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ORIGINAL ARTICLE

ECG arrhythmia classification using time frequency distribution techniques

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Abstract In this paper, we focus on classifying cardiac arrhythmias. The MIT-BIH database is used with 14 original classes of labeling which is then mapped into 5 more general classes, using the Association for the Advancement of Medical Instrumentation standard. Three types of features were selected with a focus on the time–frequency aspects of ECG signal. After using the Wigner–Ville distribution the time–frequency plane is split into 9 windows considering the frequency bandwidth and time duration of ECG segments and peaks. The summation over these windows are employed as pseudo-energy features in classification. The "subject-oriented" scheme is used in classification, meaning the train and test sets include samples from different subjects. The subject-oriented method avoids the possible overfitting issues and guaranties the authenticity of the classification. The overall sensitivity and positive predictivity of classification is 99.67 and 98.92%, respectively, which shows a significant improvement over previous studies.

Keywords Cardiac arrhythmia · Classification · Decision tree · Ensemble learner · Time–frequency analysis · Wigner–Ville distribution

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1 Introduction

Cardiac arrhythmias are group of heart conditions in which the electrical activities of the heart become irregular. Arrhythmias usually occur as a result of a malfunction in the conduction system or when a pulse is originated from where it wasn't supposed to. Some arrhythmias can be extremely dangerous and some of them can happen in an everyday life of a healthy person. However, studies show that about 80% of sudden cardiac death is the result of ventricular arrhythmias. Thus, the early and accurate detection of arrhythmias is crucial [1].

Electrocardiogram (ECG) is the recording of the electrical activity of the heart which occurs almost periodically through each heartbeat. Thus, the ECG signal is an excellent source to identify arrhythmias. Some arrhythmias don't show any persistent trace in the ECG signal and consequently a continuous monitoring of ECG is necessary for some cases. Detection and classification of different abnormalities in ECG has long been investigated by researchers in the field of biomedical signal processing. Our goal in this paper is to introduce a new prospective in cardiac arrhythmia detection and help to improve the classification process.

Notable works has been done in analyzing the time-domain features of ECG signal which include RR intervals, QT segments, QRS complexes and other morphological features [2–4]. On the other hand, the spectral domain offers a different insight and its parameters give a distinctive representation of signal which can be used for better diagnosis. Besides the subtle time-domain changes of some arrhythmias will have an evident impact on the ECG spectrum.

The most well-known tool for investigating a signal in frequency domain is the Fourier Transform (FT), which in

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