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Research paper

Arrhythmia detection using deep learning

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Abstract

Currently the demand of hospital services increasing gradually. The smart service to the patients is highly essential that counts the death rate. Cardiac problem is a vital problem and people with Cardiological problem are surviving less. The diagnosis of the heart disease facilitates to storage our data. It motivates the application of Data Mining techniques are useful in Health sectors. In this paper authors have taken an approach to detect Arrhythmia using Wavelet transform and Deep Neural Network (DNN). In first stage R-peaks of Arrhythmia data has been detected using Wavelet Transform. In the next stage the Wavelet coefficients are consider as the input features to the DNN model. The classification result for the arrhythmia detection has been presented in the result section of the paper.

Keywords: *ECG Signal; Cardiac Heart Failure; Discrete Wavelet Transform (DWT); R-Peaks; Deep Neural Network*

1. Introduction

With the fast expansion of current society, network and database technology have gained extraordinary ground, people want to get information rapidly and compactly, and they require logical determining to help and guide their conduct. As we know that Heart is an important part in the Human body. In the present situation Heart or Cardiovascular diseases are the exceptionally a major problem in Healthcare industry globally. According to WHO (World Health Organization) about 17 million death occurs due to heart attack [1]. There are many reasons for the Heart disease like high pulse, Cholesterol, Obesity, Smoking etc. It is very complicated and challenging task to make a better diagnosis system which can be executed accurately and efficiently. Automation of medical diagnosis system will be a beneficial work for both the patient and Health service providers [2]. For the diagnosis of cardiovascular diseases (CVD), Electrocardiograms (ECG) are generally utilized as a vital non-intrusive apparatus by cardiologists. Usually, cardiologists can analyze different cardiovascular arrhythmias concurring brief time ECG motions by visual identification [3].

In the past decade, several feature extraction methods of ECG signal have been proposed in the literatures such as morphological features [4], temporal intervals [5], wavelet transform [6], and statistical features [7]. In order to have the classification with high precision the ECG signal must be removed noise components by the filter. Here in this work we have used the wavelet filter for extracting the R-peak and QRS segmentation from the noisy ECG signals. The ECG signal has been characterized by five peaks like P, Q, R, S and T as presented in Fig. 1.

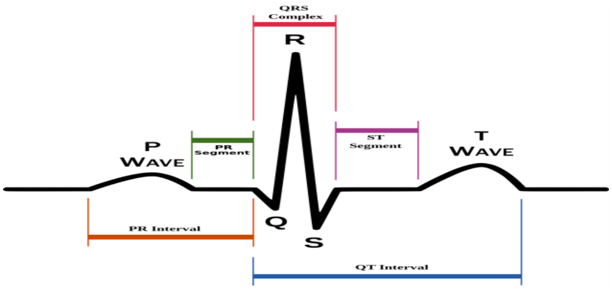

Fig. 1: Structure of ECG Signal.

Automated analysis of ECG signal detection is a prime factor where QRS envelope has a major role. Wavelet transform is an episodic scale illustration that has been utilized successfully as a part of a large range of utilizations, exclusively signal compression. Discrete Wavelet Transform (DWT) is one of the domains which can be implemented for finding the normal and abnormal heart rhythm [8]. In this paper for the analysis of the ECG signal we have used the Deep Neural Network (RBFN) which is a new method in Neural Network technology. There are several neural network methods have already used in previous. For the classification of the ECG signal we are using this DNN method which gives the classification accuracy [9-10]. The paper is organized as follows: Section-2 presents proposed method for the experiment and the experiment result has been placed in Section-3. Conclusion of the paper has been placed in the final section.

2. Proposed methodology

In this work there are four major steps are applied for the classification of the ECG signal using DNN. The propose work has been presented in Fig. 2.

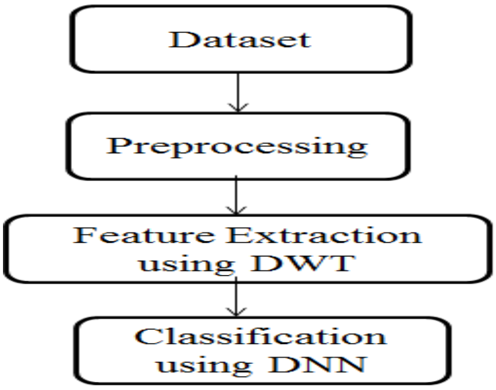

Fig. 2: Proposed Method.

2.1. Data collection

The ECG data has been collected from the MIT-BIH Arrhythmia Database [11]. MIT-BIH is an open access database in which different ECG signals collected from the patients are stored. Initially the preprocessing is performed. Here we have used the Arrhythmia and chf signals for the classification purpose. The signals have been recorded with 360Hz over 5mV range with 11bit resolution. After collecting the signals from the data base next step is preprocessing of the signals.

2.2. Preprocessing of the signal

To separate essential data from the raw ECG signal, preprocessing is needed. This Preprocessing stage is mainly divided into two parts like Noise reduction and QRS Detection.ECG signals are Normalised and Filtered to reduce noise for more reliable information. Information can be obscured by some noise like muscle artefacts, electrode friction etc. It may yield wrong information in feature extraction and further work. During Denoising the aim is to remove all unnecessary components of ECG signal without harming the useful information.

2.3. Feature extraction-using DWT

After obtaining raw signals in digitized form, signals are preprocessed. Now we need to extract useful features data from the preprocessed signal. The clean ECG signals are decomposed using wavelet transform. Here in our experiment we are using discrete wavelet transform (DWT) for collecting the useful features from the signals. Discrete Wavelet Transform (DWT) utilizes filter banks for the development of multitier solution analysis, which enhances calculation effectiveness [12]. In DWT the characteristics of normal and abnormal heart rhythms can be easily distinguished. In Fig. 3 the architecture of DWT has been presented. There are many redundant coefficients generated by the Continuous Wavelet Transform (CWT) signal analysis which will make a trouble if the function was to restore the original signal. This technique is a special case of Wavelet transform in which the coefficients are formed to be at last as fast as likely to restore the original signals. DWT provide a close relationship of signal in time and frequency domain and are defined as in (1):

$$W(m,n)=\sum_{m}\sum_{n}x[n]2^{-\frac{1}{2}}\psi(2^{-\frac{1}{2}}j-n) \tag{2}$$

Where $W(m,n)$ is the coefficients of the DWT and $x[n]$ is the discrete signal. ψ is the DWT function.

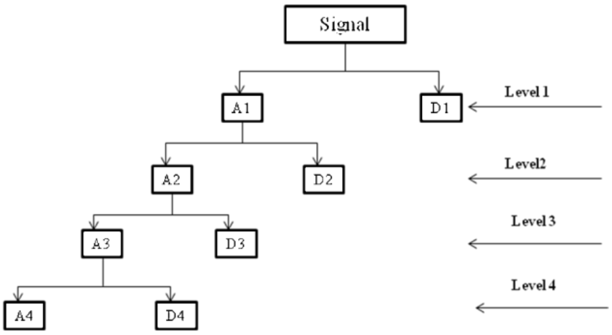

Fig. 3: Structure of Discrete Wavelet Transform for Feature Extraction

2.4. Classification using DNN

Deep learning is one sort of structure based learning technique and consists of input layers, hidden layers and output layers. In the recent years most of the researchers are employing a new advanced technique of neural network called deep neural network (DNN) which might be applied in data processing, image processing, pattern recognition, speech enhancement, biomedical signal processing etc. [13-14]. Deep learning is a kind of artificial neural network system with number of data representation layers that learn illustration by expanding the level of deliberation from one layer to another layer [15]. The structure of the DNN is represented in Fig. 4. In our purposed model we are taking the training and testing data set from the original data set which applied on the DNN model for the calculation of validation result. The experiment is done using R-studio.

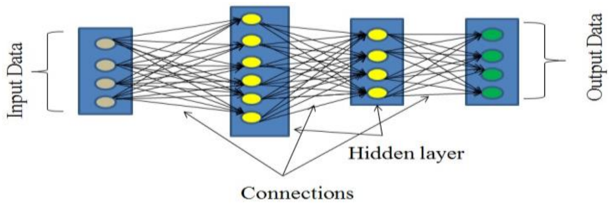

Fig. 4: Deep Neural Network.

3. Result discussion

3.1. Decomposition of ECG signal using DWT

The original signals are collected from the MIT-BIH Arrhythmia data base. The ECG signals are decomposed by Discrete Wavelet Transform (DWT). The sampling rate has been assigned with 650 for the reconstruction of the approximation and the details of the signal. The comparison of original and decomposed signal has been presented in Fig.5. After the decomposition of the original signal with DWT, the R peaks are detected.

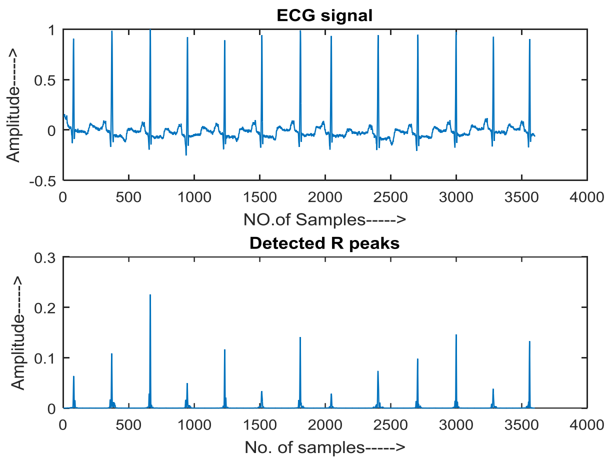

Fig. 5: Composition of Original and Reconstrucrted Arrhythrimia Signal.

The comparisons of the original signal and reconstructed clinical signals have presented in Fig. 6. Both these signals are decomposed with DWT which can detect the R peaks from the original signal. These signals are considered for training the network for classification.

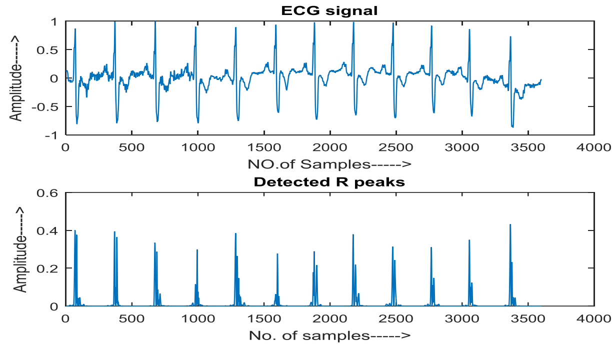

Fig. 6: Composition of Original and Reconstrucrted BW Signal.

3.2. ECG classification using deep neural network

The classification of the ECG signals is provided to the DNN. In training phase 1200 coefficients of R peaks are selected. For testing phase 850 pathological signals are considered. The network is classified the signals into normal and Arrhythmia. The Classification is achieved by utilizing the DNN and the accuracy is measured. In the training state of the network softmax activation function is used for the better classification result. After successfully completion of the network the testing of the model is occurred by taking previously separated testing data set. Classification accuracy is defined as the ratio of the number of correctly classified cases to the total number of cases (N) and is calculated using the formula:

$$Accuracy = \frac{TP + TN}{N} \times 100$$

In Table I the confusion matrixis presented in which the we are getting the classifcation accuracy arround 99%. In Fig. 7 the classification perfermance is presented.

Table 1: Confusion Matrix

Reference				
Class	Total Samples	Classified Samples	Misclassified Samples	Accuracy
Normal	769	763	6	99.2%
Affected	81	79	2	97.5%
Average Accuracy= 98.3%				

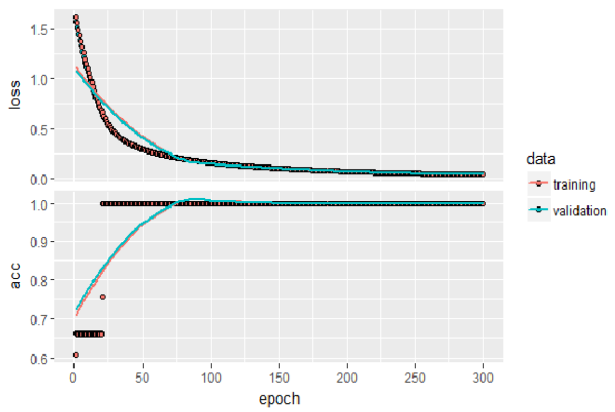

Fig. 7: Classification Perfermance.

4. Conclusion

Arrhythmia is a typical illness and is required to detect accurately. In spite of the fact that many researchers have taken a short on it, still different strategies are developed to test the same. During this work, the spectral features are obtained using DWT. Additionally DWT is used for QRS peak detection and is ascertained. DNN has been used for the classification of these wavelet features. The DNN with Softmax function shows better result as compared to other methods. Further accuracy is often improved by use of various methods as well as optimization of features.

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