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SUBSPACE SEPARATION FOR PERFORMANCE IMPROVEMENT IN FETAL CARDIAC SIGNAL EXTRACTION

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To overcome risks during pregnancy, it is important to generate fetal heart signals with minimal noise/distortion, and with as much information as possible. However, interference of various types of unwanted noisy signals such as maternal heart signal and receiver noise cause difficulty in the interpretation of the fetal heart conditions through the extracted fetal cardiac signal. The maternal heart signal interference can be removed using an adaptive Wiener filter. Cardiac signals captured from maternal abdomen and the chest are used as the reference and the input signals into the Weiner filter, respectively. The Wiener filter attempts to model the path between maternal chest and abdomen, thereby effectively cancelling the maternal cardiac signal from the abdomen sensor measurement. This concept is called the principle of correlation cancellation in the Wiener filter.

However, the Wiener filter is incapable of removing uncorrelated signals that are present in the input and the reference signals of the Wiener filter itself. Therefore, noise in the reference signal leaks directly to the extracted signal corrupting it. Further, noise at the filter causes a mismatch in the Wiener filter model. Due to this model mismatch, a mismatch noise is added to the extracted signal further corrupting it. Therefore, it is important to minimize the noise in the Wiener filter input and reference signal.

To minimize the sensory noise, normally, standard low pass IIR and FIR filtering techniques are utilized. This eliminates high frequency noise to a reasonable degree. But such techniques are susceptible to high noise environments, which in addition tend to be non-stationary. Therefore, we have proposed an Eigen filter based subspace separation technique. The subspace filters utilized have the capability to realize complicated filter structures, thereby improving performance under noisy conditions when all other methods fail.

To verify the performance enhancement of the proposed techniques, we have measured the extracted signals correlation to an ideal benchmark signal under varying noise levels. It was discovered that while the performance of other techniques decayed exponentially, only a slight linear performance degradation occurred in the subspace filters, as noise is increased. This clearly indicates the versatility of the subspace technique under high noise levels. Thereafter, we generated a spectral estimate of the extracted signal for different filter types and used appropriate parameters to generate cluster diagrams. The results further verified how the subspace filter based method best replicated the ideal fetal cardiac signal which is desired.