Clinical Feature Extraction for Mobile ECG

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Abstract

In this talk, first we present two methods, a time-domain morphology-gradient based approach (TDMG) and a time-frequency discrete wavelet transform-based approach(TFDWT) for the extraction of the following clinically important features of the ECG waveform namely, QRS-interval, ST-segment, RR-, PP-, PT-, QT-, PR-, PQ-interval, R-height and intra-QRS fractionation aiming at application in the mobile wearable environment. The TDMG method takes advantage of the distinct morphology of the three major ECG segments (P, QRS, T) coupled with the use of a gradient-threshold based technique in order to extract the beginning and end time instances of the ECG waves. The QRS steep slope facilitates the estimation of the QRS-onset and offset time instances, by comparing a feature signal defined as a linear combination of the first and second derivatives of the ECG signal against a predefined threshold value. From there the time instances of the Q,R and S waves are identified and following the remaining two waves P,T are localised in time by processing in a similar way that portion of the signal that precedes and succeeds the QRS complex respectively. Figure 1 illustrates an example of the TDMG method applied on an ECG signal from the MIT-BIH database. The developed algorithm can deduce any possible absence of the aforementioned waves as well as performs robustly even under noisy conditions. TFDWT method involves multi-resolution analysis of Discrete Wavelet Transform (DWT) over the ECG signals in the dyadic space and modulus-maxima based feature extraction technique in the wavelet domain. Based on our initial experiments on 100 PQRST complexes available at the MIT-BIH online databases comprising of mobile/ambulatory, Holter and standard 12 leads ECG signals, we propose to use the Haar function as the mother wavelet. Since this function is not computationally intensive, the DWT architecture based on this Haar wavelet would also lead to ultra-low power hardware design. Based on our observations on the experimental data, we also propose to use only wavelet resolution level 3 and 5 for extracting the above mentioned features instead of going through all of the resolution levels. By statistical analysis, it has been found that at the third and fifth resolution levels QRS complex and intra-QRS fractionation, and P and T are identified respectively by using modulus-maxima on the wavelet coefficients at those respective resolution levels. Figure 2 depicts an example of the TFDWT method applied on an ECG signal from the MIT-BIH database. Such approach would lead to ultra-low power hardware design for DWT based feature extraction in the mobile environment. However the aforementioned approaches do present certain shortcomings. The TDMG suffers from baseline wandering and may give erroneous results in the presence of uncommon ECG morphologies particular for the P- and T-wave. On the other hand, the TFDWT method seems to tackle the previous issues but cannot always estimate the R-height accurately. In conclusion we strongly believe that a hybrid approach will solve all these problems. For example, intra-QRS fractionation can be identified by TFWDT and then be purified with the use of time domain methods. Thus this hybrid approach will be robust and accurate and also ideal for implementation in the noise-prone mobile ECG environment.

The second part of this talk deals with denoising and artifact removal from the mobile ECG signal. It is expected that in mobile environments the ECG recordings will contain a significant amount of noise and activity-induced artefacts. In that direction we have investigated the use of Independent Component Analysis (ICA) and also Wavelet Transform. The initial results are promising and reveal that these two techniques can in fact be utilized to purify the mobile obtained ECG signal.

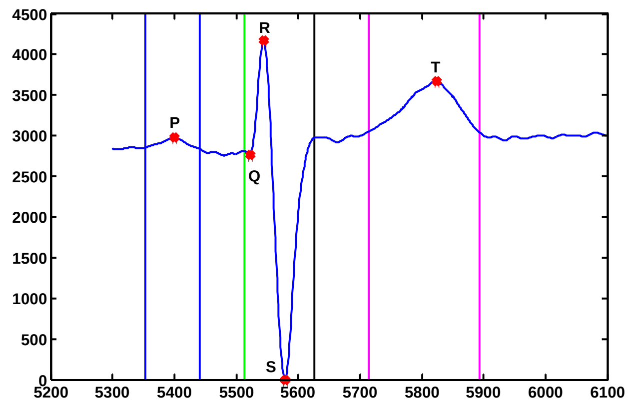

Figure 1: TDMG Method

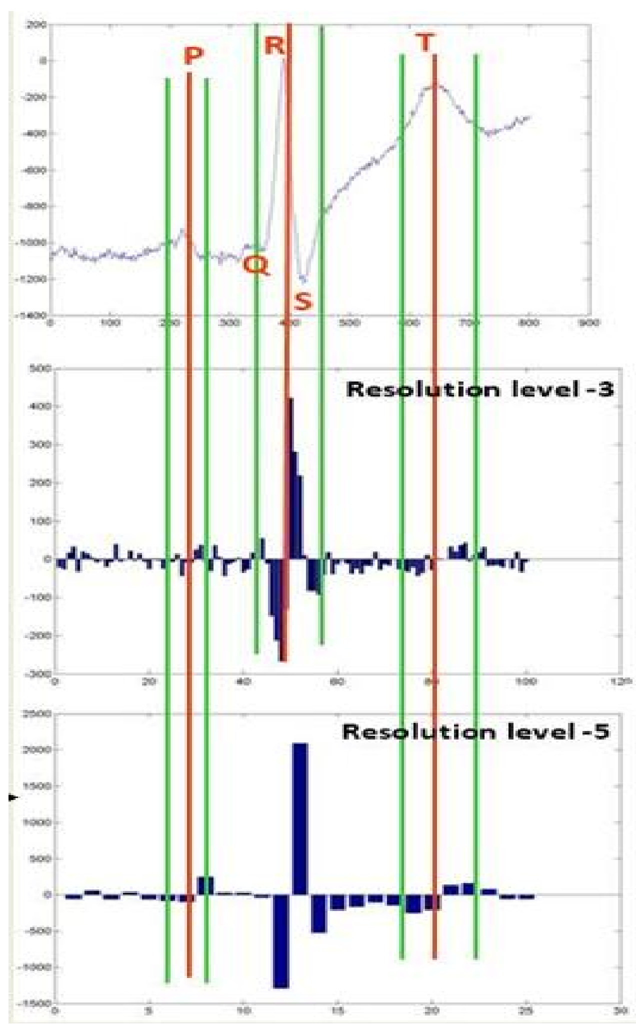

Figure 2: TFDWT Method