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Arrhythmia Classification Using Radial Basis Function Network With Selective Features From Empirical Mode Decomposition

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ABSTRACT

In this piece of work, the authors have attempted to classify four types of long duration arrhythmia electrocardiograms (ECG) using radial basis function network (RBFN). The data is taken from Massachusetts Institute of Technology-Beth Israel Hospital (MIT-BIH) arrhythmia database, and features are extracted using empirical mode decomposition (EMD) technique. For most informative contents average power (AP) and coefficient of dispersion (CD) are evaluated from six intrinsic mode function (IMFs) of EMD. Principal component analysis (PCA) is used for feature reduction for effective classification using RBFN. The performance is shown in the result section, and it is found that the classification accuracy is 95.98%.

KEYWORDS

Arrhythmia Classification, Cardiac Disease, ECG, EMD, IMF, Neural Network, PCA, RBFN

1. INTRODUCTION

Electrocardiogram (ECG) is one of the important sources for analysing any kind of cardiac disease. Electrical impulses that occur during each heartbeat can be visualized in ECG. Accurate analysis of the ECG is most important in the diagnosis of heart disease. Any changes in a normal ECG can occur during various cardiac abnormalities like atrial fibrillation, ventricular tachycardia, myocardial infarction, hypokalemia, etc. Arrhythmia is a type of cardiac illness and it can be detected by strongly analysing waves in ECG (Wu & Rangayyan, 2009). It causes due to the abnormal electrical activity in the heart. In this case the heartbeat rhythms either fast or slow. The factors that cause cardiac arrhythmia are smoking and alcohol consumption, mental stress, diet, diabetes, etc.

Due to the manual data analysis system, it is difficult to extract useful information from the clinical data. Computer-based automated disease diagnosis system will be most useful in medical sectors. The system will automatically take the decision by analyzing the data collected through

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different medical tests. Data include ECG, Ultrasonic images, Magnetic resonance imaging (MRI) are useful for analysis and diagnosis. Machine learning-based medical data analysis is one of the advanced technology that can reduce human interaction by enhancing machine efficiency and will be cost-effective. For early detection of cardiac arrhythmia, a real-time automatic ECG analysis system will be the best support to the physicians (Polat & Güneş, 2007). The characteristic of the ECG varies for different patients in different physical and temporal conditions. Due to these variations in ECG, the task is very difficult for analysis. This requires to develop an automatic ECG classification system (Hoekema, Uijen, & Van Oosterom, 2001). For the development of accurate ECG classifier it is important to extract useful features from data. Several methods for the analysis and classification of ECG signals have been proposed by the researchers over the past few decades. Wavelet Transform (WT) (Tantawi, Revett, Salem, & Tolba, 2015), frequency analysis (Lin, 2008), statistical techniques (Willems & Lesaffre, 1987), filter banks (Afonso, Tompkins, Nguyen, & Luo, 1999), support vector machines (Alonso-Atienza, Morgado, Fernandez-Martinez, García-Alberola, & Rojo-Alvarez, 2013), artificial neural network (Hu, Tompkins, Urrusti, & Afonso, 1993) are the most used methods for ECG analysis and classification.

Due to the non-stationary nature of the ECG signal, EMD is considered in the proposed work for decomposition and feature extraction. Total six number of Intrinsic mode functions (IMFs) are considered as the basic feature. In order to extract useful feature, average power (AP) and coefficient of dispersion (CD) are found from these six IMFs. AP is the mean by which the signal is characterized for reusing important information of the signal. CD of a signal signifies variation of coefficients. Here in the proposed work CD is used for building a feature vector by calculating the probability distribution of the IMFs. Again the dimension of the feature vector is reduced by using principal component analysis (PCA) method. Radial basis function network (RBFN) is used for classifying these selected ECG features. Massachusetts institute of Technology-Beth Israel hospital (MIT-BIH) arrhythmia data has been used for classifying four major types of arrhythmia. A few approaches have been considered earlier for large scale Radial Basis Function Network. In this case the data may be large scale along with the higher variance value. However, in this case, the variance is considered as 2.

2. RELATED LITERATURE

Automated ECG classification can help the cardiologist for the diagnosis of any type of cardiac abnormalities. In the last few decades, several algorithms have been developed by the researchers for the automatic classification of the cardiac signal. Preprocessing, feature extraction, and classification are the three basic steps in ECG signal classification and multiple methods have been applied by the researchers for each of these processes.

Classification of normal and coronary artery disease was performed by applying higher-order statistics and spectra (HOS) method (Acharya et al., 2017). From each heartbeat, HOS bispectrum and cumulants features were extracted. For dimensionality reduction, authors have taken PCA. K-nearest neighbor (KNN) and decision tree classifiers were used for the classification purpose as the performance of these classifiers with fewer features are better. Support vector machine (SVM) classifier was used by the authors for the detection of coronary artery disease (Babaoğlu, Fındık, & Bayrak, 2010). They have used PCA for the feature selection purpose and 79% classification accuracy was achieved by them. Genetic algorithm (GA) and binary particle swarm optimization (BPSO) methods were used for feature selection (Babaoglu, Findik, & Ülker, 2010). SVM with *k*-fold cross-validation was considered for classification purpose and 81% classification accuracy was obtained from their proposed system. S-transform and wavelet transform was used for feature extraction (Das & Ari, 2014). Multi-layer perceptron was considered for the classification of normal and abnormal ECG beats. A long term ECG classification framework was presented in a study (Kiranyaz, Ince, Pulkkinen, & Gabbouj, 2011). Exhaustive *k*-means clustering technique was used for getting an optimal number of key beats and master beats from the ECG waveform. Backpropagation algorithm based classifier