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Real time QRS complex detection using DFA and regular grammar

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Abstract

Background: The sequence of Q, R and S peaks (QRS) complex detection is a crucial procedure in electrocardiogram (ECG) processing and analysis. We propose a novel approach for QRS complex detection based on the deterministic finite automata with the addition of some constraints. This paper confirms that regular grammar is useful for extracting QRS using lexer and manipulating normal and abnormal ECG signals. A QRS is modeled by a pair of adjacent peaks which meet certain criteria of standard definitions and duration.

Results: The proposed method was applied on several kinds of ECG signals issued from the standard MIT-BIH arrhythmia database. A total of 48 signals were used. For an input signal, several parameters were determined such as QRS durations, RR differences, and the peaks amplitudes. cR1 and cR2 parameters were added to classify the regularity of RR distances and QRS durations, respectively. The sensitivity rate of the suggested method was 99.74% and the specificity rate was 99.86%. Moreover, the sensitivity and the specificity rates (statistics according to the legislation) applied to the positive one.

Conclusions: Regular grammar with the addition of some constraints and definitions has demonstrated a good behavioral for ECG signals diagnosis. Compared to traditional methods, the use of grammar provides satisfactory and competitive results and reduces their complexities to an extent it seems much simpler than those cited in the literature.

Keywords: ECG signal, QRS complex, RR distances, DFA, Regular grammar

Background

The sequence of Q, R, and S peaks complex detection is one of the most frequently addressed tasks in ECG signal processing and analysis. A wide range of methods differing in their detection rules have been proposed and used [1–4]. Nevertheless, the problem remains open given the variety of ECG signals and the noises that might impact them. Some methods include the Support Vector Machine (SVM) [5, 6], the fuzzy neural networks [7, 8] and the wavelets [9, 10, 24]. Sahambi et al. [25, 26] utilized the time-series derivatives of the Gaussian functions as a wavelet for the characterization of ECG beats. The author used the dyadic wavelet transform to detect and measure the different parts of a signal, especially the locations of the beginning and the end of the QRS complex. Sahambi et al. showed the occurrence of the algorithm in the presence of a high frequency noise added to the signal. In [11], a dyadic wavelet transform was used to extract

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