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Analysis of ECG Signal Using WP-HH Transform

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Abstract— This paper introduces a method of ECG signal de noising using Hilbert Huang and Wavelet Packet Transform. Both HHT and WPT are signal processing method. Wavelet Packet transforms is used to decompose the electrocardiogram signal into a set of narrow band signals. Later the suitable threshold value is selected for each decomposed components. For those components for which wavelet coefficients are larger than the threshold value, HHT is applied. This method removes the noise as well as base line wonder effect from ECG signal and reduces the computing quantities and the decomposition layers of EMD. Paper includes features extraction method using ECG signal (IF, mean frequency, phase) which are useful to discriminate normal and abnormal signal. The simulation result indicates the proposed method is very effective as compared to other methods.

Keywords- ***ECG signal, Hilbert Huang Transform, Wavelet Packet Transform, KNN classifier, EMD, IMF***

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I. INTRODUCTION

Electrocardiogram signal reflects the electrical activity of heart and the variation of cardiac electrical potential over time. Electrocardiogram (ECG) signal is used to diagnose many heart disorders. Analysis of electrocardiogram signal is difficult if noise is embedded with the signal.

There are various techniques given in the literature for denoising of electrocardiogram signal such as adaptive method [2], fuzzy multi wavelet de noising [4], wavelet de noising [6], FIR and IIR filters [7],. However, for non-stationary and nonlinear signal it is not sufficient to use digital filters or adaptive. Initially, the wavelet transform is used as a signal processing tool. Wavelet transform is complete, orthogonal and adaptive. All these are basis to analyze the non-linear and non-stationary signals. There are various deficiencies of wavelet transforms which generates spikes over the frequency range and makes the result confusing. Basically, wavelet transform is divided into continuous wavelet transform and discrete wavelet transform. The process of continuous wavelet transform is intensive. If the data acquired is large then it requires more time. The computing efficiency of discrete wavelet transform is very good, but the resolution in frequency at high frequency range is poor. So it is applicable to many applications such as data compression, noise removal, but not for frequency analysis in high frequency range[1].

Due to these drawbacks of wavelet transform, a new method called Hilbert Hang Transform has been proposed for the analysis of non-linear and non-stationary signal. But, the HHT also suffers from a number of shortcomings. First, the EMD will generate undesirable IMFs at the low-frequency region that may cause misinterpretation to the result. Second, it depends on the analyzed signal; the first obtained IMF may cover too wide a frequency range that the property of mono component cannot be achieved. Third, the EMD operation cannot separate signals that contain low-energy components. To overcome the shortcomings of HHT method, the improved HHT is used. The improved HHT uses wavelet packet transform (WPT) as a pre-processor. Then the EMD will be applied to decompose the narrow band signal.

The remaining paper is organized as follows. Section II gives the theoretical background of Hilbert Huang Transform and wavelet packet transform. Principal of improved Hilbert Huang Transform is explained in section III. Results were given in section IV. Finally section V gives the conclusion.

II. THEORETICAL BACKGROUND

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Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar:

A. HILBERT HUANG TRANSFORM

Hilbert-Huang transform introduces two steps for signal processing. Firstly, the EMD breaks up the original data into a limited number of intrinsic mode functions, and then the IMF components are executed Hilbert transform.

A. Empirical Mode Decomposition

The EMD method will decompose the original signal into several IMF components, and every IMF must meet the following two conditions:

(a) In the entire signal length, an IMF with the number of extreme points and zero crossings must equal or differ at most by one;

(b) At any moment, the mean value of the envelope defined by the maximum points and the envelope defined by the minimum points is zero.

The result of the EMD produces n IMFs cj and a residue signal rn(t) , so the original sequence can be expressed as:

$$x(t) = \sum_{j=1}^{n} Cj(t) + r_n(t) \qquad (1)$$

Although the definition of instantaneous frequency is always controversial, it is tenable to define that for a given length of signal, there is only one frequency value within the length of the signal, or the signal is mono component. To extract the instantaneous frequency of a mono component signal, the Hilbert transform can be used. For an arbitrary signal x(t), its Hilbert transform y(t) is defined as

$$y(t) = \frac{P}{\pi}\int_{-\infty}^{+\infty} \frac{x(t)}{t-\tau}\, d\tau \qquad (2)$$

Where P is the Cauchy principal value.

The controversial instantaneous frequency is defined as the time derivative of the instantaneous phase, as follows:

$$\omega(t) = \frac{d\varphi(t)}{dt} \qquad (3)$$

B. Wavelet Packet Transform

Wavelet Packet Decomposition (WPD) is a wavelet transform where the discrete-time (sampled) signal is passed through more filters than the discrete wavelet transform (DWT). The only difference between wavelets and wavelet packets is that wavelet packets offer a more complex and flexible analysis, because in wavelet packet analysis, the details as well as the approximations are split. WPT has the properties like orthogonal, complete and local; hence it is used as a pre-processor. WPT uses a pair of low pass and high pass filters to split a low-frequency and a high frequency component. So the WPT allows better frequency localization of signals. The operation of WPT is illustrated in the below figure. Initially, an inspected signal x(t), is divided into an approximation portion A1 and detailed portion D1 through a couple of low band filter (LF) and high band filter (HF), respectively. The approximation portion (A1) is divided into two second level approximation portion (AA2) and detailed portion (DA2), by LF and HF respectively. Similarly, the first level detailed portion (D1) will also divide into second level approximation (AD2) and detailed portion (DD2). For n-level decomposition, the signal will be decomposed into 2n narrow band signals.

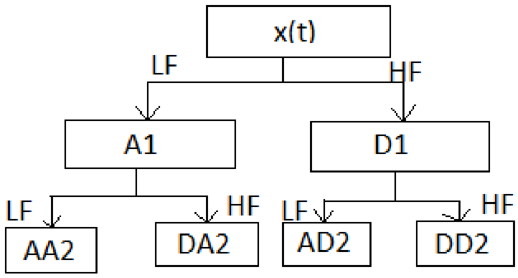

Fig 1: WPT decomposition tree

III. THE PRINCIPAL OF IMPROVED HILBERT HUANG TRANSFORM

The HHT with WPT as a pre-processor and the IMF selection process is called as an improved HHT. The operation of improved HHT is given in the flow chart as shown in the figure. There are three shortcomings were found in the HHT analysis. The three major shortcomings include the EMD generating undesirable IMFs at the low-frequency region, the first obtained IMF may cover too wide a frequency range such that the property of mono component cannot be achieved, and some signals that contain low-energy components are inseparable.

Figure 2 shows the process of improved HHT. The input taken is electrocardiogram signal. Electrocardiogram signal is applied to WPT. WPT is act as a preprocessor. The wavelet packet decomposition is used to decompose the signal into narrow band signals. Later the suitable threshold value is selected for each decomposed components. From the decomposed components, for which the wavelet coefficients are equal or less than the threshold value are considered as noise and not need to determine the EMD. Secondly, the suitable threshold value is selected for each decomposed components, respectively. Those of the decomposed components, which wavelet coefficient are equal to or less than threshold value, are regarded as noise and not need to compute EMD. The soft-threshold method is applied to signal denoising in WPD. The basic steps of signal denoising using soft threshold method are as follows: First WPT for signal. By selecting a wavelet function and deciding the total level m for wavelet packet decomposition, the decomposed components can be obtained by WPT for signal S. The value of total level m is commonly 6 or 7. According to minimum cost principle, choose the optimized wavelet packet groups. Here the Energy entropy standard as the criterion, the optimized orthogonal wavelet packet groups can be decided by selecting the least entropy value. Threshold value quantification of WPT coefficients, respectively. Last is the selection of WPT coefficients sj for EMD.

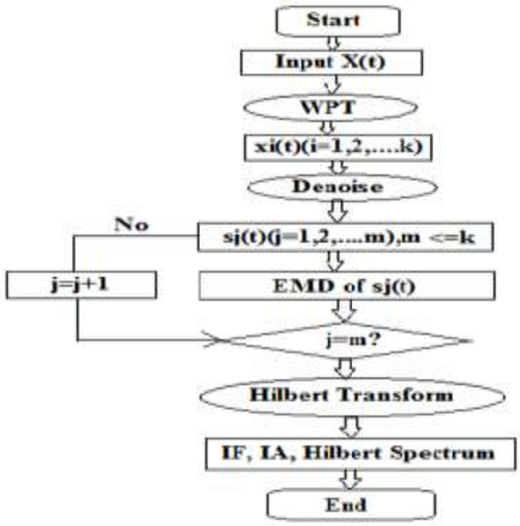

Fig 2: Process of improved HHT

IV. RESULTS

After application of Hilbert Huang transform the different features were extracted from electrocardiogram signal like instantaneous amplitude and instantaneous frequency which are shown in below figure. Fig. 3 shows the original electrocardiogram signal (ECG). Original signal is decomposed by using empirical mode decomposition method showing in fig. 4. After decomposition process reconstruction is done. Two levels of reconstruction is performed on decompose signal which is shown in fig. 6. After reconstruction the denoise signal is obtained as shown in fig. 7. Similarly fig 8 to fig 10 shows the results for abnormal

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case. Fig. 11 and fig. 12 shows the instantaneous frequency and instantaneous amplitude of original signal.

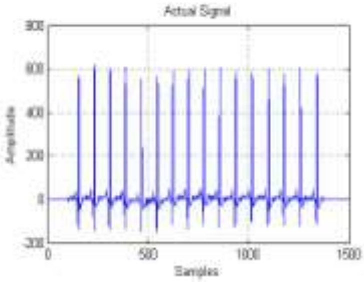

Fig 3: Original ECG signal

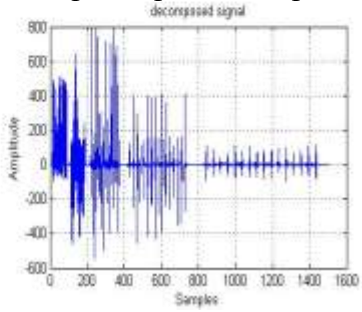

Fig 4: Decompose Signal

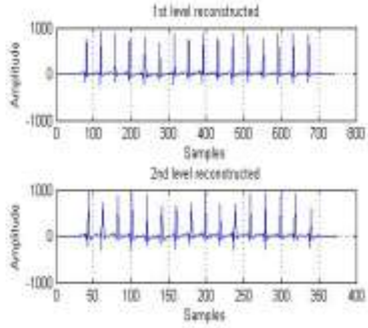

Fig 5: Reconstruction of signal

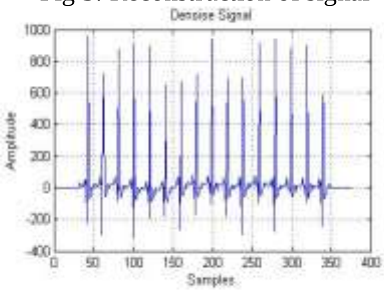

Fig 6: Denoise ECG signal

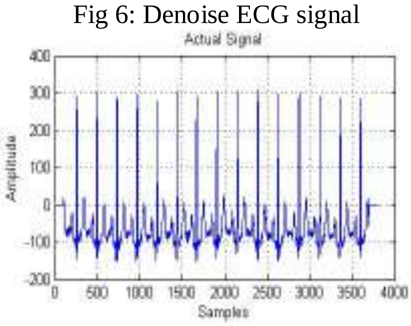

Fig 7: Original signal

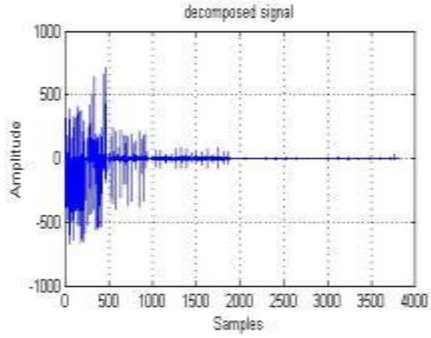

Fig 8: decompose signal

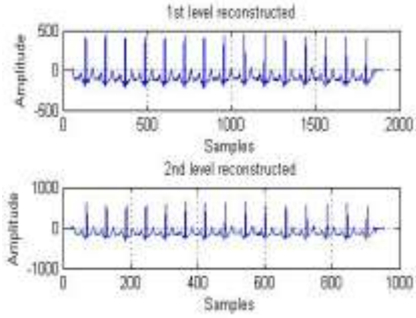

Fig 9: Reconstruction of signal

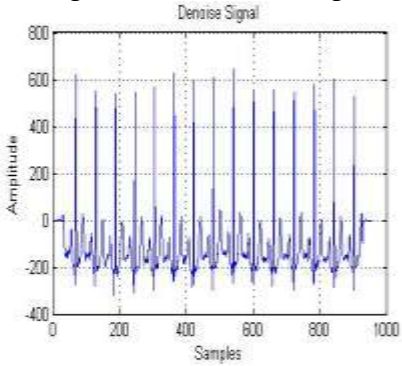

Fig 10: Denoise Signal

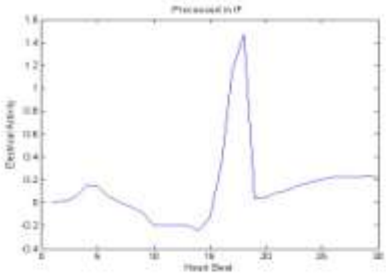

Fig 11: Instantaneous frequency of original signal

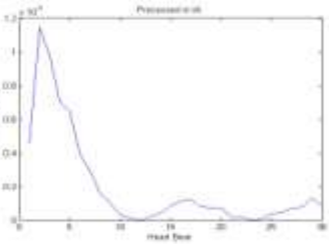

Fig 12: Instantaneous Amplitude of original signal

V. CONCLUSION

A novel time–frequency analysis method named as HHT has been given in detail. Here the improved HHT is used to denoise the electrocardiogram signal rather than using a simple HHT. The improved HHT utilizes the WPT to act as a pre processor to decompose the raw signal into a set of narrow band signals. Then the EMD will be applied to these narrow band signals and extract sets of IMFs. Finally the KNN classifier is used to identify that the patient is in normal or abnormal situation.

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REFERENCES

[1] Paithane, A. N., and D. S. Bormane. "Analysis of nonlinear and non-stationary signal to extract the features using Hilbert Huang transform." *Computational Intelligence and Computing Research (ICCIC), 2014 IEEE International Conference on*. IEEE, 2014.

[2] Paithane, A. N., and D. S. Bormane. "Electrocardiogram signal analysis using empirical mode decomposition and Hilbert spectrum." *Pervasive Computing (ICPC), 2015 International Conference on*. IEEE, 2015.

[3] D. L. Donoho, "De-noising by soft-thresholding*", IEEE Transaction on Biomedical signal Processing* Theory, 1995, vol. 42, no. 3, pp. 613-627.

[4] Wei Zhang,Xu Wang , LinlinGe , Zhuo Zhang." Noise Reduction in ECG Signal Based on Adaptive Wavelet Transform". *Proceedings of the 2005IEEE Engineering in Medicine and Biology 27th Annual conference*, September 1-4, 2005.

[5] A. K. Barros, A. Mansour, and N. Ohnishi, "Removing artefacts from electrocardiographic signals using independent component analysis, "Neuro computing, vo1.22, pp. 173-186, Nov. 1998.

[6] Y.-F. Ho, B. W.-K. Ling, T. P.-L. Wong, A. Y.-P. Chan, and P. K.-S. Tam, "Fuzzy multi wavelet denoising on ECG signal," Electronics Letters, vol. 39, no. 16, pp. 1163-1164, Aug. 2003.

[7] AnandaJonnabhotla, Nikita Sadam and Naga Deepthi, "ECG Noise Removal and QRS Complex Detection Using UWT", 2010 International Conference on Electronics and Information Engineering, Vol.2, pp. 438-442, 2010.

[8] Mashud Khan,Faizen Aslam,Tahir Zaidi,Shoab A. Khan. "Wavelet Based ECG Denoising Using Signal-Noise Residue Method" .978-1-4244-5089-3/11, IEEE Transaction on Signal Processing, 2011.

[9] Seema Rani ,Amarpreetkaur, J S Ubhi. "Comparative study of FIR and IIR filters for the removal of Baseline noises from ECG signal" *International Journal of Computer Science and Information Technologies,* Vol 2 (3), 2011.

[10] ManpreetKaur, Birmohan Singh, Seema, "Comparisons of Different Approaches for Removal of Baseline Wander from ECG Signal", *2nd International Conference and workshop on Emerging Trends in Technology (ICWET),* 2011, Issue 2, Volume 2.

[11] Pradnya B. Patil, Dr. Mahesh S. Chavan, "Analysis of Non-stationary ECG signals using Iterative Wavelet Decomposition", Proceedings of the 2011 IEEE International Conference on Mechatronics and Automation, vol. 2, pp. 316-327, 2012.

[12] Ani! Chacko, Samit Ari, "Denoising of ECG signal using Empirical Mode Decomposition based technique", IEEE International Conference on Advance In Engineering, Science and Management, Vol-3, March 2012.

[13] ChitrangiSawant, Harishchandra T. patil, "Performance Comparison of Wavelet Based ECG Signal Denoising", International Journal of Advance Foundation and Research in Computer (IJAFRC), Vol. 1, Issue 5, May 2014.