Real-time Estimation of Heart Rate Variability Parameters from Passband Filtered Interbeat Interval Series

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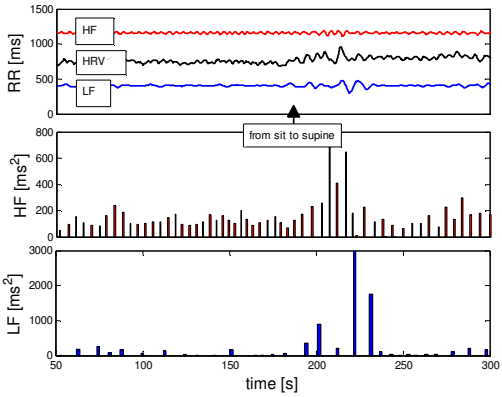
Introduction: Real-time heart rate variability (HRV) analysis provides means to measure neural system responsiveness and has recently been found useful in cardio-resynchronization therapy optimization. Computationally effective methods for LF and HF power determination are proposed.

Methods: Interbeat interval (IBI) series is determined by QRS detection, spline interpolation, artifact correction and 4Hz resampling. Then the series is split into LF and HF components with passband digital filters of cut off frequencies corresponding to LF and HF band limits. The filters are designed to optimize the passband ripple versus filter order. The instantaneous LF and HF powers of IBI series are computed for time windows of adaptive lengths corresponding to duration of LF (~10s) and HF (~3s) cycles respectively. The length of the HF cycle is computed from the breathing signal. The respiration wave is established from ECG amplitude modulation occurring due to distance changes between the heart and the V6 electrode during breathing. The algorithm was prototyped in Matlab and its real-time version was implemented in C++. The methods were applied to ECG recordings of 10 patients at rest, during body position changes and deep breath tests. Comparison to spectral methods was conducted.



Conclusion: The proposed approach allows to assess HRV parameters with a delay equal to the sum of: LF and HF cycle durations, interpolation, filter order lags (order of seconds) and the computational delay (order of milliseconds). Correlation coefficients for the mean LF and HF powers computed for the proposed algorithms and classical periodogram estimation range from 94,1% (HF power, breath enhanced method) to 99,3% (LF power, adaptive LF cycle time window). However, the spectral methods need much longer analysis periods for a sufficient spectral resolution. The proposed methods outperform considerably the spectral methods in applications requiring fast tracking of HRV parameters.