Moving Window Signal Concatenation for Spectral Analysis of ECG Waves

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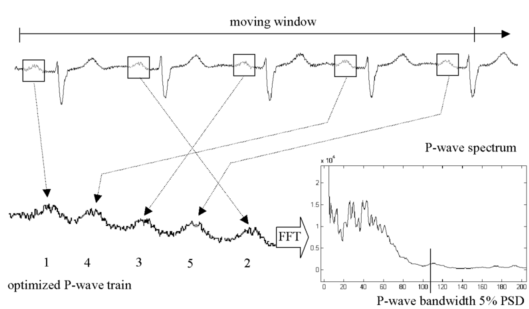
Spectral analysis of ECG waves is useful as a background for the medical analysis, as well as for estimating the necessary throughput of transmission channel or storage space. Recently introduced non-uniformly sampling ECG recorders also use the local bandwidth estimate to adjust the data acquisition to expected local properties of the signal. Unfortunately, the commonly applied spectral estimation methods are not directly applicable to the ECG waves due to their short duration.

We postulate replacing the averaging of successive waves spectra, by concatenation of selected type waves (P, QRS or T) in a moving time window. The window size is selected as a result of compromise between the spectrum resolution (high for long window) and temporal response (fast for short window). To avoid influence of border effect, the order of concatenated waves is optimized with regard to the maximum smoothness of resulting signal. The smoothness estimate is based on the similarity of the first and second derivatives of the adjacent signals in weighted contributions.

Evaluation of the proposed method was made experimentally and used ICE60601-2-51-complying ECG interpretation software for determining the wave borders. First attempt was made with use of the CSE Multilead Database, however the duration of records (10s) is too short to apply time sliding windows of different size. Second attempt was using custom-recorded long time 12-leads ECGs. Our results for 10s window shows a considerable drop of estimated bandwidth (defined as 5% of power spectrum density) due to limiting the border effect contribution. Using normal records from CSE Dataset3 for which the initial bandwidth value of 151Hz was calculated with P-wave spectrum averaging, we estimated the corrected limit to 107Hz only, which seems to be much more reasonable considering the physiological limitations of ECG signal generation. Similar results were observed for QRS and T waves.



Optimizing of P-wave train for spectrum estimation.