

Classification of heart signal using wavelet haar and backpropagation neural network

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Abstract. Researchers used many methods to extract and classify heart signals. In this study wavelet haar is used to extract characteristics of heart signals. Artificial neural networks Backpropagation for the classification of heart signals. The data is taken from Physiobank namely MIT-BIH Arrhythmia Database and MIT-BIH Normal Sinus Rhythm Database. The data is processed using Haar wavelet method for its extraction. The results of feature extraction methods will be used for the classification process. The research found that by using Wavelet Haar feature extraction and classification using Backpropagation obtained classification accuracy rate of 92%.

Keywords: Heart; electrocardiography; Wavelet Haar; backpropagation

1. Introduction

Electrocardiogram (ECG) is the electrical device to detect the activity of the human heart. The ECG is a composite of 5 waves - P, Q, R, S and T. These signals can be measured with electrode, placed on the human body. The signal from this electrode is connected to a simple electrical circuit with amplifier and analog - digital converter. Application of heart rate and heart rate detection by using an electronic circuit with a stethoscope and pulse sensor as input to detect. The pulse sensor is used to determine the heart of a person and a stethoscope is used to detect heart sound. While the series of electronics used arduino series as an interface to the monitor screen. From Test results on 10 subjects, to measure of heart rate with the pulse sensor obtained the accuracy of the tool sensory pulses by way of 99% [1].

The heart frequency can be detected by many methods and algorithms. Many heart signal detection algorithm is based on the distance between the QRS complexes. Complex QRS algorithms are from the field of artificial neural networks, genetic algorithms, wavelet transforms or bank filters [2]. In addition the next way to detect complex QRS is to use adaptive threshold [3] such as Direct method for detection of heart rate spectral signal spectral ECG [4] and the method of Short-Term Autocorrelation [5]. ECG signals can be used to diagnose heart disease, however, ECG signals do not fully describe the heart characteristics. It is because the heart is also affected by the opening and closing of the heart valve is a factor in the conscience. In addition, there is a heart damage that is difficult to detect using an ECG, such as natural structural abnormalities or opening and closing imperfect heart valves, as well as heart murmurs or abnormal sounds [6].

There are several studies by taking data from MIT-BIH data base. This research uses Heart Rate Variability (HRV) analysis method to look for feature extraction and classification using artificial neural network classifier. Results obtained with an accuracy of 99.38% [7]. F. Yaghouby et al., In his thesis using Generalized Discriminant Analysis (GDA) method for extracting and using Multilayer Perceptron (MLP) method of artificial neural network grouping, the result is 100% [8]. R. Acharya et al., This study took eight classes, feature extractions used by taking from the spectral entropy, the Poincaré geometry plot and the largest Lyapunov exponent (LLE). Then classification using artificial neural network method and fuzzy relationship. This research yields value. 80-85.5 [9]. L. Hussain et al., This study to look for feature extraction using HRV



analysis includes linear (time and frequency domain) and non-linear techniques and with the result of 92.5% method using LMT (logical tree model) method [10].

This study divides the heart signals into two classes of normal heart and abnormal heart. The first presents a method of Wavelet Haar to as a heart signal feature extraction. The retrieved characteristic is then classified using a backpropagation neural network.

2. Method

Heart signal data is taken from Physiobank database are MIT-BIH Normal Sinus Rhythm Database and MIT-BIH Arrhythmia Database. This database includes for 18 ECG recordings from subjects at the Arrhythmia Laboratory at Bethlehem Israel Beth (now Beth Israel Deaconess Medical Center). Subjects, included in this database were found to have insignificant arrhythmia; They are 5 men, aged 26-45, and 13 women, aged 20 to 50. The database contains 48 half-hour citations of two-channel ECG recordings of a person treated on the road, obtained from 47 subjects studied by BIH Arrhythmia Laboratory between 1975 and 1979. Twenty-three randomly selected records of a set of 4,000 24-hour ambulatory ECG records are collected from a mixed population of inpatients (about 60%) and outpatients (about 40%) at Home Pain of Israel Beth Boston; 25 remaining records are selected from the same set to include less common but clinically significant arrhythmias that would not be represented in the sample randomly. Digital recording at 360 samples per second per channel with 11-bit resolution at 10 mV range. Two or more cardiologists independently described each record; Disputes were resolved to obtain a readable computer reference explanation for each beat (about 110,000 annotations at all) included with the database [11].

The used data are 15 files of 1 minute length and 360 Hz sample frequency, normal pulse signal and various types of pulse arrhythmias. All selected files take 6 seconds segmentation to get 150 samples from the experimental data.

Wavelet transformation is an improvement of the Fourier transform. If the Fourier transform only provides information about the frequency of a signal, the wavelet transform provides information about the combination of scale and frequency. Wavelet comes from a scaling function, can be made as a mother wavelet. Other wavelets will come from scaling, dilation and mother wavelet shifts. Wavelet transformation is improvement of the Fourier transform. If the Fourier transform only provides information about the frequency of a signal, the wavelet transform provides information about the combination of scale and frequency. Wavelet comes from a scaling function. From this scaling function can made a mother wavelet. Other wavelets will come from scaling, dilation and mother wavelet shifts.

There are two functions that play a major role in wavelet analysis, which is function of the wavelet scale (wavelet) and wavelet ψ (mother wavelet). The simplest wavelet analysis is based on the Haar function scale [12]. The Haar scale function is define as another using formula (1).

$$\varphi(x) = \begin{cases} 1, & \text{if } 0 \leq x < 1 \\ 0, & \text{OTHER} \end{cases} \quad (1)$$

The Haar mother wavelet function is define as formula (2).

$$\Psi(x) = \varphi(2x) - \varphi(2x - 1)$$

$$\Psi(x) = \begin{cases} 1, & 0 \leq x < 1/2 \\ -1, & \frac{1}{2} \leq x < 1 \\ 0, & \text{OTHER} \end{cases} \quad (2)$$

Like all wavelet transforms, the Haar Wavelet transform is a discrete signal that decomposes into two sub-signals of half its length. One sub signal is averages in a row. Haar Level Wavelet Transformation 1, Haar Wavelet transformation is do in several stages, or levels.

Assume 1 dimension of signal f with signal length equal to N . Haar level transformation 1 for $f = (x_1, x_2, \dots, x_N)$.

$$f \xrightarrow{H_1} (a^1 | d^1) \quad (3)$$

Where :

$$a^1 = \left(\frac{x_1 + x_2}{\sqrt{2}}, \frac{x_3 + x_4}{\sqrt{2}}, \dots, \dots, \frac{x_{N-1} + x_N}{\sqrt{2}} \right)$$

$$d^1 = \left(\frac{x_1 - x_2}{\sqrt{2}}, \frac{x_3 - x_4}{\sqrt{2}}, \dots, \dots, \frac{x_{N-1} - x_N}{\sqrt{2}} \right)$$

Heart signals that have been selected based on normal and abnormal heart, then each signal is process using Wavelet Haar level 4. Totals of 300 heart signals are extract to get two special features. 300 cardiac data signals consisting of 150 normal and 150 abnormal heart signals. Extraction of heart signal features is take from the Haar Wavelet process with level 4.

3. Results and Discussion

In this study, Haar Wavelet transformation was use for characteristic extraction of normal and abnormal heart signals. Normal and abnormal heart signals can be seen in Figure 1.

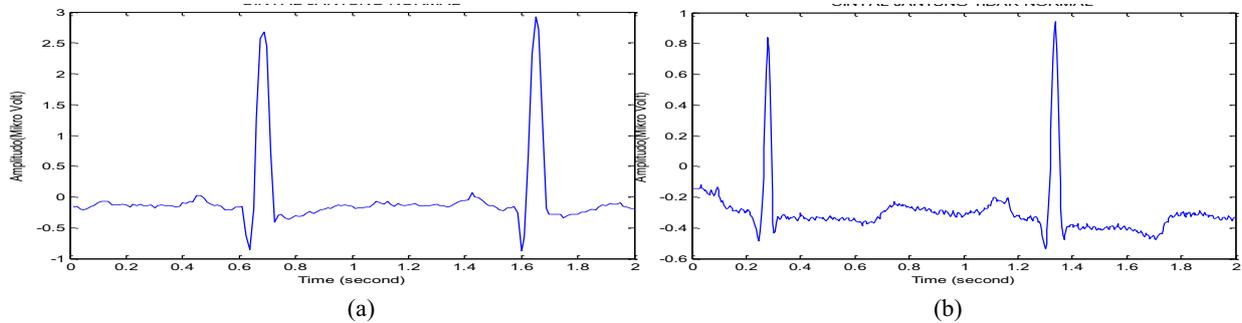


Figure 1. (a) a normal heart signal (b) an abnormal heart signal

Results Haar Wavelet process in the form of a vector consisting of several data point elements. In this study using Wavelet Haar level 4, the results of the wavelet haar process can be seen in Figure 2.

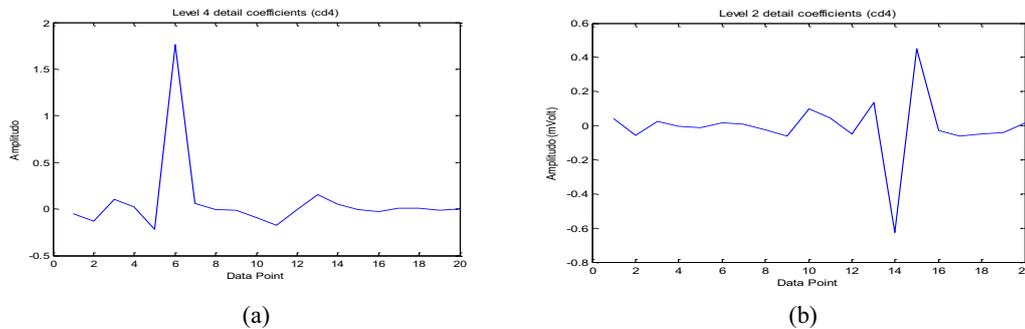


Figure 2. Wavelet Haar level 4 results (a) normal heart signal (b) abnormal heart signal

The data taken in this study is 300 data files of heart signals. A normal heart signal file has 350 data points and an abnormal heart signal file has 80 data points. The result of the wavelet haar value is show in Table 1 by taking five samples of haar wavelet results on each signal.

Table 1. Result Of Wavelet Haar Of Heart Signal

Signal	Signal 1	Signal 2	Signal 3	Signal 4	Signal 5
	20 Point data				
Normal heart signal	0.03	-0.013	-0.06	-0.02	0.001
	-0.05	-0.05	0.03	0.045	-0.015
	0.02	0.03	0.02	-0.075	0.013
	-0.02	0.01	0.01	-0.02	0.014
	-0.02	0.02	0.03	0.03	0.002
	0.01	-0.01	0.02	-0.02	-0.032
	0.02	0.02	0.01	0.02	-0.08
	-0.02	-0.04	0.03	0.11	0.08
	-0.05	0.01	0.02	0.03	0.04
	0.15	0.04	0.02	0.01	-0.01
	0.06	0.02	0.01	0.62	0.05
	-0.04	0.45	-1.61	-1.58	-0.05

	0.13	-2.61	1.43	1.08	0.30
	-0.62	2.23	0.02	0.02	0.02
	0.44	0.02	0.01	-0.07	-0.04
	-0.02	-0.02	0.05	-0.03	-0.04
	-0.05	-0.03	0.01	-0.03	-0.13
	-0.04	-0.05	0.01	0.02	0.03
	-0.03	0.01	0.03	0.04	-0.03
	0.01	0.02	0.02	-0.02	-0.02
abnormal heart signal	-0.04	-0.015	-0.07	0.00	-0.02
	-0.12	-0.22	-0.15	-0.06	-0.01
	0.12	0.11	0.12	0.09	-0.07
	0.02	0.03	0.021	0.09	-0.03
	-0.21	-0.61	-0.751	0.05	0.16
	1.75	1.46	1.632	0.26	0.01
	0.05	0.04	0.042	0.22	-2.20
	-0.02	-0.01	0.013	0.00	0.42
	-0.02	-0.02	-0.013	-0.01	0.00
	-0.08	-0.05	-0.074	-0.01	-0.02
	-0.16	-0.13	-0.142	-0.10	-0.02
	-0.02	-0.02	-0.022	-0.15	-0.07
	0.15	0.12	0.174	0.04	-0.16
	0.04	0.02	0.075	0.13	-0.07
	-0.02	-0.01	0.012	0.00	0.17
	-0.02	0.01	0.002	0.02	0.05
	0.012	0.01	0.022	-0.02	-0.04
	0.014	0.02	0.012	0.00	-0.01
	-0.015	0.012	0.013	0.03	-0.03
	0.001	-0.013	0.034	-0.01	0.00

Classification of heart signals processed using neural network Back Propagation as show in Figure 3. Final processing is do after the initial process is feature search.

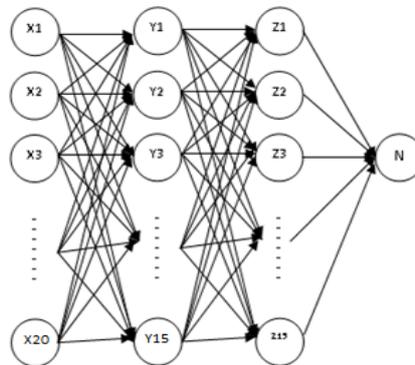


Figure 3. Neural Network Architecture Backpropagation with 2 Hidden layers

Extraction feature of wavelet haar is use for input to Backpropagation, this study using Backpropagation (20-15-15-1) number 20 is the input of the wavelet haar value, the number 15 layer is hidden one to the number of nodes 15, the number 15 represents the number of nodes in the layer Hidden second, and the number 1 is the target (normal heart and abnormal heart).

There are two stages for the classification process that is the learning process and Mapping process. The learning process using learning rate parameter 0.1 and error be achieved 0,00001. The value for weights is random in the range of -1 to 1. In search of optimal parameter performance to produce the best value of the neural network is to assess the size of Mean squared error (MSE) and the number of hidden layer units at training. Examples of performance results can found in Figure 4.

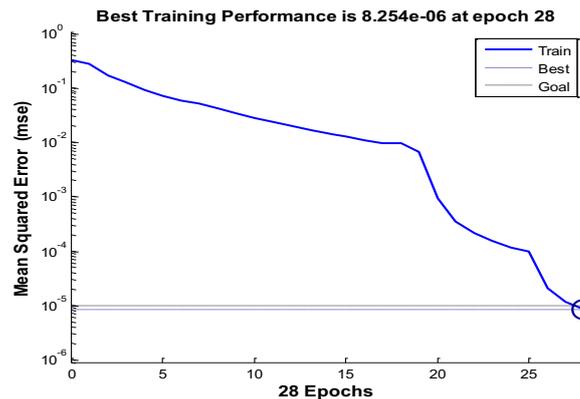


Figure 4. Performance performance results of the identification of Backpropagation (20-15-15-1)

The backpropagation performance of 20-15-15-1 show that the desired target error of 0.00001 has been achieved. In this network come about error 8.25. 10⁻⁶ so that the training process for the classification on this heart signal can already reach 100% accuracy. The result of the training process for classification of heart signals by using the 20-10-15-1 network has obtained the value of bias and weight. After the training process, the next process is the testing process. The data used in this trial process is to retrieve data as much as 100 heart signal data, consisting of 50 data of normal heart signals and 50 data of heart signals upnormal. In this research, data training and data testing with total data amount 300 data yield accuracy level $276/300 * 100\% = 92\%$. From Figure 4 shows that by using 2 hidden layers have reached the desired target.

Table 2. The Performance Of The Neural Network To The Different Number Of Hidden Layer

	1 Hidden Layer	2 Hidden Layer	3 Hidden Layer
Time	30	53	62
Iteration	1000	503	407
MSE	9.9×10^{-4}	8.25×10^{-6}	3.55×10^{-6}
Accuracy	89 %	92 %	92 %

5. Conclusion

In this study, researchers introduced Wavelet Transformation by taking a 4th level haar wavelet to extract features. Backpropagation neural network is used to train 200 heart signal data files. The testing process used 300 data file data signal heart. The precise classification of two hidden layers of backpropagation is 92%. The future research will be focused on exploration of better feature extraction methods.

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