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Detection of Atrial Fibrillation by Analyzing the Position of ECG Signal using DWT Technique

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Abstract - *Heart disease is one of the dreadful diseases in the world. Using Electro Cardio Graph (ECG), electrical activity of the heart is recorded by placing the electrodes over the skin. The tiny electrical changes from the electrophysiological pattern of heart muscle are detected by the electrode placed on the skin. Cardiac problems are detected from these patterns. ECG signals are prone to various noises and it becomes difficult to detect and diagnose these diseases. In spite of progress in telemedicine, reading of ECG signals are inaccurate resulting in improper diagnosis and hence delay in the patient's treatment. Therefore, effective de-noising technique is developed to obtain noise free signal. Therefore the design and development of strategies for the detection of atrial hypertrophy is carried out carried out. Cross-correlation of ECG signal distinguishes between healthy and atrial fibrillation patients.*

***Key Words*: Atrial Fibrillation, Cross-correlation, De-noising, DWT, ECG, Savitzky-Golay filter.**

1. INTRODUCTION

The electrical wave duration decides whether the electrical activity is normal, slow or irregular. ECG signal has P, Q, R, S and T peaks. Another peak called U is also seen in some cases[1]. Figure 1 shows ECG signals with various peaks. P, QRS and T are the waves present in ECG signal. ECG signal has three segments namely, PR segment, ST segment and TP segment[2]. Usually ECG signals are contaminated by various kinds of noise. Hence proper de-noising of the ECG signal is carried out.

Wavelet transform is applied to the de-noised ECG signal to obtain various peaks in the ECG. From these Q-peak of the ECG signal is determined. From Q-peaks Q-peak interval is obtained if this Q-peak interval is below 0.6 seconds atrial fibrillation is seen.

Cross-correlation of ECG signal is obtained to determine whether ECG signal is normal or not. Cross-correlation of ECG signal with normal ECG signal gives symmetrical graph for healthy condition and asymmetric graph in the case of unhealthy condition.

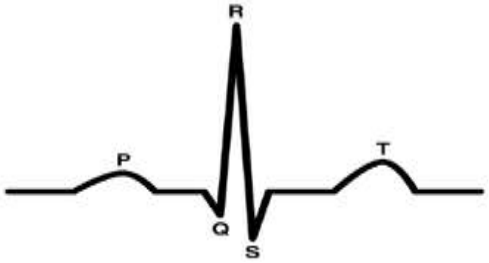

Fig -1: ECG signal showing various peaks[3].

2. LITERATURE SURVEY

Muhammad Arzaki et al. 2017 [4], which describes about the de-noising of ECG signal.

Hudson et al. 2017 [5], which describes about the Savitzky Golay filter. Peak shape preservation property of the Savitzky Golay filters are attractive in applications such as ECG signal processing. The major advantage of this method is the preservation of important features of the original time series, like relative widths and heights. SG filter fits a polynomial in a window of points around each sample point using least squares fitting.

Lim Choo Min et al. 2007 [6], describes the steps in ECG signals analysis.

Nilesh M. Verulkar et al. 2016 [7], which describes about the cross correlation of ECG signals. Cross-correlation is defined as the degree of similarity between two time series in different times or spaces as a function of time lag applied to one of them.

Jyothi Singaraju et al. 2011 [8], describes about the analysis of non-stationary signals using Discrete wavelet Transform (DWT).

3. PROPOSED METHODOLOGY

The proposed methodology is based on the technique to detect arrhythmia using DWT based on Q-peak detection. Original input signals are taken from atrial fibrillation database directory of ECG signals from www.physionet.org. Flow chart is as shown in Figure 2 which depicts the steps involved in the detection which are as follows:

3.1 De-noising of ECG signal

Noises in ECG signal leads to high difference signals. Therefore, initially smoothing using Savitzky-Golay filter and filtering of ECG signal is carried out to remove these low frequency noises in ECG signal. Smoothing of signal is done using SG filtering.

3.2 Detection of Q peak

Signals are often localized in time and frequency, analysis and estimation are easier when working with reduced representations. DWT is used to find the Q-peak from ECG signal. DWT transformation is as given by equation 1.

$$T_{m,n} = \sum_{-\infty}^{\infty} x(t)\, \Psi_{m,n}(t) \quad (1)$$

Where, $x(t)$ is the signal to be analysed,
$\Psi_{m,n}(t)$ is the mother wavelet.

All the wavelet functions used in the transform are derived from the mother wavelet through wavelet translation (n) and scaling (m).

3.3 Detection of atrial fibrillation

ECG signal is de-noised and wavelet transformed. Then the Q-peaks are detected from these ECG signals. From the detected Q-peaks, interval between the Q-peaks is determined. If the Q-peak interval is below 0.6 second then atrial fibrillation is observed.

3.4 Cross-correlation of ECG signal

Cross-correlation is defined as the degree of similarity between two time series in different times or spaces as a function of time lag applied to one of them. Flow chart for cross-correlation of ECG signal is as shown in Figure 2. Cross-correlation is calculated as shown in equation 2.

$$r_{xy} = \sum_{n=-\infty}^{\infty} x(n)\, y(n-l) \qquad l = 0, \pm 1, \pm 2, \ldots\ldots \quad (2)$$

Where, $x(n)$ and $y(n)$ are the ECG signals.

r_{xy} is the cross-correlation function.

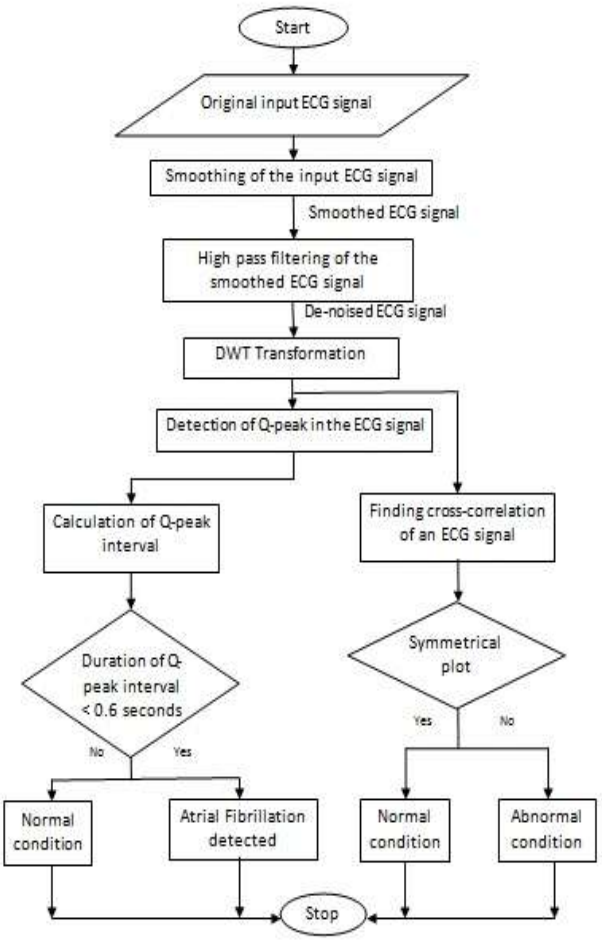

Fig -2: Flow chart.

4. RESULTS AND DISCUSSION

Original ECG signals are taken from atrial fibrillation database directory of physionet. Original atrial fibrillation signals are smoothened and filtered to remove low frequency noises present in signal to obtain de-noised signal. Wavelet transform is applied to the de-noised ECG signal. Q-peaks are detected from transformed ECG signal. From the detected Q-peaks, interval between the Q-peaks is determined. If the interval between Q-peaks is below 0.6 second then atrial fibrillation is observed. Original and de-noised normal ECG signal is as shown in Figure 3. Figure 4 shows Q-peaks detected in normal ECG signal. Cross-correlation of normal ECG signal is symmetric which is as shown in Figure 5. Hence signal is normal. Q-peak interval obtained for normal ECG is 0.6979 second.

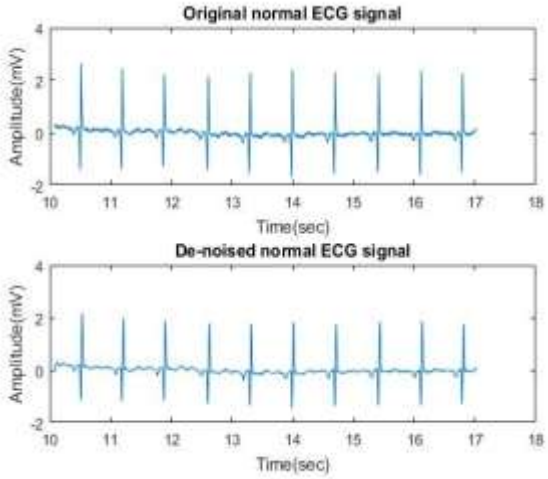

Fig -3: Original and de-noised normal ECG signal.

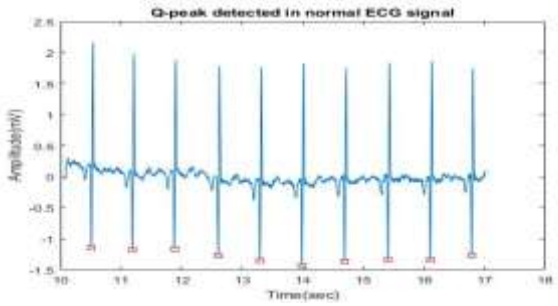

Fig -4: Q-peak detected in normal ECG signal.

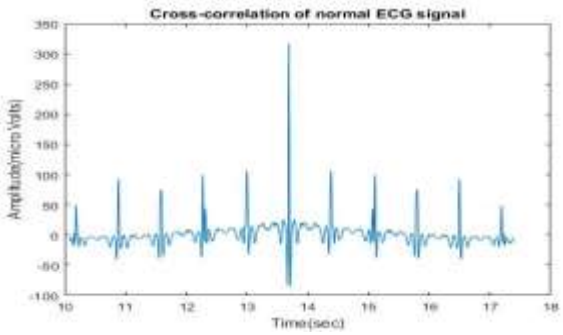

Fig -5: Cross-correlation of normal ECG signal.

Original and de-noised atrial fibrillation (record 04126) ECG signal is as shown in Figure 6. Figure 7 shows Q-peaks detected in atrial fibrillation (record 04126) ECG signal. Cross-correlation of the atrial fibrillation (record 04126) ECG signal is as shown in Figure 8 which is asymmetric and irregular. Hence the condition of ECG signal is atrial fibrillation. Q-peak interval obtained for atrial fibrillation (record 04126) ECG signal is 0.5521 second.

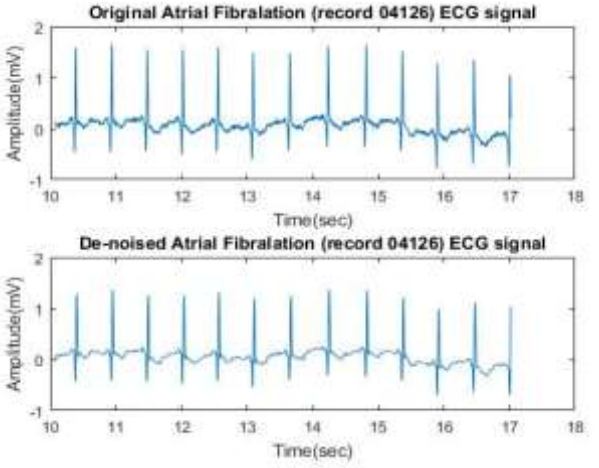

Fig -6: Original and de-noised atrial fibrillation (record 04126) ECG signal.

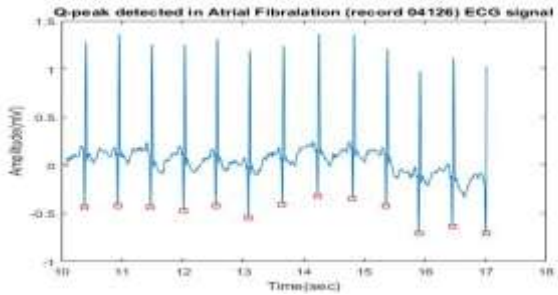

Fig -7: Q-peak detected in atrial fibrillation (record 04126) ECG signal.

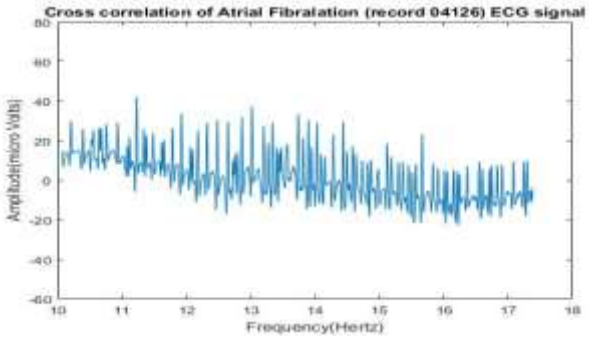

Fig -8: Cross-correlation of atrial fibrillation (record 04126) ECG signal.

Original and de-noised atrial fibrillation (record 04126) ECG signal is as shown in Figure 9. Figure 10 shows Q-peaks detected in atrial fibrillation (record 04126) ECG signal. Cross-correlation of the atrial fibrillation (record 04126) ECG signal is as shown in Figure 11. Q-peak interval obtained for atrial fibrillation (record 04126) ECG is 0.5673 second. Various ECG signals with Q-peak interval and heart conditions are as shown in Table 1.

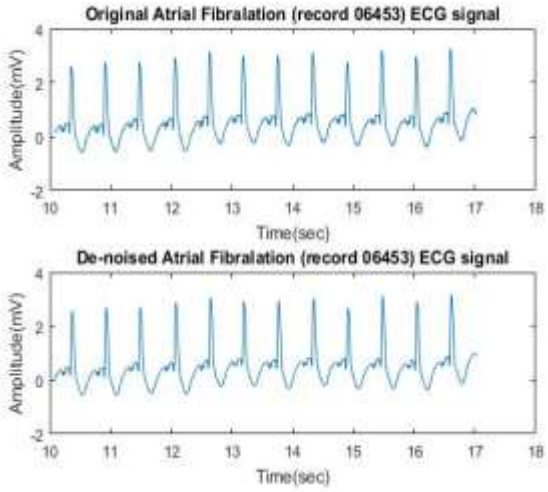

Fig -9: Original and de-noised MIT-BIH 107 ECG signal.

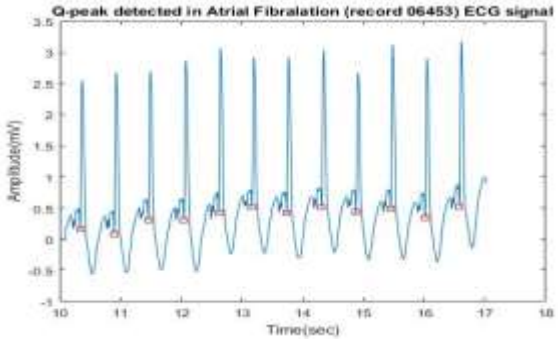

Fig -10: Q-peak detected in atrial fibrillation (record 06453) ECG signal.

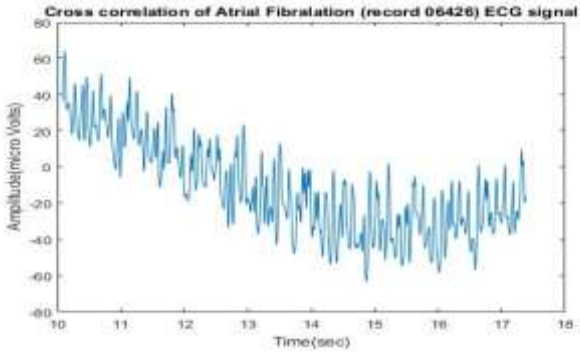

Fig -11: Cross-correlation of atrial fibrillation (record 06453) ECG signal.

Table -1: Various ECG signals with Q-peak interval and heart conditions.

Record No.	Q-peak interval (in Seconds)	Heart Condition
06453	0.5673	Atrial Fibrillation
06426	0.4487	Atrial Fibrillation
05121	0.5350	Atrial Fibrillation
04126	0.5521	Atrial Fibrillation
05091	0.6979	Normal condition
05261	0.5733	Atrial Fibrillation
06995	0.4561	Atrial Fibrillation
07879	0.6305	Normal condition
07910	0.7209	Normal condition
08215	0.5725	Atrial Fibrillation
08219	0.3405	Atrial Fibrillation

5. CONCLUSIONS

Heart is one of the most important organs of a human body. ECG is a very useful bio-signal which is used by physicians for the purpose of diagnosing and monitoring heart disease and cardiac disorder. Therefore it becomes essential to examine ECG signal so as to detect chronic diseases in its early stages. ECG signals are prone to various noises. Therefore de-noising of the ECG signal is carried out where low frequency noises are removed. A method has been proposed to detect heart conditions. From the detected Q-peaks using wavelet duration between Q-peaks is determined. Depending on this duration atrial hypertrophy is detected. Plot of cross-correlation is analyzed which is used to distinguish between healthy persons and cardiac patient.

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