

Chapter 12

Electrocardiogram Dynamic Interval Feature Extraction for Heartbeat Characterization

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ABSTRACT

In the chapter, dynamic time domain features are extracted in the proposed approach for the accurate classification of electrocardiogram (ECG) heartbeats. The dynamic time-domain information such as RR, pre-RR, post-RR, ratio of pre-post RR, and ratio of post-pre RR intervals to be extracted from the ECG beats in proposed approach for heartbeat classification. These four extracted features are combined and fed to k-nearest neighbor (k-NN) classifier with tenfold cross-validation to classify the six different heartbeats (i.e., normal [N], right bundle branch block [RBBB], left bundle branch block [LBBB], atrial premature beat [APC], paced beat [PB], and premature ventricular contraction[PVC]). The average sensitivity, specificity, positive predictivity along with overall accuracy is obtained as 99.77%, 99.97%, 99.71%, and 99.85%, respectively, for the proposed classification system. The experimental result tells that proposed classification approach has given better performance as compared with other state-of-the-art feature extraction methods for the heartbeat characterization.

INTRODUCTION

The cardiac heart activity of the arrhythmic patients is analyzed by the electrocardiographic (ECG). The analysis of the ECG signals are important for the detection of irregular, slower or faster electrical activity of the heart (Kass and Clancy 2005) which is known as arrhythmia. The arrhythmias are basically divided into life-threatening and non-life-threatening arrhythmias. The life-threatening arrhythmias are explained in (Hu et al. 1997; Lagerholm et al. 2000; De Chazal et al. 2004; Alonso-Atienza et al. 2014) whereas, the non-life-threatening arrhythmias represent long-term threats which are crucial and needs special care of it. The long-term ECG recordings are useful for the detection of non-life-threatening arrhythmias. Manual detection of the arrhythmic heartbeats is impractical and time consuming. So, the researchers (Prasad and Sahambi 2003; Osowski et al. 2004; Rodriguez et al. 2005; de Chazal and Reilly 2006; Jiang et al. 2006; Jiang and Kong 2007b; Ince et al. 2009a; de Oliveira et al. 2011; Ebrahimzadeh and Khazaee 2011; Martis et al. 2011; De Lannoy et al. 2012; Huang et al. 2012; Banerjee and Mitra 2014) develops the automatic heartbeat classification system. The researchers differ the existing methods of the classification system in the two main aspects i.e., feature extraction, and classification. A number of papers existing in the literature which uses the different feature sets. Some of the features are summarized as: wavelet features (Jiang et al. 2006; Ince et al. 2009b; Ye et al. 2012; Yang and Shen 2013), waveform features (Rodriguez et al. 2005), hermite coefficients (Lagerholm et al. 2000; Osowski et al. 2004; Jiang and Kong 2007b), ICA and RR features (Huang et al. 2012), wavelet and RR features (Ince et al. 2009a), waveform and RR features (De Chazal et al. 2004; de Chazal and Reilly 2006; de Oliveira et al. 2011), ICA and RR features (Ye et al. 2012), Morphology and RR features (Zhang et al. 2014), and projection & weighted RR features (Chen et al. 2017). After the feature extraction, the classifier is utilized for the classification of the different arrhythmias. The classifier utilized in the existing works are self-organizing map (Lagerholm et al. 2000), support vector machine (SVM) (Osowski et al. 2004; Jiang et al. 2006; Ye et al. 2012), artificial neural network (Prasad and Sahambi 2003; Jiang and Kong 2007a; Ince et al. 2009a), decision tree (Rodriguez et al. 2005), *k*-nearest neighbor classifier (Kutlu and Kuntalp 2012), and linear discriminates (De Chazal et al. 2004; De Chazal and Reilly 2006). From the literature (Raj et al. 2015b; Raj et al. 2015a), (Martis et al. 2013), (Llamedo and Mart'inez 2012), (Hu et al. 1997), (De Chazal and Reilly 2006), (Ince et al. 2009a), (Inan et al. 2006), (Sayadi et al. 2010), (Khadra et al. 2005), (Jiang and Kong 2007b), (Martis et al. 2013), (Jung and Lee 2017), and (Ray and Sharma 2016), it is clear from the literature that the beat classification system requires the classifier with the different feature sets are not efficiently classify the different classes. So, Inspired by the works reported in literature the new feature set is develop which only uses the dynamic time-domain information of the heartbeats to classify them into different classes using *k*-NN classifier. The *k*-NN classifier is used in the proposed work due to its less complexity and very less time consuming with efficient classification of the beats. The new feature set combined RR interval, Pre-RR, Post-RR, ratio of Pre to Post RR, and Post to Pre RR intervals for the heartbeat classification.

In this study, experimentation is done on the six types of heartbeats which are normal (N), right bundle branch block (RBBB), left bundle branch block (LBBB), atrial premature beat (APC), paced beat (PB), and premature ventricular contraction (PVC). From each heartbeat, the RR interval, Pre-RR, Post-RR, ratio of Pre to Post RR, and Post to Pre RR intervals are to be evaluated and used as a feature vector. The new feature vector is fed to the *k*-NN (Zhang et al. 2014) classifier with tenfold cross-validation scheme to classify the different beats. The classified heartbeat data using the proposed classification technique

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