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Recognition of Arrhythmic Electrocardiogram using Wavelet based Feature Extraction

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***Abstract*—Arrhythmia is one of the most common cardiac diseases. Efficient methods of detecting arrhythmia have been proposed in literatures. Our study proposes a unique feature extraction approach with entropy and Hjorth descriptor to classify a set of ECG signals into normal and arrhythmic with a considerable amount of accuracy. The conventional approach involving wavelet decomposition as the primary feature extraction method yields classification accuracy of 81.8%. The method proposed in the study using entropy and Hjorth descriptor provides higher classification rate at 82.9%. Our study is validated by a reliable dataset.**

Keywords—Electrocardiogram; arrhythmia; machine learning; wavelet transform; biomedical signal processing

I. Introduction

Electrocardiogram (ECG) in simple words can be defined as a time-sequence recording of the electrical activities of the heart. Proper examination of electrocardiographs can help in detection of several cardiac diseases. In fact, visual interpretation of ECG signals is a common approach followed by physicians and paramedics to diagnose cardiac diseases. With the evolution of computers, and the use of machine learning approaches in problems like pattern recognition and clustering, there are high chances that computer based diagnosis will replace visual approaches.

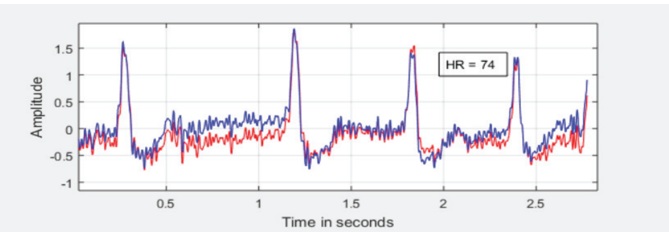

Fig.1. Visual Representation of Non-Arrhythmic ECG with Corrected Baseline

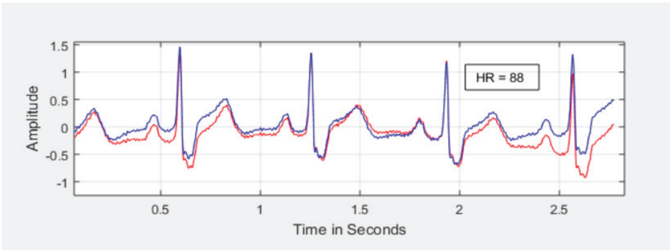

Fig.2. Visual Representation of Arrhythmic ECG with Corrected Baseline

Fig.1. and Fig.2. represent the visual representation of the Electrocardiogram of Arrhythmic and Non-Arrhythmic patients respectively.

Previously many approaches on computer based arrhythmia detection are proposed:

Daqrouq et al. propose a method based on wavelet transform to recognize arrhythmic ECG recordings [1].

Rizal et al. propose a method based on Hjorth descriptor to classify ECG Signals [2].

Wachowiak et al. propose a method on analyzing multiresolution wavelet entropy with visual analytics [3].

Balachandran et al. proposed daubechies algorithm for ECG signal feature extraction [4].

For better accuracy on computer based recognition of Arrhythmic Electrocardiogram we propose Hjorth descriptor and Entropy.

We take a Target Matrix which has two values 1 and 2 representing patient with arrhythmia and without arrhythmia respectively for each dataset. We compare the dataset matrix with the Target Matrix with Ensemble (Subspace K-NN) classifier in MATLAB.

II. MATERIALS AND METHODS

A. Database

We collect dataset from MIT-BIH ARRHYTHMIA DATABASE [5]. The dataset is sampled at 360 Hz. For our study, we consider 35 ECG recording of 1 minute duration. Out of the 35 recordings, 15 recordings correspond to healthy subjects while the rest are associated with diseased (arrhythmic) subjects.

B. Preprocessing

To remove the most common problem of baseline drift, we perform high pass filtering of 6th order at 0.5 Hz. The signal thus obtained is free from base line drifts. The digital filter used in this case is Butterworth filter. We use Savitzky-Golay filter for smoothening the ECG signal and removing any noises. The original and corrected waveforms are displayed graphically in Fig.3.

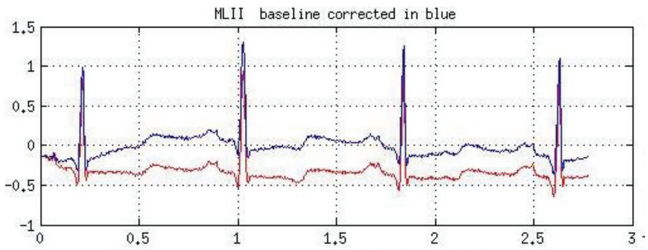

Fig.3. Correction for Baseline Wandering Problem

C. Feature Extraction Methods

The success of any classification process relies heavily on the choice of feature extraction tools. In this study, we use a number of features that have been used individually in the past. However, through this work we propose a multi-feature set that combines the others.

We use the following:

1. **Discrete Wavelet Transform (DWT):** Wavelets are rapidly decaying wave like oscillations with zero mean. There are various well known wavelets. We use Daubechies 5 wavelet for our study.

$$W(a,b) = \int_{-\infty}^{\infty} x(t) \frac{1}{\sqrt{a}} \psi \left(\frac{t-b}{a} \right) dt \tag{1}$$

Scaling and Shifting are two important wavelet transform concepts. Scaling is represented as :

$$\varphi \left(\frac{t}{s} \right), s > 0 \tag{2}$$

The constant of proportionality between time and frequency of a signal is the center frequency C_f . Wavelets have bandpass characteristics in the frequency domain [1].

$$F_{eq} = \frac{C_f}{s \partial t} \tag{3}$$

2. **Hjorth Descriptor:** Hjorth descriptor incorporates function to measure signals in time domain like electroencephalogram (EEG) , ECG signal, EMG signal and processing of lungs sound. Three parameters include this method i.e. activity, mobility and complexity. The activity represents the power of a signal, mathematically the variance of time function signal.The variance function is denoted mathematically as a square of standard deviation of the signal. The standard deviation of signal $x(n)$ can be described as .

$$\sigma_x = \sqrt{\frac{\sum_{i=1}^{n} (x(n) - \bar{x})^2}{N}} \quad \text{where } \bar{x} = \frac{1}{N} \sum_{n=0}^{N-1} x(n) \tag{4}$$

$n = 0,1,2,3,4,\ldots\ldots, N-1$.

Mobility factor represents the mean frequency

$$mobility = \frac{\sigma_X{}'}{\sigma_X} \tag{5}$$

Change in frequency is represented by complexity parameter

$$complexity = \frac{\sigma_X{}'' / \sigma_X{}'}{\sigma_X{}' / \sigma_X} \tag{6}$$

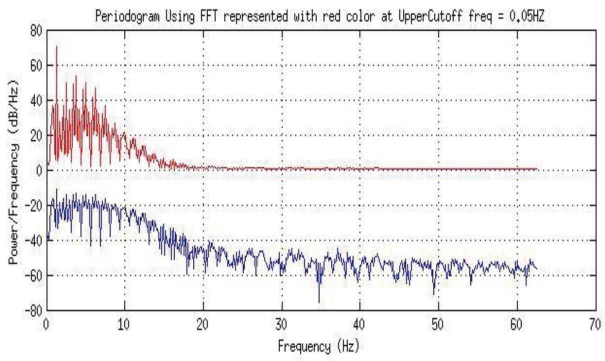

Fig.4. Spectral pattern of original and filtered ECG recordings [2]

3. **Entropy:**

Shannon Entropy, $H = -\sum_i p_i \log_b p_i$ (7)

In this study involving feature extraction, we consider log-energy and Shannon entropy [3]. These methods are used to detect the degree of randomness in a particular ECG sequence.

III. Experiment and Results

We compare four different feature sets in terms of their classification accuracy.

1. Set I: Discrete Wavelet Transform (DWT) Coefficients
2. Set II: Hjorth Descriptor.
3. Set III: Entropy.
4. Set IV: Hjorth Descriptor + Entropy (Proposed Feature set)

We compare the accuracy of previously proposed feature set and our proposed feature set on our collected dataset. [5] The compared results are shown in tabular format.

For classification, we use Subspace K-NN Ensemble classifier.

TABLE I. Classification Performance comparison with DWT coefficients and our proposed feature set

Classification Accuracy (%)	**Feature Set Used**	
	Set I	***Set IV***
Ensemble (Subspace K-NN)	81.8	**82.9**
Linear SVM	76.0	**80.0**
Weighted K-NN	74.3	**77.0**

TABLE II. Classification Performance with Hjorth descriptor and our proposed feature set

Classification Accuracy (%)	**Feature Set Used**	
	Set II	***Set IV***
Ensemble (Subspace K-NN)	63.6	**82.9**
Linear SVM	68.6	**80.0**
Weighted K-NN	66.7	**77.0**

TABLE III. Classification Performance with entropy and our proposed feature set

Classification Accuracy (%)	**Feature Set Used**	
	Set III	***Set IV***
Ensemble (Subspace K-NN)	79.9	**82.9**
Linear SVM	62.9	**80.0**
Weighted K-NN	74.3	**77.0**

The Confusion Matrix for the Ensemble (Subspace K-NN) Classifier for our proposed feature set is shown in Fig.3.

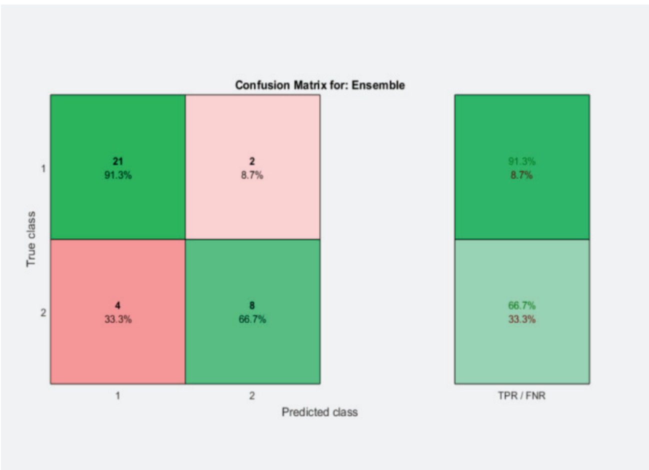

Fig.3. Confusion Matrix for Ensemble (Subspace K-NN) Classifier

IV. Conclusions and Future Scopes

The results draw out a clear comparison between the performance accuracies of wavelet features and our proposed feature sets. The study can be further implemented for classification and clustering of other bio-signals.

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