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Heart Rate Variability Analysis Using Wavelet Transform

Doc. Moniza Nurez Khan[1], Debarghya Biswas[2], Dr. Parul Malik[3]
[1]Assistant Professor, Department of Pharmacy, Kalinga University, Raipur, India.
ku.monizanurezkhan@kalingauniversity.ac.in, 0009-0004-9879-6445
[2]Assistant Professor, Department of CS & IT, Kalinga University, Raipur, India.
ku.debarghyabiswas@kalingauniversity.ac.in, 0009-0004-0730-9948
[3]Professor, New Delhi Institute of Management, New Delhi, India., parul.malik@ndimdelhi.org, https://orcid.org/0009-0009-4711-501X

Abstract
The heart's primary job is to pump blood throughout the body through the arterial system to deliver oxygen and essential nutrients. In this case, the coronary arteries are the arteries that, like those in all other muscles, provide oxygen and nutrition to the heart. A blockage of these veins often results in a heart attack, or the cessation of the heart's beating. In fact, coronary heart disease has been shown to be the leading cause of death in wealthy countries. Angina, heart failure, myocardial infarction1 (MI), and unexpected death can all be caused by coronary artery blockages. However, the likelihood of another infarction is increased because the heart has often already suffered severe damage and lost muscle tissue. Heart-related issues may arise from degeneration in the central nervous system (CNS), which regulates the circulatory system. One important indicator of cardiac conditions and conditions affecting the autonomic nervous system (ANS) is heart rate variability (HRV). HRV is more valuable since it can be investigated noninvasively. Electrocardiography and the difference between the peaks of R-to-R intervals can be used to determine HRV. A three-lead ECG can be used to extract HRV for experimental treatments. This is adequate for studying the autonomic nervous system.
Keywords: *Heart Rate Variability, information, propranolol, hypothesis*

1. INTRODUCTION

The Electrocardiogram (ECG) is one non-invasive technique that has been used extensively to diagnose heart disease [1]. The electrical signal produced by the heart's activity is known as the ECG. An electrocardiogram (ECG) is a representation of the millions of heart cell depolarization potentials. The bioelectrical health and conditions of a subject's heart can be evaluated using the P QRS T wave[2]. The P wave, QRS complex, and ST segment must be recognized in order to extract the key components of the ECG signal [9]. Therefore, irregularities of particular ECG readings are linked to cardiac conditions. A person's health is generally described by a variety of physiological indicators, most of which are self-interdependent. Not all of them are equally important and educational. When designing the entire monitoring system, it is necessary to consider not only the importance of the observed characteristics but also how to measure them and whether they can be applied to real-world systems [3]. According to medical study, the most important features are those that determine how the heart and respiratory system work.

Removing or improving signal components is an essential signal processing function. For the same reason, filters are commonly used. In particular, they are essential components of numerous state-of-the-art electronic applications. Both digital and analogy filters are possible, and they can have either a restricted impulse response (FIR type) or an infinite impulse response (IIR type).

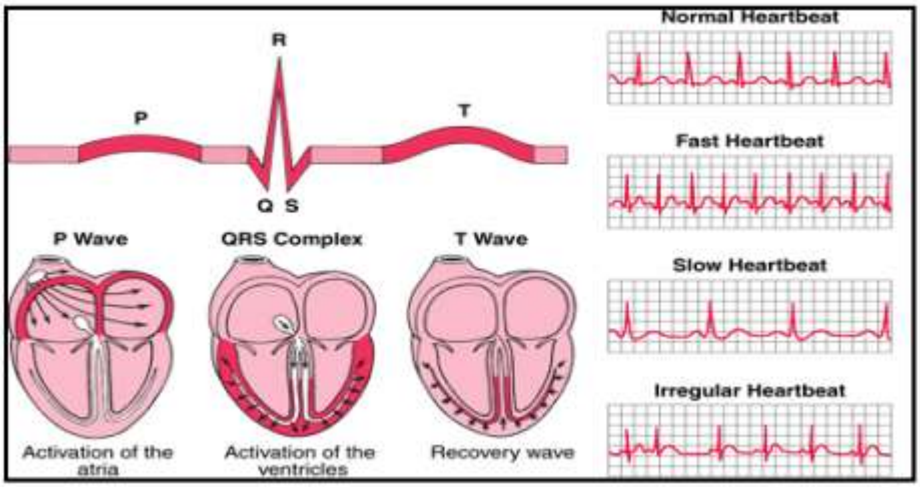


Figure 1: ECG Waveforms at different positions of Heart

Digital filters that have finite impulse response (FIR) can be used in a variety of DSP approaches. Compared to their IIR cousins, they are more dependable and durable because the design does not include feedback. HRV can be assessed using both short-term and long-term ECG signal recording [13]. Numerous software applications, such as Kubios Software, Lab VIEW, and, to a lesser extent, Matlab software, are used to analyze the data that has been gathered. The lengthy duration is twenty-four hours, whereas the short duration is roughly five minutes. For a medical practitioner, this is a diagnostic tool [4]. Ideally, HRV should be understood as the outcome of many minute alterations in the ANS. This data can be used for both subject therapy and sickness prognosis. Since HRV analysis is a difficult and complicated phenomenon that needs to be investigated and assessed despite the availability of several software applications, non-linear components are looked at[10].

2. REVIEW OF LITERATURE

The time intervals between consecutive heartbeats, specifically between subsequent R-waves (also called N for normal beats), which are local maxima linked to ventricular depolarizations, are measured by heart rate variability (HRV) in an electrocardiogram (ECG). In recent years, HRV has garnered significant attention across various fields of modern medicine. Unfavourable changes in HRV have been shown to be markers for a variety of potentially fatal illnesses. Techniques in the time or frequency domains can be used to assess HRV [5]. Standard deviation of the N-N interval of N-N intervals (SDNN, which represents overall HRV), the square root of the mean squared differences between consecutive N-N intervals (RMSDD), the count of adjacent N-N intervals that differ by more than 50 milliseconds (NN50), and the standard deviation of the average N-N interval over roughly five minutes (SDANN) are among the simplest methods, which are usually time domain. Conversely, frequency domain techniques examine the relationship between frequency and the variance (or power) of the ECG signal. Discrete Fourier Transform Application Using the Fast Fourier Transform Transforming the beat-to-beat interval time series is a common frequency domain method for calculating variance across various frequencies. It has been demonstrated that humans possess a variety of intriguing frequency bands. The High Frequency band (HF), which is defined as 0.15 to 0.4 Hz, is mostly controlled by breathing [6]. It is closely linked to the parasympathetic nervous system or vagal activity [11].

3. MATERIALS AND METHODS

From a frequency domain perspective, these sub-bands hold significance as they represent distinct values, each a dyadic fraction of the original bandwidth [7].

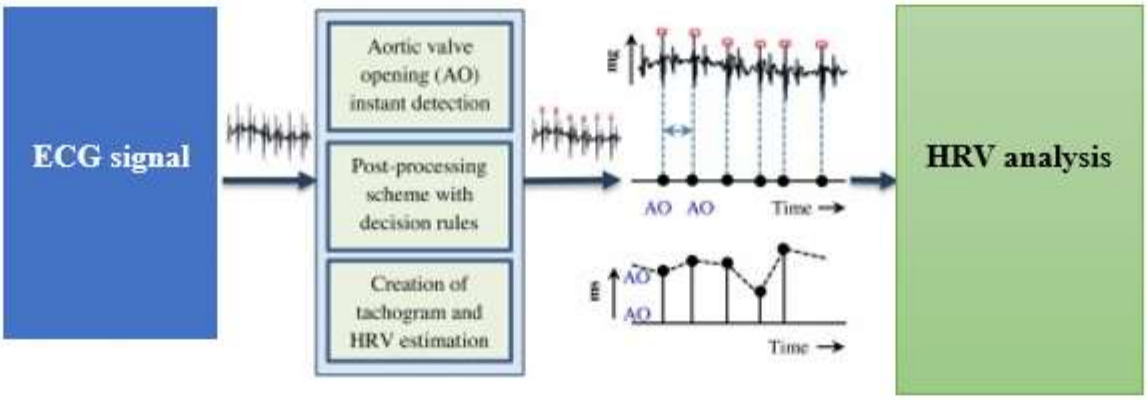
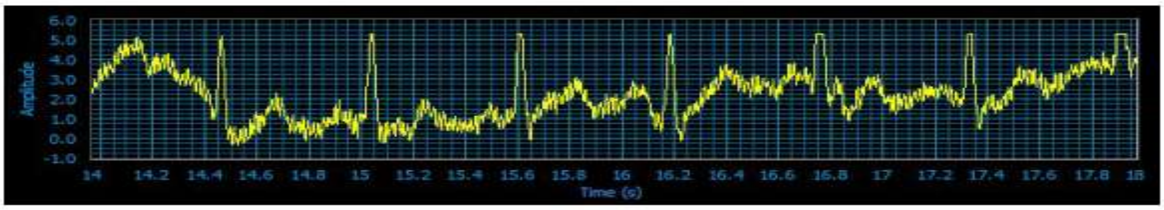


Figure 2: Proposed framework

Two separate peaks have been identified by spectral analysis of heart rate variability (HRV): the low frequency band (0.05-0.15 Hz) and the high frequency band (0.15-0.5 Hz) [15]. While changes in the low frequency range are linked to sympathetic modulation, albeit with some parasympathetic effect (sympathetic-vagal interactions), variations in the high frequency band are suggestive of parasympathetic (vagal) activity [8]. It is commonly recognized that the HRV power spectrum clearly reflects the degree of physical activity [12]. The Physio Bank's "Long Term ECG Database" provided the data used in this investigation [14]. The suggested technique is described, which entails acquiring a suitable sample rate by interpolating and resampling the R-R interval time series at a constant signal energy level. The HRV signal's Wavelet Packet (WP) decomposition at level j allows for the analysis of two sets of sub-band coefficients, each of length N/2j. The 6th level WP decomposition is used to create the nodes N (6, i), where i is between 0 and 63, using a sample rate of 5 Hz.

4. RESULT AND DISCUSSION

Finding the right metric to assess and correlate HRV remains a major challenge. A task force was established as a result of this search to address issues including calibrating the data, determining the most reliable method of measuring the HRV and its physiological components, and determining correlations. [8].



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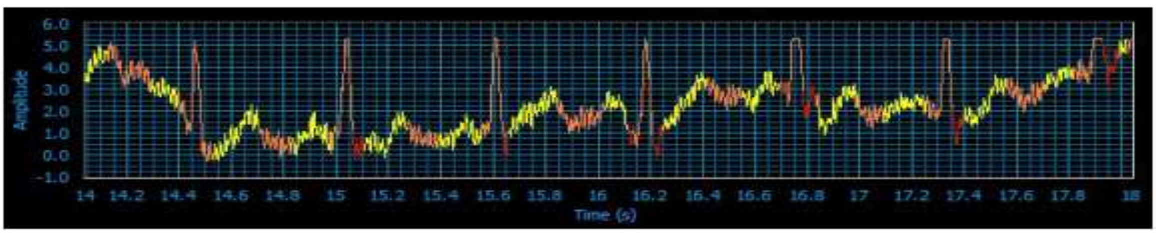

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Figure 3: Result of MECG experiment

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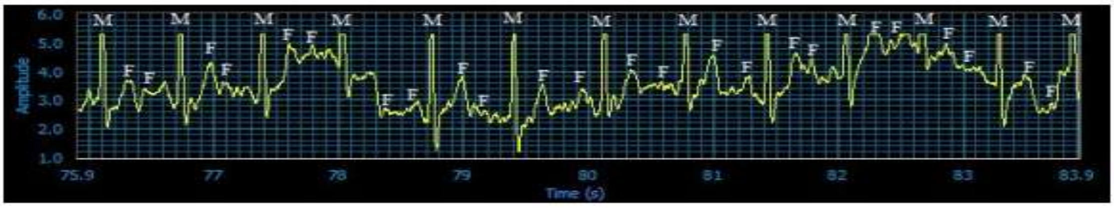
An interdisciplinary method involving mathematicians, engineers, medical practitioners, and computer specialists was used to accomplish this. The emphasis must be on guidelines that should support rather than hinder HRV research.



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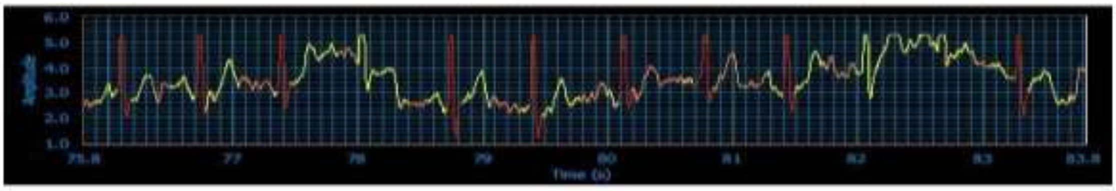

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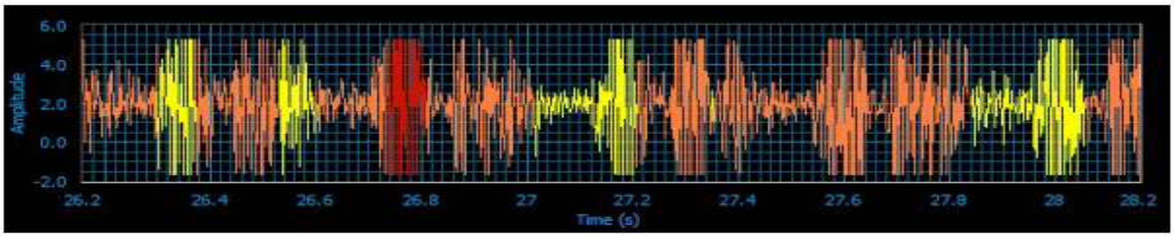
Figure 4: Result of FECG experiment

Numerous terms, such successive cardiac cycles and cycle length variability, have been used to assess these heart alterations; however, they only examine the beat-to-beat interval and not the heart rate per second.



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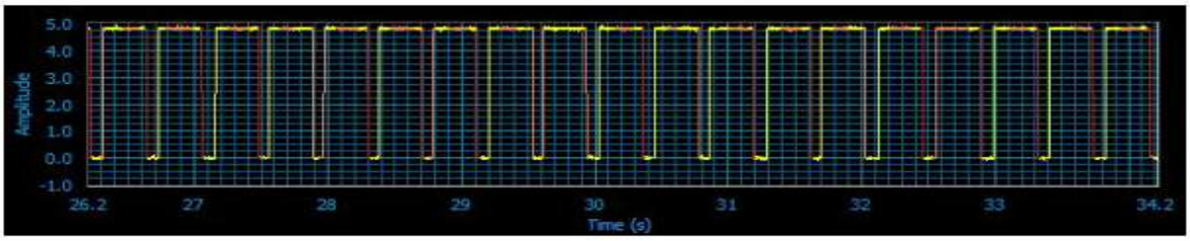

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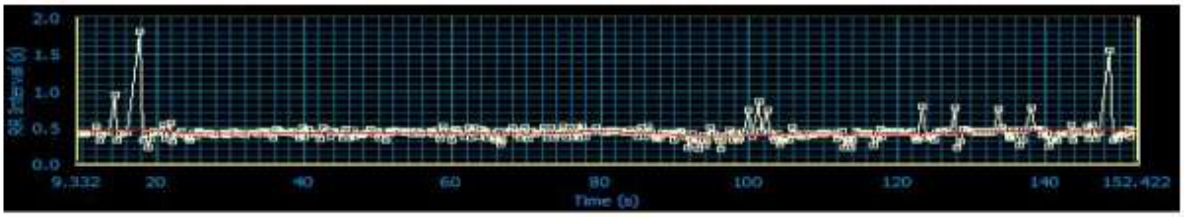

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Figure 5: Result of Doppler ultrasound monitoring

Even though the aforementioned nomenclature is in use, it has not received as much recognition as HRV. For this reason, we will utilize HRV and attempt to analyze it for a variety of diseases and addiction disorders that are caused by stress.

5. CONCLUSION

In order to do this, a study was conducted on young people between the ages of 17 and 23 to use ECG signals to examine the HRV in addictions. Additionally, individuals between the ages of 40 and 50 were chosen to research the HRV utilizing PPG signals in pre-diabetic, hypertensive, and stressful circumstances. The issue was chosen for the study because it is pertinent to both society and medicine. An individual won't recognize the effects of consuming these addictive substances until their body has suffered significant and irreversible harm. Early detection of these addictive substances and stress-related symptoms aids the doctor in making an early diagnosis and averting problems. The ANS is impacted by stress and addiction. As a result, efforts have been made in this work to examine ANS behavior by HRV data analysis.

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