Signal Processing Subsystem Validation for T wave Alternans Estimation

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Background. A number of methods have been proposed to estimate microvolt T-Wave Alternans (TWA), which typically include several ECG processing subsystems. However, there is no systematic procedure for analyzing the robustness of each whole estimation system in terms of these processing subsystems, hence making the standarization difficult.

Methods. We used a basic TWA estimation temporal system to study the effect of some relevant preprocessing subsystems. The subsystem inclusion and its parameters tuning were analyzed. TWA episodes were included in real ECG signals by adding an alternan waveform with different patterns, namely, in the 0%, 10%, 50%, and 100% of the signal. Additional and different noise sources were also added to the signals. In each experiment, two estimation systems were evaluated, which were different in just one preprocessing characteristic. We randomly obtained 50 semi-synthetic signals, and for each one, the TWA amplitude and area estimation errors were computed. To evaluate the differences between each pair of systems, different statistics (mean M, power P, and others) were obtained, and their increase (dM, dP; Mean [95% Interval Confidence]) was evaluated with bootstrap resampling.

Results. (a) Baseline cancellation subsystem: for noise-free signals, when this subsystem was not included, TWA estimation improved sigificantly, dM = 0.76[0.46,1.06], dP = 22.88[15.50,30.43]; for SNR=25 dB, estimation improved, dM = 0.80[0.15,1.46], dP = 29.97[7.24,52.66]; and for SNR=15 dB, estimation performance decreased dM = -0.01 [-0.02,-0.002], dP = -0.01 [-0.03,-0.003]. Including this subsystem, the use of a median filter, instead of a mean filter, significantly improved the estimation. Different filter window lengths (T) were tested, obtaining significantly better results with T=1500 ms. (b) High frequency noise filter subsystem: for noise-free signals, when this subsystem was not included, TWA estimation improved, dM = 1.86[0.78,2.94], dP = 55.11[27.22,83.92]; however, for SNR=25 dB, estimation did not improve, dM=1.55[-2.18,5.69], dP = 152.40[-50.10,382.21]; and for SNR=15 dB, estimation performance decreased dM = -25.16[-32.67,-18.70], dP = -2154.2[-3037.8,-1417.3].