An Instantaneous Measure of ECG Signal Quality

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Purpose: The majority of the biomedical data recorded today deal with heart function, as cardiovascular diseases are the main mortality factor worldwide. With the vast number of ECGs recorded every day, automatic processing of the ECG has been continuously gaining momentum. Although various ECG based analyses have been carried out, the issue of ECG signal quality has not been addressed properly as the ECG and noise contaminating it present unpredictable dynamics. The aim of this study is to propose an instantaneous ECG signal quality index (ISQI) in a non-binary and online fashion.

Methods: Using a non-linear filtering technique, called relative energy (Rel-En) [1], a 'denoised' version of the original ECG is created and used to derive the ISQI. First, the QRS complexes are separated from the ECG using Rel-En. The denoised ECG is then created as the QRS complexes added to the band pass filtered QRS-less ECG. Finally, using a sliding window, the ISQI is derived as the correlation coefficient between the original ECG and the denoised ECG. The performance was evaluated by adding different types (baseline-wander, EMG, and motion artifact) and amounts of noise from the MIT/BIH noise stress database, to clean segments of MIT/BIH arrhythmia database.

Results: Against different noises, the ISQI monotonously decreased as higher levels of noise (from -12db to 18db) were added to clean ECGs, suggesting the effectiveness of the algorithm in deriving signal quality. Moreover, a significant difference was observed between the ISQI values derived from different levels of noise. Table 1 reports detailed results for different noise types.

Conclusions: Our preliminary results suggest that the developed ISQI, can efficiently provide a non-binary measure of ECG quality. More importantly, the approach is easily implementable by two filters with low computation costs, which makes it suitable approach for online scenarios.

Table 1 - Average quality indexes obtained by the proposed method.

SNR/Noise	Baseline Wander (BW)	Motion Artifact (MA)	Muscle Activity (EMG)	BW+EM+MA
-12dB	0.53 ± 0.25	0.47 ± 0.26	0.46 ± 0.30	0.47 ± 0.27
-6dB	0.63 ± 0.17	0.64 ± 0.21	0.56 ± 0.22	0.56 ± 0.20
0dB	0.80 ± 0.09	0.75 ± 0.12	0.67 ± 0.12	0.66 ± 0.11
6dB	0.93 ± 0.02	$0.82 \pm 0.0.5$	$0.83 + 0.05$	0.74 ± 0.05
12dB	0.95 ± 0.01	0.95 ± 0.02	0.94 ± 0.02	0.88 ± 0.01
Clean ECG	0.97 ± 0.01	0.97 ± 0.01	0.97 ± 0.01	0.97 ± 0.01

[1] S. Yazdani, S. Fallet, and J-M. Vesin. A novel short-term event extraction algorithm for biomedical signals. *IEEE Trans Biomed Eng* 2018;65(4):754:762..