RSA Component Extraction from Cardiovascular Signals by Combining Adaptive Filtering and PCA Derived Respiration

Suvi Tiinanen*, Antti Kiviniemi, Mikko Tulppo and Tapio Seppänen

Computer science and engineering laboratory, University of Oulu, Finland

Respiratory sinus arrhythmia (RSA) is a phenomenon where heart rate changes synchronously with respiration. In non-laboratory environments and certain measurements protocols respiration rates may, however, alter in both low frequency range (LF, 0.04-0.15Hz) and high frequency range (HF, 0.15-0,4Hz) and thus distort the analysis of sympathetic and parasympathetic activity from the series of heart rate intervals (RRi) and systolic blood pressures (SBP). In addition, other spectrally calculated autonomic nervous system (ANS) indexes such as baroreflex sensitivity (BRS) may be biased due to respiration rate. Methods such as adaptive filtering have been applied to extract the RSA from cardiovascular time series. However, these methods require simultaneously measured respiration signal as a reference. This paper demonstrates how ECG derived surrogate respiration can be used as a reference signal in Least Mean Square (LMS) adaptive filter to extract RSA component from cardiovascular signals. Surrogate respiration signal is obtained by principal component analysis (PCA) applied for QRS complexes. A method minimizing residual energy is used to select an optimal PC component for the surrogate. Data set consists of 20 healthy males who performed spontaneous and controlled breathing at rest. Two cases were analyzed: 1) adaptive filtering with ECG derived surrogate respiration signal and 2) adaptive filtering with measured respiration. Results indicate that one PC is adequate as respiration reference for adaptive filter and that the ECG-based surrogate produces comparable results to the actual respiration signal. As a conclusion, ECG-based respiration surrogate is adequate to extract the RSA component.