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HEART RATE VARIABILITY ANALYSIS

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ABSTRACT
Heart rate variability signals, derived from an ECG signals strongly related to the activity of the Autonomous Nervous Systems (ANS). HRV is usually investigated as R-R variability since R wave is far easier to detect due to its peak shape. The classical methods based on autocorrelation, there is holds or derivatives, Time domain methods and frequency domain methods give a course quantification of the variability, without distinguishing between short term and long-term fluctuations. In this paper, we propose a new wavelet based methods to analyze heart rate variability (HRV) signals. In time domain analysis, the frequency information is lost. In frequency domain analysis the time information is lost. By using the wavelet translation we get the information in the form of scale. We got both time domain and frequency domain information.
Keywords : auto correlation, heart rate variability

HEART RATE VARIABILITY ANALYSIS

Heart rate variability refers to the beat-to-beat alterations in heart under resting condition. The heart rate variability measurements are Heart rate variability analysis using signal decomposed into 4 levels. From the detailed co-efficient, the Rwavo is detected in all the scales by using threshold method Rwave is detected. Then spectral power ratio LF/HF is calculated. The difference between the adjacent RR interval spectral power ratios LF/HF gives variability of the particular abnormality from this we can able to find different cardiac abnormality.

(1) Non inversive technique
(1) Non inversive technique
(2) Easy to perform

Biological systems are complex systems. Specifically they are systems that are spatially and temporally complex, built from a dynamic web of interconnected feedback loops marked by interdependence, pleiotropy and redundancy. The properties of the system are distinct from the properties of the parts, and they depend on the integrity of the whole. Characteristics patterns of variation overtime, namely rhythms, represent a defining feature of complex systems. Variability analysis provides a novel technology with which to evaluate the overall properties of a complex system. Changes in the patterns of interconnections and patterns of variations overtime contain variable information about the state of the overall systems. This technology of variability analysis is valuable in the intensive care unit, where patients are critically ill and numerous parameters are routinely measured continuously.

METHOD

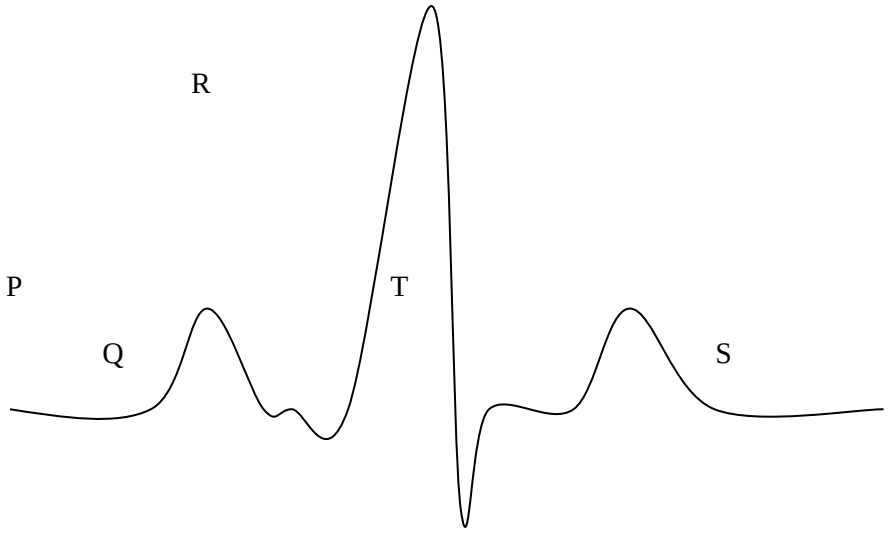
The analysis of the beat-to-beat variability of cardiovascular time series represents a non-invasive approach for the study of the ANS's regularity action and supplies important information in much patho-physiological condition. Spontaneous heart rate fluctuations are mainly due to intuitions between cardiac pacemaker cells and the sympathetic and parasympathetic system. The HRV results from the balance between both components. Accordingly the sympathetic and parasympathetic systems modulate the cardiac activity. Due to the dynamic action of ANS, the physiological parameters do not remain in the time stationary status, but as modified by the evolving condition of the cardiovascular system. In conventional spectral approaches, such as Fourier transform, they are applied based on the assumption of stationary. In wavelet transformation window size is selected to be long at low frequencies and sort at high frequencies so that the signal representation has good frequency resolution at low frequency as well as good time resolution at high frequencies. WT achieved much better quantitative analysis of HRV than FT. From ECG signal, the 'R' wave is detected. An algorithm based on wavelet transforms has been developed for detecting ECG characteristic points. With the multi-scale feature of wavelets, the QRS complex can be distinguished from P or T waves, noise, base line drift and artifacts.

ELECTRO CARDIO GRAPHY

ECG signals are commonly used in medical care for monitoring, diagnosis and the treatment of patient suffering from heart disease. They are obtained by measuring the potential difference between electrodes, which are placed on patients. Patient's heartbeats are detected and the field variations transferred to a voltage signal. This signal may be detected by single channel or multi-channel.

The ECG records (indirectly) the electrical activity of the heart. This activity reflects the action of the cardiac muscles as it depolarizes and repolarizes during the cardiac cycle. In order to get on electrical signal from the body, suitable electrodes, amplification and appropriate display are required. Some cardiac cells generate action potentials. Once generated and under the physiological conditions, the action potential propagates through the cardiac muscles. The temporal and spatial summation of the mono phasic action potentials of the myocardial fibers produces the electrical signals known as ECG.

Cardiologist can use minute features of these signals to obtain important knowledge about the function of their patient's heart. Heart rate variability (HRV), derived from an ECG signal is a measure of beat-to-beat (RR interval) changes in heart rate.



An ECG reflects the sequence of depolarization and repolarization over the contractile chambers of the heart seen using body surface electrodes. This electrical activity is related to the contraction and

relaxation of the heart chambers. P wave generated due to the action of the atrial depolarization. QRS complex is generated due to the action of ventricular depolarization. T wave is due to the ventricular repolarization.

ECG Nominal Data

PR interval	.18 sec
QRS duration	.08 sec
QT interval	.40 sec
ST interval	.32 sec

The QRS complex is the most prominent wave from with in the cardio graphic signal, with normal duration from .06 S to .1 S. It reflects the electrical activity with in the heart during the ventricular activation. Its shape, duration and time of occurrence provide valuable information about the current state of the heart. Because of this specific shape, the QRS complex serves as an entry point for almost all automated ECG analysis algorithms. The QRS detection is not a simple task, due to the varying

R WAVE DETECTION

In wavelet analysis method, we are able to decompose the signal into very very low frequency level. By using this advanced method, we are able to find the variation at very low frequency level. The R wave detection method is organized as follows :

morphologies of normal and abnormal complexes and because the ECG signal experiences several different types of disturbances with complex origin. Once the QRS complex can be identified. By using the variability analysis method different cardiac abnormalities all identified.

1. **Decomposition level**
2. **Location of R wave**
3. **Group location**
4. **Multi-scale search**
5. **Values on position**

DECOMPOSITION LEVEL

It can be seen that the, small scales reflects the high frequency components of the signal and, at large scales, reflects the lows frequency components of the signal. Most energies of the QRS complex are at the scales of 2^3 and 2^4, and the energy at scale 2^3 is the largest from scale 2^3 to smaller or larger scales, the energy of the QRS complex decreases gradually.

According to the experiments, for QRS complex with more high frequency components, the energy at scale 2^2 is larger than at scale 2^3, and for the QRS complex with more low frequency component, the energy at scale 2^4 is larger than at the energy of the QRS complex is decreased. Further and at the same time, the energies of motion artifact, and noise are increased. So, we only select decomposition level from 2^1 to 2^4. The signal is decomposed to approximations and detailed co-efficient. Fig 1 shows original signal. Fig 2 shows at different decomposition levels. Fig 3 shows different scales, the decomposed signal.

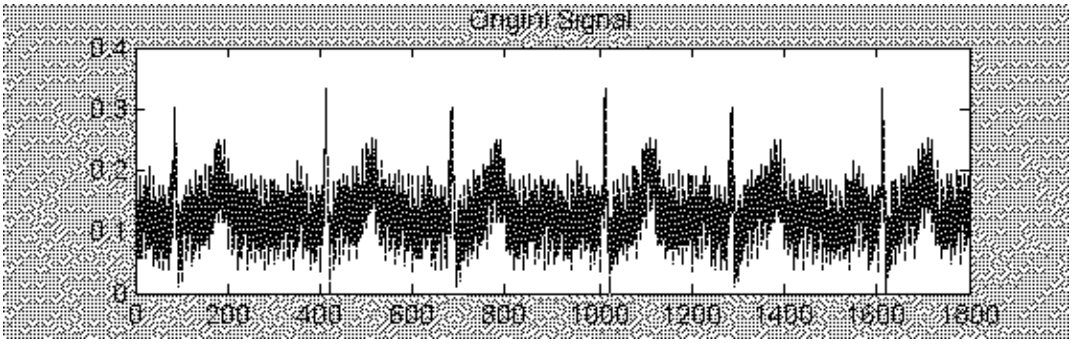


Fig 1. ORIGINAL SIGNAL

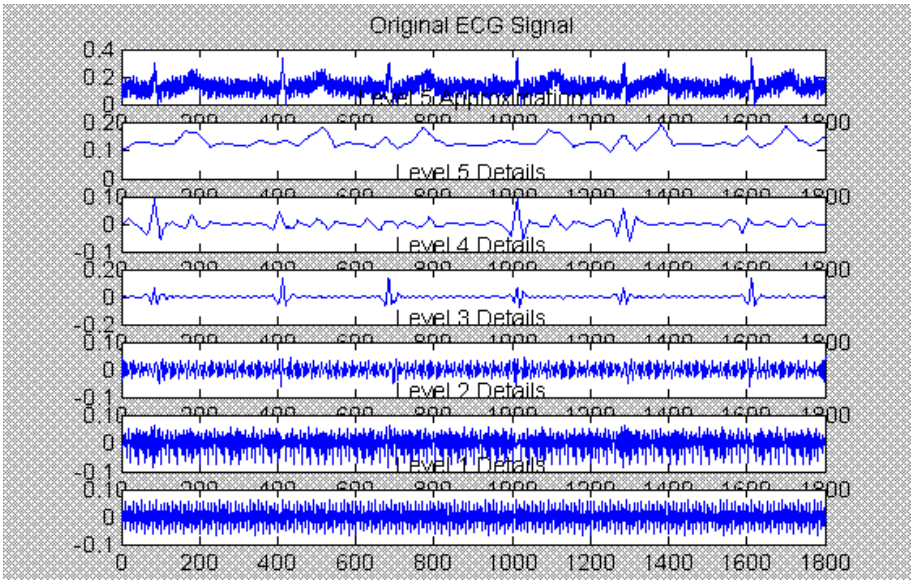


Fig 2. DECOMPOSITION LEVELS

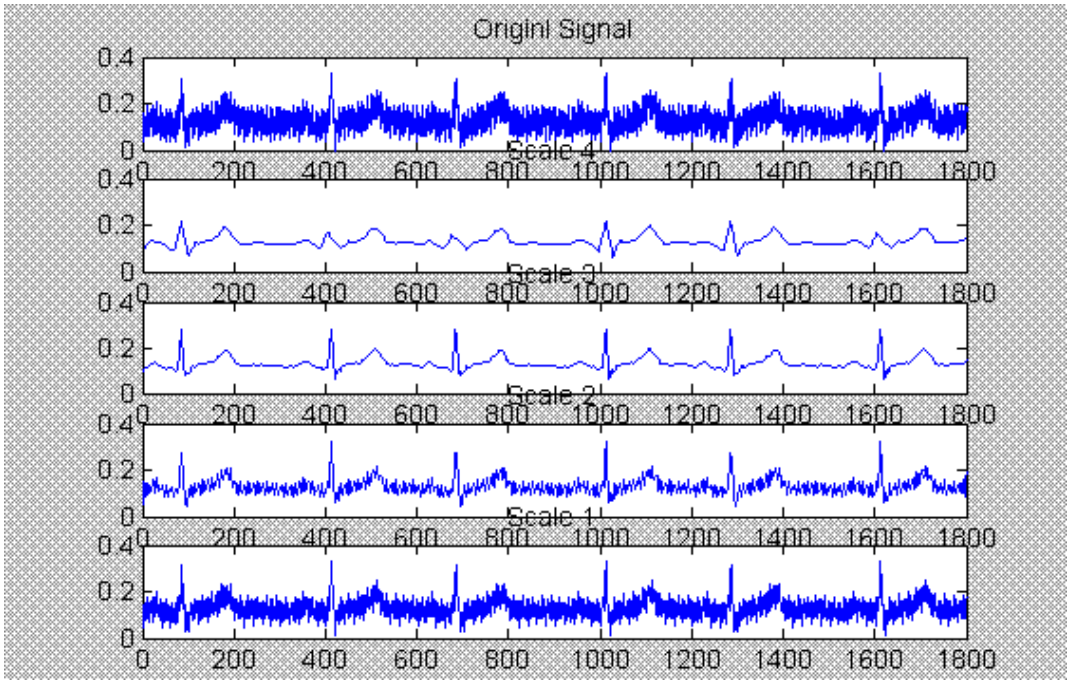


Fig 3. DIFFERENT SCALES

Location of R –wave

In a temporary file the locations are stored. A thresholds is fixed. If the data is above threshold means, the location is stored in the temporary file. At different scales, the above threshold locations are stored. Fig 4 shows the above threshold values.

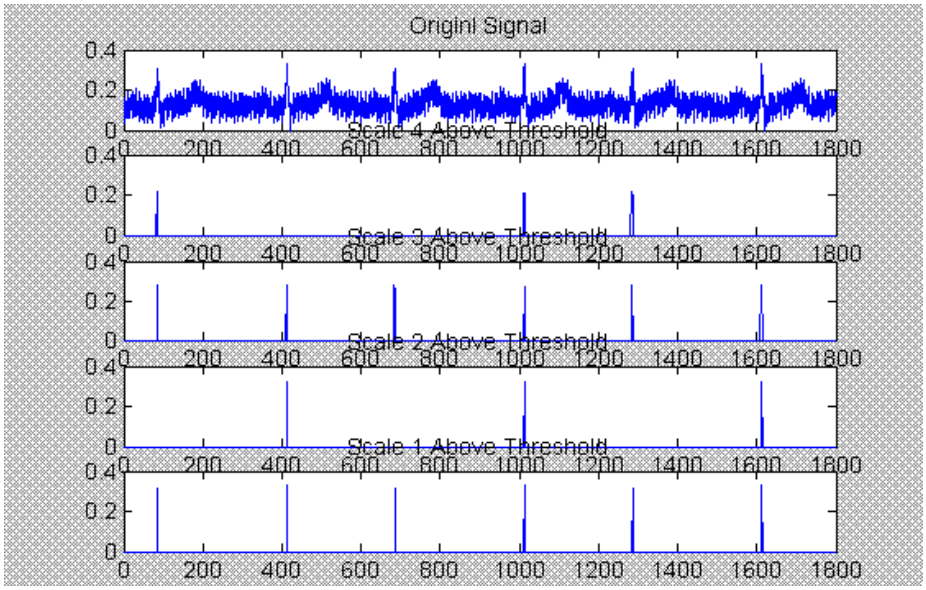


Fig 4. ABOVE THRESHOLD VALUES

Group location

By matrix model, we can identify the group. M*N*O

M - Represent the different scale.

N - Represent the planes.

O - Represent the same complex.

Now at different scales, the above threshold values are identified. Next we have to grouping the same group components. The reason is depends on the sampling rate it will be varied. So, First value is compared to the next value, if the difference is less than 4 means, it is identified as same group.

Multi scale search

After the identification of the same group in a single scale, we have to check the same group is present in the other scales. The differences between adjacent values are greater than to means it belongs to the next scale. Fig 5 shows the identified R wave.

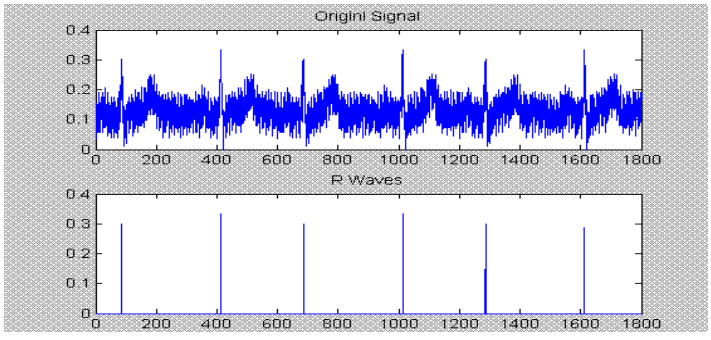


Fig 5. R WAVE

Values on position

Data of the particular location is loaded. From that maximum value is selected from that process. R-wave is identified.

Spectral power ratio

HR can identify the sympathovagal status via the spectral power ratio LF/HF. We performed DWT computations in dyadic structure because it is simple. Such computations occur when the length of a signal is specified as multiples of two's power. The analyzing window length was set to 'M', No of samples present in the detailed signal is dj(k). Pi,j, the power associated with each windowed segment can be calculated by

$$P_{i,j} = \frac{1}{Tj} \sum_{k=(i-1)m}^{im-1} d_j^2(k)$$

Tj Represents the equivalent real time interval of the windowed segment dj(k) I m-1 .
The HRV may be reflected by quantifying LF to HF power ratio as

$$\frac{LF}{HF} = \frac{(P_{i,5}) + (P_{l,4})}{(P_{m,3}) + (P_{n,-2})}$$

At different scales, the LF/HF spectral power is calculated. From that value by averaging method or entropy method averaging method or entropy method identifies one value. The different between adjacent LF/HF spectral power ratios is the variability of that particular abnormality.
For different values of the cardiac abnormality is identified.
Example:

11.3	For NSVT episode.
3.5	For Ischemic episode.
3.6	For Normal episode

CONCLUSION

The diagnosis of cardiac abnormality remains difficult for the physician. Establishing the correct diagnosis is important not only for choosing appropriate initital therapy to terminate the arrhythmia episode, but also for subsequent management. With multiscale information, it is easy to characterize the ECG waves. The QRS complex is easy to distinguish from P & T waves. The algorithm for detecting ECG characteristics points based on WT shows the potential of the wavelets, especially for processing time varying bio-medical signals. It is clear that the wavelet method will lead to a new way of bio-medical signal processing.

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