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# Real time QRS complex detection using DFA and regular grammar

Saharj Hameed<sup>1\*</sup>, Fahad Bin Abdulaziz and Mubashir Habib Bokhan

\*Correspondence: [saharj.hameed@uqu.edu.sa](mailto:saharj.hameed@uqu.edu.sa)  
<sup>1</sup>Department of Information and Medical Systems, Umm Al-Qura University, P.O. Box 71551, Makkah, Saudi Arabia  
Full list of author information is available at the end of the article

## Abstract

**Background:** The acquisition of Q, R, and S peaks (QRS) complex detection is a crucial procedure in electrocardiogram (ECG) processing and analysis. We propose a novel algorithm for QRS complex detection based on the dynamic time warping (DTW) algorithm with the addition of some constraints. This paper considers that signals can be used for detecting QRS complex and rejecting non-QRS signals. A QRS is considered to be a pair of adjacent peaks which meet the four criteria of standard deviation and duration.

**Results:** The proposed method was applied on several trials of ECG signals received from the standard MIT-BIH arrhythmia database. A total of 40 signals were used. For an input signal, several parameters were determined such as QRS duration, RR distance, and the peak amplitude. RR and rRRS parameters were added to quantify the regularity of RR distance and QRS duration, respectively. The sensitivity of the suggested method was 99.74% and the specificity was 99.94%. Moreover, the sensitivity and the specificity rates according to the top-100 cases that were performed.

**Conclusions:** Regular grammar with the addition of some constraints and additional parameters proved beneficial for ECG signal analysis. Compared to traditional methods, the use of grammar provides satisfactory and competitive results and it could be more comparable to or more better than those used in the literature.

**Keywords:** ECG signal, QRS complex, RR distance, DFA, Regular grammar

## Background

The acquisition 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 allowing high detection rates have been proposed and used [1–4]. Nevertheless, the problem remains open since the variety of ECG signals and the noise that might impact them. These methods include the Support Vector Machine (SVM) [5–10], the fuzzy neural networks [11–14] and the wavelets [1, 17–24]. Saha *et al.* [15, 16] utilized the first-order derivatives of the Gaussian function as a window for the discrimination of ECG beats. The authors used the dyadic wavelet transform to detect and measure the different parts of a signal, especially the duration of the beginning and the end of the QRS complex. Subsequently, it showed the robustness 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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**Asiya Mohamed Al-Busaidiyah**



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Proceedings of the 2nd International Conference on Electronics, Biomedical Engineering, and Health Informatics Triwiyanto Triwiyanto, Achmad Rizal, Wahyu Caesarendra, 2022-06-24 This book presents high quality peer reviewed papers from the International Conference on Electronics Biomedical Engineering and Health Informatics ICEBEHI 2021 held at Surabaya Indonesia virtually The contents are broadly divided into three parts i electronics ii biomedical engineering and iii health informatics The major focus is on emerging technologies and their applications in the domain of biomedical engineering It includes papers based on original theoretical practical and experimental simulations development applications measurements and testing Featuring the latest advances in the field of biomedical engineering applications this book serves as a definitive reference resource for researchers professors and practitioners interested in exploring advanced techniques in the field of electronics biomedical engineering and health informatics The applications and solutions discussed here provide excellent reference material for future product development

Real Time Matched Filter Detection of the QRS Complex by Replica Correlation, 1970 The report describes an approach to optimum detection of each cardiac cycle from noisy electrocardiograms A filter matched to the QRS complex of the electrocardiogram is proposed to achieve the results It is demonstrated analytically that such a filter yields the optimum signal to noise ratio obtainable in the presence of stationary Gaussian noise While this type of filtering is done on a digital computer and not in real time the advent of medium and large scale integrated circuit technology has made it feasible to implement a specific piece of hardware for this purpose Author *QRS Detection Using Automata Theory in a Battery-powered Microprocessor System* Gregory S. Furno, 1982

**An Efficient Algorithm for ECG Denoising and Beat Detection** Tarun Mani Tiwari, 2008 Due to physical variability of ECG waves detection of the QRS complex becomes a difficult task in a real time situation Jiau Pan and Willis J Tompkins of the University of Wisconsin developed a real time QRS detection algorithm for a Z 80 microprocessor They demonstrated an overall performance of 99.325% when tested against the MIT BIH arrhythmia database

*Real-Time QRS Detection and Electrocardiogram Signal Compression Using Wavelet Based Subbands* Asiya Mohamed Al-Busaidiyah, 2016

**QRS Detection Using Wavelet Transform** Anuja Nanavati, 2012 The electrocardiogram ECG provides information about the heart ECG is a biological signal which generally changes its physiological and statistical property with respect to time tending to be non stationary signal For studying such types of

signals wavelet transforms are very useful The most striking waveform when considering the ECG is the QRS wave complex which gives the R wave peak which is time varying This report describes an algorithm for detection of QRS complex using the Wavelet transform This detector is reliable to QRS complex morphology and properties which changes with time and also to the noise in the signal The performance of the Wavelet transform based QRS detector is illustrated by testing ECG signals from MIT Arrhythmia database We also compare the performance of Wavelet based QRS detector with detectors using Derivative based method From the comparison the Wavelet detector exhibited superior performance for different ECG signals like multiform premature ventricular contractions bigemy and noisy signals

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