac.be/∼vrins)

Abstract

In recent years, *blind source separation* (BSS) techniques have been used as promising approaches for the non-invasive extraction of fetal cardiac signals from maternal abdominal recordings [1]. With the new developments in BSS, it is believed that the complete shape of the fetal ECG should be extractable from a sufficient number of electrodes well-positioned over the abdomen of a pregnant woman. Based on this intuition, in a previous research a multi-channel recording system containing an array of 72 electrodes was developed, which can be placed as a belt of electrodes over the abdomen and the back of a pregnant woman [2].

However, many of the recording channels are contaminated with the maternal ECG noise and contain little information about the fetal ECG. Moreover, the processing of all the different combinations of these electrodes ($72\times71/2$ electrode pairs), can be very time-consuming and inefficient, since a much smaller subset of the electrodes (which can also vary with time depending on the pose of the fetus, shape of the abdomen, or stage of pregnancy), may be sufficient to extract the required 'information'. Based on this idea, in a recent study, an electrode selection strategy was proposed to reject the channels which correspond to the maternal ECG, by minimizing the *mutual information* (MI) between the different electrodes and a reference channel of the maternal ECG [3].

On the other hand according to the *dipole theory* of the cardiac electrical activity, it is known that the electrodes placed on the body surface are recording a projection of the heart's dipole vector depending on their position. This suggests that the different electrodes should be compared with different references (depending on their location), rather than a single reference. In this work the electrode selection algorithm has been improved by using a novel 3-dimensional model of the cardiac dipole vector. Using this model the reference channel has been customized for each of the recording channels and the MI of each channel has been calculated with respect to its own reference. Moreover the channel selection strategy has also been

modified by preserving the channels which have the most MI with the fetal ECG and the least MI with the maternal ECG, at the same time. For this, as a pre-processing stage, the location of the fetal R-peaks have been detected and used to construct the fetal reference signals.

The proposed method has been tested on real recordings, by first removing the baseline wander noises, and then applying the channel selection algorithm. The selected channels have been later decomposed into independent components (ICs) by using the JADE ICA algorithm. The results show that the ICs extracted from 6-12 selected channels, very well correspond to the fetal ECG components with the least interference from the maternal ECG. This shows that the MI criterion together with an appropriate model of the cardiac dipole vector can be used as an effective means of channel selection for the application of interest.

References:

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