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Understanding Electrocardiogram Signals-A Comprehensive Overview

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ABSTRACT

The transthoracic interpretation of the heart's electrical activity over time is called an electrocardiogram, or ECG. Information on the state of the heart may be obtained through the analysis of the ECG signal. Many techniques, including Wavelet Transforms and Fast Fourier Transforms, have been utilized to identify cardiac conditions. We have reviewed the work that has been done in the last several years in the field of ECG signal analysis in this study.

Keywords : Frequency, Plant growth, Sound wave

Introduction

The heart's electrical activity is recorded via an electrocardiogram. This is a visual representation of how biopotential changes with time [1]. To record the ECG on graph paper or a monitor, the leads are positioned at specified points on the patient's body. The right atrium, left atrium, right ventricle, and left ventricle are the four chambers that make up the human heart. The two ventricles are the lower chambers, while the two atria are the top chambers. When the heart is in good health, the heartbeat starts at the Sino Atria (SA) node in the right atrium. A unique collection of cells in the heart transmits these electrical signals throughout the body. From the atria to the atrioventricular (AV) node, this signal travels.The AV node is connected to a network of fibers in the Ventricles, which transports electricity and sends impulses to every area of the lower chamber. This propagation channel has to be precisely tracked in order to verify if the heart is operating normally [2].Figure 1 illustrates the heart's fundamental structure.

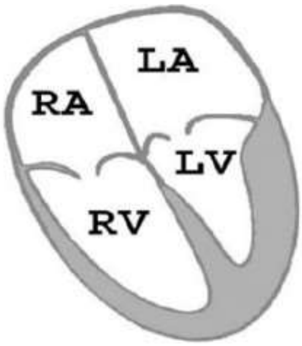

Figure 1. Schematic anatomy of the human heart [3]

ECG WAVEFORM

A series of peaks and troughs in electrical waves make up each heartbeat that is seen. Two primary types of information are provided by ECG. The first determines if the heart's electrical activity is regular, sluggish, or irregular. It is the length of the electrical wave that passes through the heart. To determine whether the heart's components are overly big or overworked, the second factor to consider is the electrical activity that flows through the heart muscle. The frequency range and dynamic range of an ECG signal are 0.05–100 Hz and 1–10 mV, respectively. The five peaks and valleys that make up the ECG signal are represented by the letters P, Q, R, S, and T. U wave is sporadically detected as well. The basis for the efficacy of ECG analysis is the capacity to consistently and precisely identify the T- and P waves in addition to the QRS complex [4] [5]. The ideal ECG wave is shown in Figure 2.

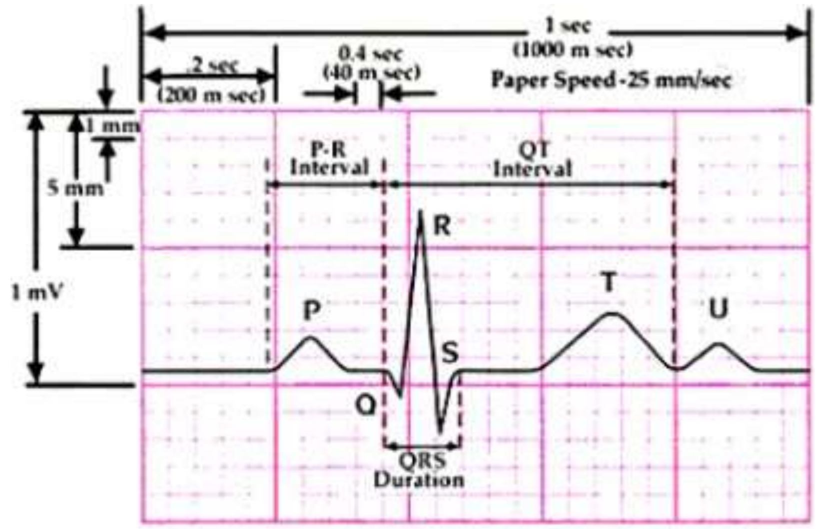

Figure2. A typical Cardiac Waveform [4]

The P-wave signifies the activation of the two atria, the heart's upper chambers, while the QRS complex and T-wave stimulate the ventricles, the heart's lower chamber. QRS detection is one of the fundamental issues with automatic ECG signal analysis. As soon as the QRS complex is identified, the ECG data is thoroughly analyzed. The P, QRS, and T waves are indicative of the regular electrical depolarization and repolarization of the myocardium brought on by the contractions of the ventricles and atria [6]. The horizontal section of this waveform that appears before the P-wave is called the baseline, or isopotential line.The atrial musculature's depolarization is connected with the P-wave. The QRS complex provides the combined result of the almost simultaneous depolarization of the ventricles and repolarization of the atria. The U-wave, if it manifests, is generally believed to be the result of ventricular muscle after potentials, while the T-wave symbolizes the ventricular repolarization wave. In order to diagnose different disease states, cardiac arrhythmias, conduction abnormalities, ventricular hypertrophy, and myocardial infections, the length, amplitude, and shape of the QRS complex are helpful.The average heart rate ranges from 60 to 100 beats per minute. Bradycardia, or a sluggish heart, is a slower pace than the usual range, whereas tachycardia, or a fast heart, is a greater rate. An arrhythmia is indicated if the ECG signal is abnormal [6] [7]. Figures 3, 4, and 5 display the normal ECG waveform as well as the aberrant waveform:

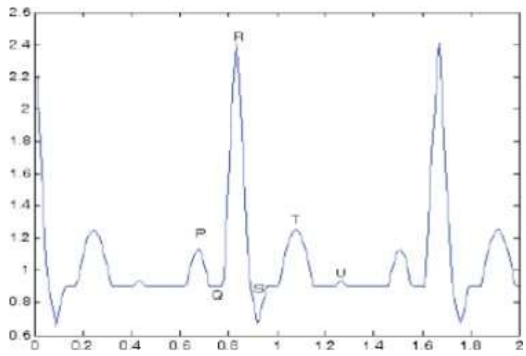

Figure3. Normal sinus rhythm [6]

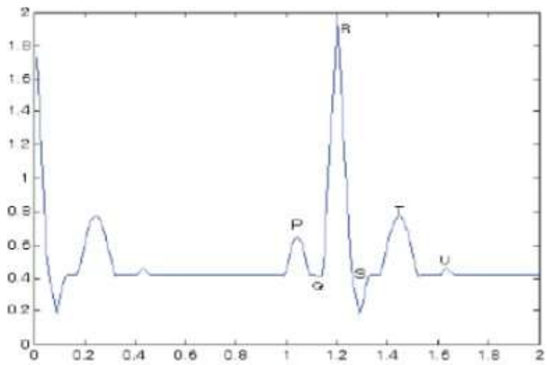

Figure 4. Sinus Bradycardia [6]

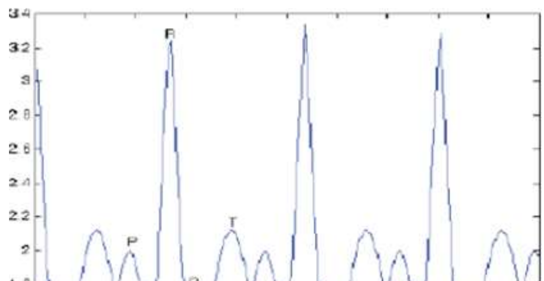

Figure 5. Sinus Tachycardia [6]

METHODS

Research on ECG signal processing and identification has been going on for a long time since these are interesting topics. Many methods have been developed for ECG analysis, such as the Fast Fourier transform and the Short time Fourier transform.

1 **Fast Fourier Transform (FFT) :** The analysis of ECG signals was previously done using the time domain technique. The disadvantage was that it wasn't enough to look at every facet of the ECG signal [9]. Thus, a new approach known as FFT was developed. The Fourier transform, which changes a signal from the time domain to the frequency domain, is a well-known method for getting frequency coefficients [10]. The fast Fourier transform (FFT) has several applications in digital signal processing, such as signal processing and frequency analysis [11]. The same result may be obtained more rapidly and efficiently by calculating the Discrete Fourier Transform (DFT) [12]. FFT is defined by the formula given in equation (1).

$$X\mathrm{k} = \sum_{n=0}^{N-1} x e^{-nk2\pi i/n} \qquad \ldots\ldots (1)$$

whereby the integer k falls between 0 and N-1[13]. Many methods may be used to compress ECG signals. FFT is among the most significant methods. The following steps make up the entire process:

- Getting an ECG sample or input signal.
- Taking out the low frequency components of the input signal in order to compress it.
- Recovering the initial signal with the utilization of inverse FFT [14]

However, one drawback of FFT is that it was unable to yield information about the precise position of frequency components across time [1].

2 **Short Time Fourier Transform (STFT) :** In an attempt to overcome this FFT problem, Dennis Gabor first suggested the windowed-Fourier transform in 1946 [15]. It is sometimes referred to as the Short-Time Fourier Transform or Gabor transform. Timing and frequency data are contained in STFT [10]. It is used to determine the sinusoidal frequency and phase content of the signal as it varies over time. The STFT-based spectrogram is a simple and fast method in comparison to other time-frequency analysis techniques. This is a straightforward way of segmenting the target waveform into many smaller sections. It then subjects each segment to a standard Fourier transform for analysis. By using a window function, a data segment may be efficiently separated from the full waveform before undergoing the Fourier transform. This is known as a spectrogram, or Short-Time Fourier Transform. The definition of STFT for a signal x (t) is given by equation (2):

$$X(\tau, f) = \int_{-T/2}^{T/2} x(t) w(t - \tau e^{-i2\pi f t}) dt \qquad \ldots\ldots (2)$$

The windowed signal x (t) w (t - τ), where w (t) is a window of duration T, centered at time point t, is Fourier transformed to produce the STFT [16]. However, STFT has many shortcomings, one of which is its inferior temporal frequency accuracy. As a result, a more effective solution is selected to address this issue.

3 **Wavelet Transform:** There is no information supplied about the multi-resolution of the signal since the STFT window should always have a fixed size. On the other hand, the Wavelet Transform offers a multiresolution capability that use a modifiable window size to provide data on frequency and time [17].

The French geophysicist Jean Morlet coined the word "Wavelet" for the first time in 1982. A "wavelet" is a very small wave, and studying the wavelet transform provides a novel way to analyze seismic data. Theoretical physicists headed by Alex Grossmann expeditiously investigated the inverse formula for the wavelet transform [15]. A wavelet is a small wave with energy concentrated in time that is used as a tool for studying transitory, nonstationary, or time-varying signals [18].

Numerous Wavelets can be used to a variety of circumstances. Among them are the wavelet families Daubechies, Haar, Coiflet, Symlet, and biorthogonal. Some of the qualities that make them advantageous are:

- Wavelets may be used to analyze non-stationary signals with uneven characteristics and frequent level fluctuations, like the ECG.
- They are localized in both time and frequency.
- A wavelet divides a signal into components with many resolutions [2].

The Wavelet Transform, a time-scale representation, has been helpful in a variety of applications, most notably signal compression. This is a linear technique where the signal is divided into many scales that correspond to distinct frequency components, and each scale is subjected to a resolution-based analysis [19]. Another advantage of the Wavelet technique is the availability of several Wavelet functions, which allows the selection of the best function for signal analysis. On the other hand, only the sinusoid feature morphology may be examined using Fourier analysis [20].

Wavelet transformations can be grouped into two categories:

- Continuous Wavelet Transforms (CWT)
- Discrete Wavelet Transforms (DWT)

Continuous Wavelet Transform: Strong localization of high-frequency signal features in time is made possible by the CWT time-frequency analysis technique, in contrast to the traditional STFT. The CWT's variable window width, which is flexible in separating out high-frequency data and associated with the observational scale, enables this. Another important difference between the CWT and the STFT is that the CWT is not restricted to the use of just sinusoidal analyzing functions. Alternatively, localized waveforms satisfying the given mathematical conditions can be selected [20].

The CWT of a signal x (t) is defined as:

$$W(a,b) = 1/\sqrt{a} \int_{-\infty}^{\infty} f(t) h * ((t-b)/a) dt \qquad ....(3)$$

The mother wavelet h (t) is represented by the scale parameter a on the y-axis and the shift parameter b on the x-axis [2].

PERFORMANCE ANALYSIS

It is expressed by following equations:

Sensitivity (Se) = TP/ (TP+FN) (5)

Positive predictivity (P+) =TP/ (TP+FP) (6)

TP=True Positive, FN=False Negative, FP=False Positive

CONCLUSION

This paper examines a variety of techniques for locating abnormalities in the ECG signal. The flexible method known as the wavelet transform is helpful for signal analysis. Future research on the use of the Wavelet Transform to ECG may be undertaken.

REFERENCES

[1] Apoorv Gautam and Maninder Kaur, “ECG Analysis using Continuous Wavelet Transforms (CWT)”, IOSR Journal of Engineering, Apr.2012, Vol.2 (4), 632-635.

[2] Nagendra H, S. Mukherjee and Vinod Kumar, “Application of Wavelet Techniques in ECG Signal Processing: An Overview”, International Journal of Engineering Science and Technology (IJEST), October 2011, Vol.3, No.10, 7432-7443.

[3] Adam Josko and Remigiusz J. Rak, “Effective Simulation of Signals for Testing ECG Analyzer”, IEEE Transactions on Instrumentation and Measurement, June 2005, Vol.54, No.3, 1019-1024.

[4] K.V.L. Narayana, A. Bhujanga Rao,” Wavelet based QRS detection in ECG using MATLAB”, Innovative Systems Design and Engineering, 2011, Vol. 2, No 7, 60-69.

[5] B. Anuradha, K. Suresh Kumar and V.C. Veera Reddy, ”Classification of Cardiac signals using Time Domain Methods”, ARPN Journal of Engineering and Applied Sciences, June 2008, Vol.3, No.3, 7-12.

[6] C. Saritha, V. Sukanya, and Y. Narsimha Murthy,” ECG Signal Analysis Using Wavelet Transforms”, Bulg.J.Phys.35, 2008, 68-77.

[7] Rajiv Ranjan, V.K Giri, “A Unified Approach of ECG Signal Analysis”, International Journal of Soft Computing and Engineering (IJSCE), July 2012, Volume-2, Issue-3, 5-10.