Advances in Electrocardiogram Information Management

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INTRODUCTION

Cardiac disease is one of the main causes of human mortality in the modern world. Interpreting the underlying mechanisms related to various heart ailments is essential for developing new treatments and improving the quality of life and provisioning a better, low cost patient-specific health care. An ECG is used to measure the rate and regularity of heartbeats, as well as the size and property variations of the chambers. It is also used to study the existence of any damage to the heart and the effects of drugs or devices used to regulate the heart. The study of Electrocardiogram (ECG) is one of the highly researched fields in biomedical engineering. In ECG machine's data acquisition system, analog ECG signal is captured and converted to digital data. This is then made available for further processing.

The normal ECG recordings have a number of different morphologies depending on the patient, type of the lead used for recording etc. The normal clinical features of the electrocardiogram, which include wave amplitudes and inter-wave timings, are shown in Figure 1. In an ECG waveform P-wave represents depolarization of the atria, QRS complex corresponds to the ventricular depolarization and the T-wave represents ventricular repolarisation. The amplitude and relative position of different waves P-Q-R-S-T give valuable information about the functioning of heart.

Any clinical analysis of ECG waveform starts from identifying the QRS complex, its amplitude and width as well as its regularity. This will be followed by P- wave and T- wave analysis, and the analysis of various intervals, P- R, R- R, S-T and Q-T segments. In order to get accurate detection of these fiducial points pre-processing is done on ECG signals. From the pre-processed signal features are extracted and analyzed.

This discussion presents certain methods used for noise removal, feature extraction, logical processing and pattern recognition of ECG signal.

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BACKGROUND

For the purpose of long-term ECG recording, Holter method has been continuously improved over the years leading to miniaturization, digitalization, and an increased use of memory. Visual inspection of these signals is time consuming and requires intensive analysis by experts. ECG signals commonly exhibits inter and intra patient variability in morphology and this phenomenon sometimes leads to inconsistent interpretation of it even by experienced medical professionals. The automated methods for the study and interpretation of ECG can provide a powerful way for the continuous monitoring of patients. As the medical field is moving towards more automated and intelligent systems, requirement for better methods of ECG signal analysis and interpretation are becoming very crucial.

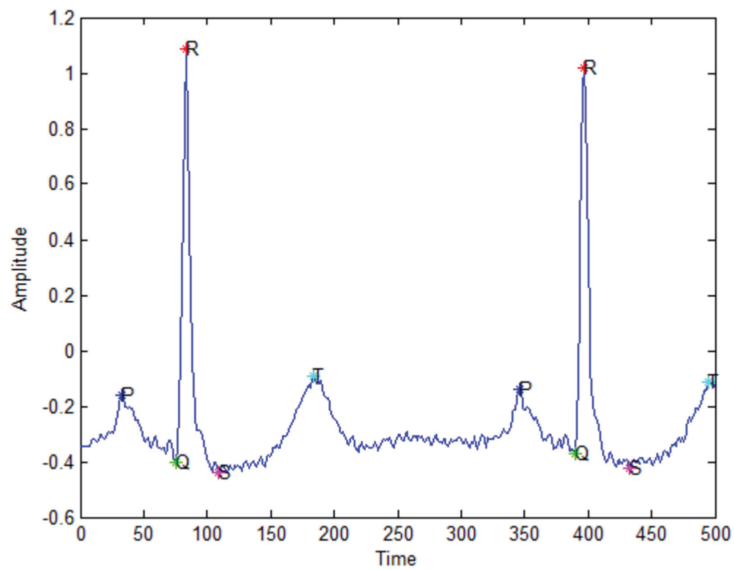
The first step in the analysis of any ECG signal is the identification of fiducial points. The presence of different morphologies of ECG signal and the additive noise levels, usually leads to errors in identification of peaks. Since the automatic interpretation solely depends upon the accuracy of detection of fiducial points, better methods are required to extract these points.

Figure 2 describes the stages of automatic ECG analysis and the scheme for interpretation

Noise Removal

ECG waveforms are usually contaminated by noise and artifacts such as power line interference, contact noise, patient– electrode motion artifacts, electromyographic(EMG) noise, baseline drift etc. EMG interference appears as rapid fluctuations on ECG waves with frequency content that ranges from dc to 10 kHz. The breathing cycle can cause signal variation owing to electrode motion relative to the heart and due to thoracic electrical impedance change as the lungs fill and empty the air. This can be observed as

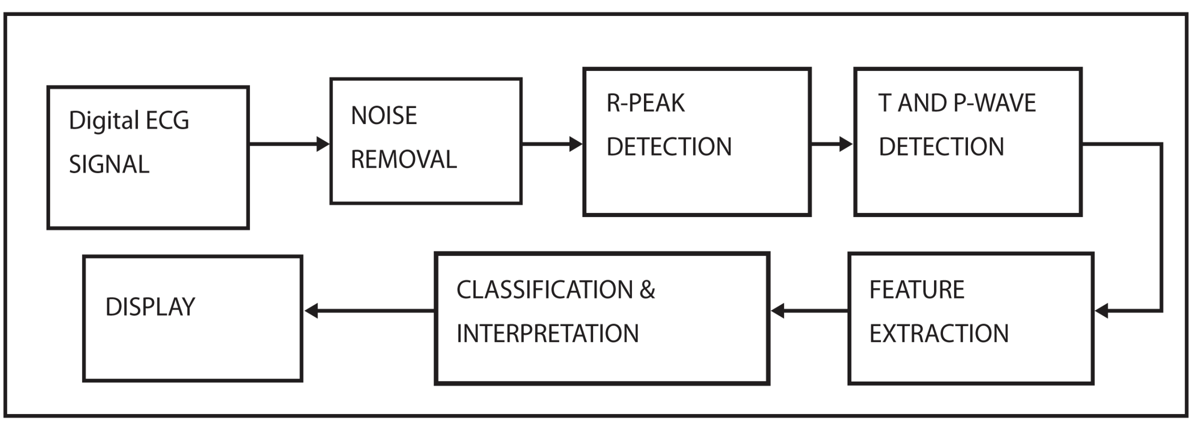
Figure 1. A normal ECG waveform



a slow modulation of the ECG amplitude at the same frequency as the breathing cycle results in baseline drift of ECG wave. In peak detection methods based on threshold cutoff, the major noise factor is baseline drift. Baseline drift can also be caused by offset voltages in the electrodes and body movement. Presence of noise or artifacts leads to wrong detection features and the subsequent interpretation errors. Since the sources of noise and their features are known, removal or reduction of these noises is relatively easy.

Band pass filters and transform domain techniques are the most commonly employed methods for noise reduction. EMG interference can be removed using morphological filter. The frequency content of baseline wander is usually in a range well below 0.5 Hz. Median filtering with multiple range can be used to get the baseline corrected ECG signal (de Chazal, Heneghan, Sheridan, Reilly, Nolan & O'Malley, 2003). Low-frequency baseline wander (BW) correction and high-frequency artifact noise reduction from the raw ECG can also be achieved using wavelet transform

Figure 2. ECG processing stages



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