DETECTION OF ARTIAL FIBRILLATION DISORDER BY ECG USING DISCRETE WAVELET TRANSFORMS

SHARMILA A, MAHALAKSHMI P, VISHNUBHATLA N V L N G SHARMA, GOURAV DEY, YASHWANTH K

School of Electrical Engineering, VIT University, Tamil Nadu, India. Email: asharmila@vit.ac.in

ABSTRACT

Atrial fibrillation (A-fib) is the most common cardiac disorder. To efficiently treat or inhibit, an automatic detection based on electrocardiograph (ECG) monitoring is significantly required. ECG is a key function in the analysis of the heart functioning and diagnostic of diseases. Currently, a computer based system is used to analyze the ECG signal. The main aim of this project is to analyze a heart malfunctions named as A-fib, using discrete wavelet transforms (DWT). The ECG signals were decomposed into time-frequency representations using DWT, and the statistical features were calculated to describe their distribution. The DWT detailed coefficients are used to obtain various parameters of the ECG signal such as the mean, variance, standard deviation, and entropy of the signal. An analysis had been made with these parameters of various patients with normal heart functioning and A-fib to identify the disorder.

Keywords: Atrial fibrillation, Electrocardiogram, Discrete wavelet transforms.

INTRODUCTION

Cardiac diseases and heart failure are one of the most significant causes of death now-a-day. According to the World Health Organization, cardiac disease or cardiovascular diseases is the number one cause of death universally. Of these deaths, 82% take place in low - and middle-income countries. Atrial fibrillation (A-fib) is the most common cardiac arrhythmia [1]. Arrhythmia is a kind of disease which shows abnormal beats and such abnormal heartbeats may cause increase or decrease in blood pressure which can be dangerous as it may lead to paralysis or stroke or even sudden death. Cardiac arrhythmias are abnormality or disturbances in the behavior of the heart's electrical activities. These disturbances lead to abnormality in rate and rhythm hence referred as arrhythmic.

The analysis of the electrocardiogram (ECG) signal is the method available for diagnosing cardiac arrhythmias. However, it is not life frightening in itself, insistent cases of A-fib may cause palpitations, fainting, chest pain, or congestive heart failure and even stroke. To effectively treat or prevent A-fib, automatic A-fib detection based on ECG monitoring is extremely necessary [2,3]. The ECG is the interpretation of the electrical activity of the heart for a period of time. It is an essential part of heart monitoring for a patient [5]. It is a non-invasive technique to measure the heart functioning and, for this reason, is used widely in heart monitoring. It records the electrical activity of the heart by electrical signals reached to the surface of the skin. The ECG wave is shown in the Fig. 1

The ECG graph essentially consists of the PQRS and T components. The P-wave is due to the electrical depolarization of the atria; the QRS complex is due to the ventricular depolarization and atrial repolarization of the ventricles of the heart. However, the effect of atrial repolarization is minimal in the QRS complex, and the T-wave is due to the ventricular repolarization. The width of the T-wave is about 0.16 seconds for a normal healthy heart Fig. 5.

Any defect in the ECG graph can be detected easily and by analyzing the ECG doctors can decide on the state of the heart functioning, cardiovascular muscle functioning and also any abnormalities that arise in the valves of the heart.

SYSTEM IMPLEMENTATION

The ECG data for normal and abnormal is obtained from PhysioNet [11], loaded using MATLAB command. This signal is then pre-processed using notch filter, and discrete wavelet transform (DWT) can be used to obtain the features which are used for diagnosing the disorder as shown in Fig. 2

The normal and atrial fibrillation ECG signal, after loading from the PhysioNet is shown in Fig. 3a and b. The pre-processing of ECG signals using notch filter is shown in Fig. 4a and b.

DWT

The DWT decomposes the obtained noise-free signal into various levels. Filters of different cut-off frequencies are used to obtain the detailed coefficients of the signal [6,7]. Various low pass and high pass filters are applied to obtain these coefficients [8,9]. The High pass filter gives the detailed coefficient, whereas the low pass filter gives the approximated coefficients Fig. 6. However, we have chosen only the detailed coefficients to extract the features of the signals. The obtained signal is decomposed into 6 wavelet signals using Daubechies wavelet transform [10,13]. According to the wavelet theory, the [n-1]th signal resembles the original signal. This fifth detailed coefficient is used to

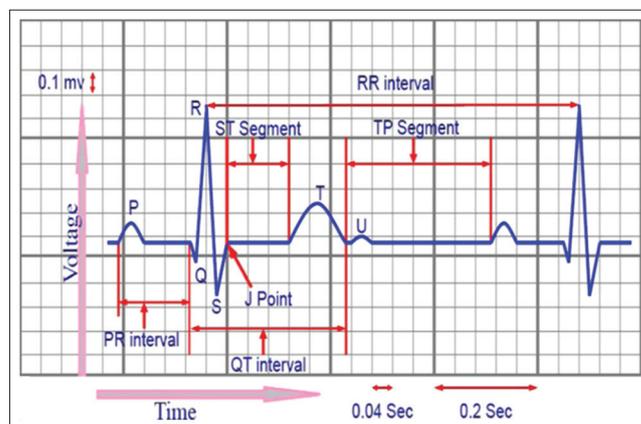**Fig. 1: Electrocardiograph waveform for a healthy heart**

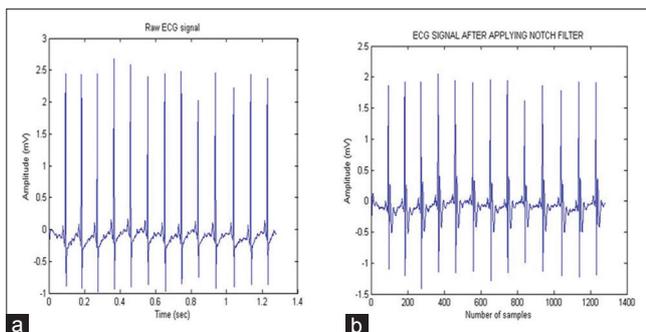**Fig. 2: System implementation**

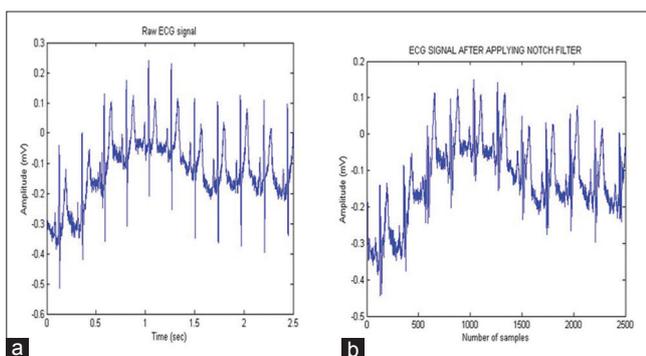**Fig. 3: (a) Output from normal electrocardiograph, (b) Output from notch filter**

Fig. 4: (a) Output from atrial fibrillation electrocardiograph, (b) Output from notch filter
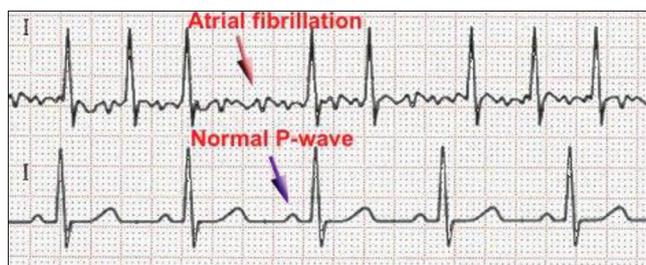

Fig. 5: ECG waveform of normal and A-fib

Fig. 6: Wavelet decomposition

Fig. 7: Wavelet decomposition up to 5 detail coefficient of normal electrocardiograph signal

obtain the features of the signal such as the mean, variance, Standard deviation, and entropy.

The DWT, as said above is done by the application of low pass and high pass filters simultaneously. In this project, the high pass butterworth filter is used to obtain the detailed coefficients of the signal. The processed signal is decomposed into six detailed coefficients, and the features are extracted from the fifth coefficient. These above steps are done for both the signals, of a normal heart and that of a heart with A-fib. The results are plotted as shown in Fig. 7 and 8.

FEATURE EXTRACTION

Feature extraction is the extraction of input data in a form that is required for the analyzer, by reducing the data representation pattern. The data is extracted by the feature set to perform the classification task. It is a non-destructive process, i.e. it does not vary the input signal but just derives a particular data from the signal, which is essential for the analyzer to accurately classify the models.

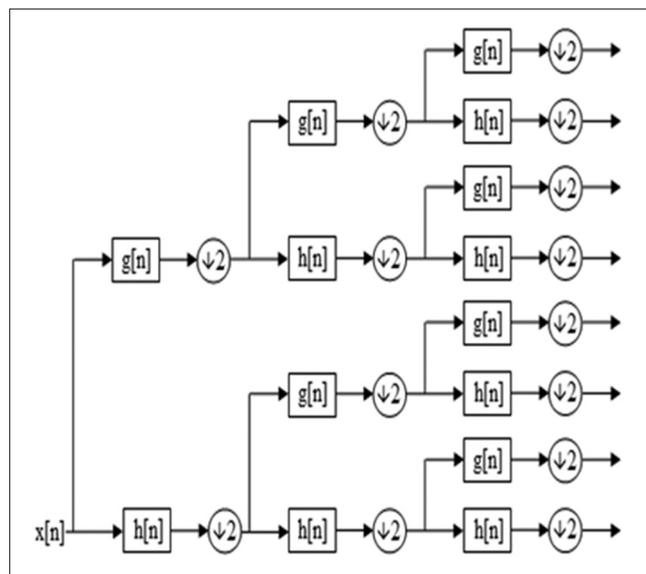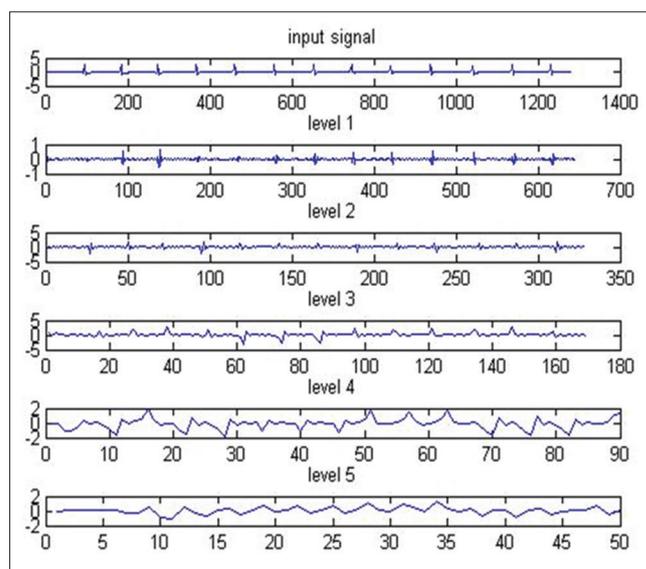In the feature extraction stage, several different approaches can be used so that numerous different features can be extracted from the same raw data. The WT provides very wide-ranging methods which can be applied to several tasks in signal processing [4]. Wavelets are preferably suited for the analysis of sudden short-duration signal changes. One of the important applications is the ability to compute and influence data in compressed parameters which are frequently called features [12]. Thus, the time-varying ECG signal, consisting of several data points, can be compressed into a few parameters by the usage of the WT. These parameters describe the performance of the time-varying ECG signal. This feature of using a lesser number of constraints to represent ECG signal is predominantly important for recognition and diagnostic purposes [14-17].

RESULT AND DISCUSSION

The extracted features for normal and A-fib using DWT are compared and tabulated in Table 1. From the table, the statistical parameters for normal ECG are higher than the A-fib and the extracted features show the differences more clearly.
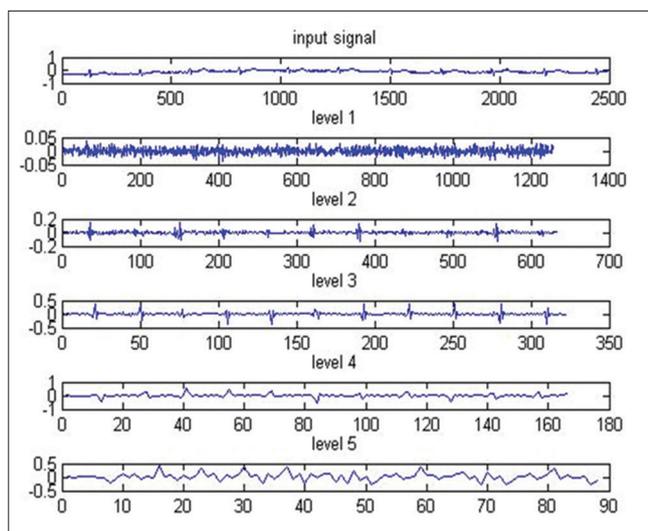
Fig. 8: Wavelet decomposition up to 5 detail coefficient of (atrial fibrillation) electrocardiograph signal

Table 1: Statistical parameters from Wavelet decomposition

Features	Normal	A-fib
Mean	0.057623	0.015957
Variance	0.23544	0.021782
Norm	0.23073	0.021534
SD	0.48523	0.14759
Covariance	0.23544	0.021782
Entropy (log energy)	−107.2528	−301.2876
Entropy (Shannon)	3.283	3.1108

A-fib: Atrial fibrillation, SD: Standard deviation

CONCLUSION

Automatic detection of heart arrhythmias might be very essential in medical practice and lead to early detection of an equitably common disorder and might aid contribute to reduced mortality. In this study, the use of DWT for extraction of features from the ECG signal has been presented. The main advantage of this study is that by using 5 scales in computing DWT of signals, the morphological differences between several types of ECG signal are emphasized, and the extracted features show the differences more clearly.

REFERENCES

1. Clavier L, Boucher JM, Lepage R, Blanc JJ, Cornily JC. Automatic P-wave analysis of patients prone to atrial fibrillation. Med Biol Eng Comput 2002;40(1):63-71.
2. Ros E, Mota S, Fernandez F, Toro F, Bernier J. ECG characterization of paroxysmal atrial fibrillation: Parameter extraction and automatic diagnosis algorithm. Comput Biol Med 2004;34(8):679-96.
3. Kim D, Seo Y, Jung WR, Youn CH. Detection of long term variations of heart rate variability in normal sinus rhythm and atrial fibrillation ECG data. Vol. 2. In: International Conference on BioMedical Engineering and Informatics, BMEI 2008, Sanya, Hainan, China; 2008. p. 404-8.
4. Lin HY, Liang SY, Ho YL, Lin YH, Ma HP. Discrete-wavelet-transform-based noise removal and feature extraction for ECG signals. IRBM 2014;35:351-61.
5. Goldman M, editor. Principle of Clinical Electrocardiography. 11th ed. Drawer L., Los Altos, California: Lange Medical Publication; 1982.
6. Li C, Zheng C, Tai C. Detection of ECG characteristic points by wavelet transforms. IEEE Trans Biomed Eng 1995;42(1):21-8.
7. Hamilton PS, Tompkins WJ. Quantitative investigation of QRS detection rules using the MIT-BIH arrhythmia database. IEEE Trans Biomed Eng BME 1986;33:1157-87.
8. Mallet S. A theory of multiresolution signal decomposition: The wavelet representation. IEEE Trans Pattern Anal Mach Intell 1989;11(7):674-93.
9. Grap A. An introduction to wavelets. IEEE Comput Sci Eng 1995;2(2):50-61.
10. Mahamoodibad SZ, Ahmadian A, Abolhasani MD. ECG feature extraction using Daubechies wavelets. In: Proceedings of Fifth IASTED International Conference; 2005. p. 343-8.
11. Available from: http://www.physionet.org.
12. Pal S, Mitra M. Detection of ECG characteristic points using multiresolution wavelet analysis based selective coefficient method. Measurement 2010;43:255-61.
13. Daubechies I. The wavelet transform, time-frequency localization and signal analysis. IEEE Trans Inf Theory 1990;36(5):961-1005.
14. Addison S, Watson JN, Clegg GR, Holzer M, Sterz F, Robertson CE. Evaluating arrhythmias in ECG signals using wavelet transforms. IEEE Eng Med Biol 2000;19(5):104-9.
15. Soltani S. On the use of the wavelet decomposition for time series prediction. Neurocomputing 2002;48:267-77.
16. Akay M. Wavelet applications in medicine. IEEE Spectr 1997;34(5):50-6.
17. Unser M, Aldroubi A. A review of wavelets in biomedical applications. Proc IEEE 1996;84(4):626-38.