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Empirical Mode Decomposition and Principal Component Analysis implementation in processing non-invasive cardiovascular signals

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Abstract

Biomedical signals are relentlessly superimposed with interferences. The nonlinear processes which generate the signals and the interferences regularly exclude or limit the usage of classical linear techniques, and even of wavelet transforms, to decompose the signal.

Empirical Mode Decomposition (EMD) is a nonlinear and adaptive technique to decompose data. Biomedical data has been one of its most active fields. EMD is fully data-driven, thus producing a variable number of modes. When applied to cardiovascular signals, the modes expressing cardiac-related information vary with the signal, the subject, and the measurement conditions. This makes problematic to reconstruct a noiseless signal from the modes EMD generates.

To synthesize and recompose the results of EMD, Principal Component Analysis (PCA) was used. PCA is optimal in the least squares sense, removing the correlations between the modes EMD discovers, thus generating a smaller set of orthogonal components. As EMD–PCA combination seems profitable its impact is evaluated for non-invasive cardiovascular signals: ballistocardiogram, electrocardiogram, impedance and photo plethysmogram.

These cardiovascular signals are very meaningful physiologically. Sensing hardware was embedded in a chair, thus acquiring also motion artefacts and interferences, wh

the signals.

Highlights

▸ 4 non-invasive cardiovascular signals of one healthy subject were acquired. ▸ Empirical Mode Decomposition and Principal Component Analysis were applied. ▸ EMD is very adaptable but a varying subset of the IMFs produced is cardiac-related. ▸ PCA is able to synthesize the IMFs in fewer PCs with reasonable overhead. ▸ EMD-PCA is able to isolate cardiac data from noise for a variety of signals.

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Keywords

Ballistocardiography; Biomedical signal processing; Cardiovascular signals; Electrocardiography; Empirical Mode Decomposition; Plethysmography; Principal Component Analysis; Unobtrusive instrumentation

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