Real-time Signal Quality Assessment and Improvement Methods for ECGs Collected using Mobile Phones

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Considering that the uncertainty noise produced the decline in the quality of ECGs, this paper proposed systematic quality assessment and improvement methods for real-time ECGs collected using mobile phones. Firstly, a QRS wave detection algorithm based on template matching was constructed. Simultaneously, the existing algorithms based on digital filtering and length transform were also used to identify QRS wave. After the accurate QRS wave was located, an individual ECG template signal was constructed, which only contained a single cardiac cycle ECG. Then we used the location information of QRS wave and individual ECG template to assess the signal quality for twelve-lead ECGs. The former could provide quality information about the signal time axis and the latter could provide quality information about the modality of the signal. The analyzing method for quality assessment integrated five algorithms: 1) the analysis of a single lead ECG by comparing two type differences: one was the location information of QRS wave using different method, another was the matching results between ECG recording and individual ECG template; 2) the analysis of twelve-lead ECGs as well as by comparing the above two differences; 3) based on the power spectrum distribution of each ECG; 4) based on the entropy measure analysis of each ECG. The single signal quality index (SSQI) for each ECG and the integrative signal quality index (ISQI) for twelve-lead ECGs were calculated after signal quality assessment. The range of ISQI was between 0 and 1 inclusively. High value of ISQI means good quality of the ECGs. Each ECG record would be assigned to two groups according to ISQI, acceptable and unacceptable group. Finally, a wavelet de-noising method was used to improve the signal quality for acceptable ECG record and an ECG template de-noising method was used to improve the signal quality for unacceptable ECG record.