RESEARCH ARTICLE OPEN ACCESS

Review Paper :Comparative Analysis Of Mother Wavelet Functions With The ECG Signals

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ABSTRACT
Electrocardiographic ECG gives the information about electrical activity of the heart captured over time by attaching an external electrode to the skin. Now a days ECG signal is used as a baseline to determine the hearts condition. It is very much essential to detect and process ECG signal accurately. ECG consists of various types of noise such as muscle noise, baseline wander and power line interference etc. To remove such types of noise wavelet transform is used. Mother wavelet is an effective tool for denoising such signals. But selection of proper mother wavelet for the ECG signal is again a challenging task. This paper gives the survey about the wavelet transforms useful for ECG denoising. The different wavelet transform are compared and from that we can decide which one is more suitable.
Keywords- CWT, DWT , Electrocardiogram, FFT, Heart Rate Variability, QRS, Wavelet Transform

I. INTRODUCTION

Electrocardiogram (ECG) is a diagnostic tool that is used to assess the electrical and muscular functions of the heart. ECG gives the regular rhythmic activity of the heart by placing the electrodes at specific position of the body[1].Electrocardiography is the first step to detect any heart related problems such as congenital heart defects, coronaryartery diseases etc. Preprocessing of ECG signal is an important task to conserve the useful information of ECG. Wavelet provides a consolidated system for different techniques that used in the biomedical signal processing which developed for various applications. Wavelet transform is a robust technique to represent the signal in time-frequency domain.

Wavelet coefficients give the time segment and frequency band of the measured ECG signal[2]. The more similar the mother wavelet function is to the wavelet coefficients across signals, the more precisely the signal of interest can be identified and isolated; hence, identification of a mother wavelet function is of paramount significance .Wavelet technique quantify the noise may be caused by the electrode movement, muscle activity and electrical line interference, those gives a sharp wave and spikes in the signal. This technique is used in other signals for this purpose. With the proper choice of wavelet level and mother wavelet, most of the interference noise can be suppressed. It provides the time-frequency representation. Many times a particular spectral component occurring at any instant can be of specific or particular interest. In these cases it may be very beneficial to know the time intervals these particular spectral components occur. Wavelet transform is capable of providing the time and frequency information together, hence giving a time-frequency representation of the signal.

The rest of the paper is organized as follows. In Section II theory of wavelet transform is given . Section III covers Literature Survey Crux. In section IV comparative analysis is given. Finally in section V, we summarize the comparative results.

II. THEORY

There are two types of Wavelet Transform.

2.1 Continuous Wavelet Transform

The continuous wavelet transform was developed as an alternative approach to the short time Fourier transform to overcome the resolution problem[3].
The continuous wavelet transform is defined as follows

$$CWT_x^{\psi}(\tau, s) = \Psi_x^{\psi}(\tau, s) = \frac{1}{\sqrt{|s|}} \int x(t)\psi^*\left(\frac{t-\tau}{s}\right) dt$$

From above equation , the transformed signal is a function of two variables, tau and s , the translation and scale parameters, respectively. psi(t) is the transforming function, and it is called the mother wavelet . The term mother wavelet gets its name due to two important properties of the wavelet analysis as explained below:

The term wavelet means a small wave. The smallness refers to the condition that this window function is of finite length. The wave refers to the condition that this function is oscillatory.

The term mother implies that the functions with different region of support that are used in the transformation process are derived from one main function, or the mother wavelet. The mother wavelet is defined as a prototype for generating the other window functions.

Computation of the CWT:

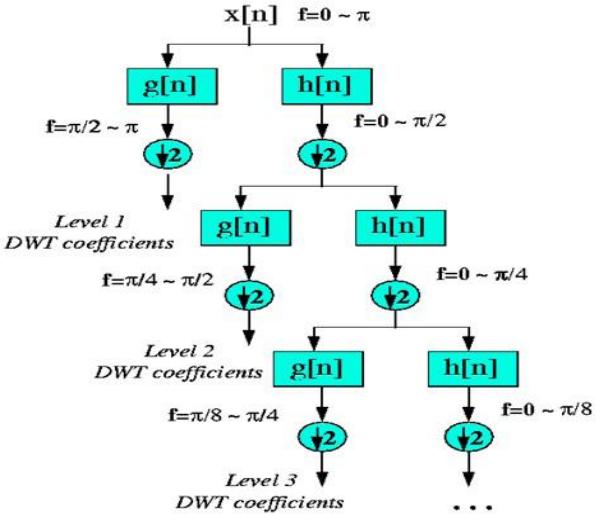
- The signal to be analyzed is taken.
- The mother wavelet is chosen and the computation is begun with s = 1. The CWTis computed for all values of s. the wavelet will dilate is s increases and compresseswhen s is decreased.
- The wavelet is placed in the beginning of the signal at the point which correspondsto time = 0.
- The wavelet is multiplied with the signal and integrated over all times. The result isthen multiplied by the constant 1/sqrts.
- The above step normalizes the energy so that the transformed signal has same energyat every scale.
- The wavelet at scale s =1 is then shifted to the right by t and the above steps arerepeated until the wavelet reaches the end of the signal.

2.2 The Discrete Wavelet Transform

Discretized continuous wavelet transform enables the computation of the continuous wavelet transform by computers, but it is not a true discrete transform[3]. In fact the wavelet series is simply a sampled version of the CWT, and the information provided by it is highly redundant as far as the reconstruction of the signal is concerned. This redundancy requires a significant amount of computation time and resources. Whereas the discrete wavelet transform (DWT), provides sufficient information both for analysis and synthesis of the original signal, with a significant reduction in thecomputation time. The DWT is considerably easier to implement when compared to the CWT. The basic concepts of the DWT is introduced in this paper along with its properties and the algorithms used to compute it.

Wavelet Decomposition and Construction:

Wavelet analysis is the breaking up or subsampling of a signal into shifted and scaled versions of the original (or mother) wavelet. It conserves the time-frequency components of a signal at different resolution and scales. Noise components from the contaminated ECG signal can be removed at a good resolution of wavelet analysis. The discrete wavelet transform DWT can be achieved by successive low pass and high pass filter at discrete time domain. x[n] is the input signal which pass through a high pass filter where the impulse response is h[n]. The same signal x[n] simultaneously pass through the low pass filter with an impulse response g[n].The output of the high pass filter gives the detail coefficient and the output of the low pass filter gives the approximate coefficient. The filter output is given in Y_{high} and Y_{low} where kvaries from -∞ to ∞[3] .



The signal is then subsampled by 2 since half of the number of samples are redundant. This doubles the scale. This procedure can mathematically be expressed as

$$y[n] = \sum_{k=-\infty}^{\infty} h[k] \cdot x[2n - k]$$

$$y_{high}[k] = \sum_{n} x[n] \cdot g[2k - n]$$

$$y_{low}[k] = \sum_{n} x[n] \cdot h[2k - n]$$

where Yhigh[k] and Ylow[k] are the outputs of the high pass and low pass filters, respectively, after subsampling by 2.

The reconstruction in this case is very easy since halfband filters form orthonormal bases. The above procedure is followed in reverse order for the reconstruction.

$$y_{high}[k] = \sum_{n} x[n] \cdot g[-n + 2k]$$

$$y_{low}[k] = \sum_{n} x[n] \cdot h[-n + 2k]$$

Therefore, the reconstruction formula becomes (for each layer).

$$x[n] = \sum_{k=-\infty}^{\infty} \left(y_{high}[k] \cdot g[-n + 2k]\right) + \left(y_{low}[k] \cdot h[-n + 2k]\right)$$

Mother Wavelets Used For ECG Signal:

- Daubechies Wavelet
- Haar Wavelet
- Symlet
- Cubic B-Spline Wavelet

III. LITERATURE SURVEY CRUX

3.1 S.Sumathi, Dr.M.Y. Sanavullah [4]

In [4] authors has proposed a new robust algorithm for the QRS detection using the properties

of the wavelet transform. Wavelet transform provides time and frequency information simultaneously. In this paper author has studied useful properties of the wavelet transform for QRS detection and new QRS detector has proposed. The proposed algorithm has explained the effect of wavelet with different properties such as linearity and time frequency localization on the accuracy of QRS detection. In this paper the authors has applied different mother wavelets such as Haar wavelet, Db4 wavelet and Cubic Spline wavelet on the ECG data to detect the QRS complex. The results are obtained for each wavelet. After observing the results it is found that a novel, effective, and noise tolerance QRS detection algorithm based on Cubic Spline wavelet transform is more suitable for QRS detection because it reduces the probability of error in the detection of the QRS complex. The Cubic Spline Wavelet has more accurate and fast results as compared to other. The main advantage of this kind of detection is less time consuming for long time ECG signal.

3.2 Yamini Goyal, Anshul Jain [5]

In[5] the study of HRV dynamics and comparison using wavelet analysis and Pan Tompkins algorithm is given. This work aims to study heart rate variability during normal or abnormal functioning of the heart and whether it can be used to predict the occurrence of any abnormality. This study aims to compare results based on wavelet analysis and Pan Tompkins algorithm. Here time domain analysis as well as frequency domain analysis of HRV are presented. Actually, this study investigated the role of QRS detection algorithm for calculating HRV parameters Pan-Tompkins algorithm is the most widely used tool for QRS detection from ancient time while application of wavelet transform is relatively new in ECG signal processing but the wavelet based analysis had a greater level of noise tolerance(in case of reconstructed ECG signal and not HRV parameters) and was also faster than the former. In wavelet transform the choice of mother wavelet as well as values of scale parameters will require solid investigations in order to improve its clinical usefulness. Here Db4 and Db6 wavelets are used but Db4 provides excellent results. In this paper authors has analyzed the results both Wavelet transform and Pan Tompkins algorithm. Author says that Wavelet based method acts as a mathematical magnifier. The Db4 wavelet cleans the signal from any kind of distortion. After analysis and comparison it is found that wavelet based QRS detection method is faster and effective technique than Pan Tompkins algorithm.

3.3 Rashmi A. Deshpande, Prof. Dipali S. Ramdasi[6]:

In [6] authors has analyzed HRV data on the basis of LF/HF ratio. Here Wavelet and Wigner Ville Transforms are used for data analysis and the results are mentioned for standard MIT database as well as database collected by using PowerLab. In this study authors has obtained results for both transforms. Theyhad given same ECG signal to both transforms as a input. By using Wavelet transform, the HRV signal is decomposed into different frequency bands and then the power in each band is calculated. As usual LF/HF ratio is used as a measure of HRV. Wigner – Ville is also another efficient method of obtaining time – frequency representation of a signal. The result obtained from Wigner – Ville transform can also be divided into the specified LF and HF bands and power in each band can be used for analysis. From the results obtained we can state that Wavelet transform is an efficient method to calculate the LF/HF ratio.

3.4 Ibtihel Nouira, Asma Ben Abdallah, Mohamed Hédi Bedoui, and Mohamed Dogui[7]:

In [7] authors has proposed an algorithm to detect R waves based on the Dyadic Wavelet Transform DyWT by applying a windowing process. This algorithm is tested on a sample of synthesis ECG signal with and without noise which we have proposed and on real data. Finally, once the R peaks of real data are detected, they used three methods of RR intervals analysis by calculating the standard deviation of heart rate and applying the Fast Fourier Transform FFT and the Wavelet Transform on detected RR intervals to study the Heart Rate Variability (HRV). A comparative study between the analysis results of detected RR intervals in healthy and diseased subjects through the application of the FFT and the Wavelet Transform has given in this paper.

The study of the Heart Rate Variability(HRV) will be useful for the prognosis, diagnosis and treatment of certain diseases. In this paper authors has obtained the results from all the wavelets by giving ECG signal as input. The results of proposed wavelet and other wavelets such as Cubic Spline Wavelet, Haar Wavelet, Db4 Wavelet is analyzed. Here time domain analyses as well as frequency domain analysis of HRV are presented. The obtained results show that the R peaks can be estimated with a good accuracy. The accuracy of Cubic Spline Wavelet is more but the accuracy of proposed wavelet is also good.

IV. COMPARATIVE ANALYSIS:

Authors	Year	Methods Compared	Best Method
S.Sumathi, Dr.M.Y. Sanavullah[4]	2009	Cubic Spline Wavelet,Haar Wavelet, Db4 Wavelet	Cubic Spline Wavelet
Yamini Goyal, Anshul Jain[5]	2012	Db4 Wavelet,Db6 Wavelet, Pan Tompkins Algorithm	Db4 Wavelet
Rashmi A. Deshpande, Prof. Dipali S. Ramdasi[6]	2012	Wavelet Transform, Winger-Ville Transform	Wavelet Transform
Ibtihel Nouira, Asma Ben Abdallah, Mohamed Hédi Bedoui, and Mohamed Dogui[7]	2013	Db4Dy Wavelet, Cubic Spline Wavelet,Haar Wavelet, Db4 Wavelet	Cubic Spline Wavelet

V. CONCLUSION

In this paper different wavelet transform are studied for denoising the ECG signal. Paper gives the survey about mother wavelet useful for ECG processing. Here the comparative analysis is carried out by studying different research papers which gives the suitable methods for ECG detection and processing.

REFERENCES

[1] TAN Yun-fu,Du Lei, "Study on Wavelet Transform in the Processing for ECG Signals", *World congress on Software Engineering, IEEE p515-518, 2009.*

[2] THE WAVELET TUTORIAL by ROBI POLIKAR

[3] Nagendra H, S.Mukharji, Vinod Kumar, "Application of Wavelet Techniques in ECG Signal Processing: An Overview", *International Journal of Engineering Science and Technology (IJSET), ISSN: 0975-5462, Oct 2011.*

[4] S.Sumathi, Dr.M.Y. Sanavullah , "Comparative Study of QRS Complex Detection in ECG Based on Discrete Wavelet Transform",*International Journal of Recent Trends in Engineering, Vol 2, No. 5, November 2009.*

[5] Yamini Goyal, Anshul Jain,"Study of HRV dynamics and comparison using wavelet analysis and Pan Tompkins algorithm",*International Conference on BioMedical Computing IEEE 2012* .

[6] Rashmi A. Deshpande, Prof. Dipali S. Ramdasi,"HRV Analysis Using Wavelet Transform and Wigner – Ville Transform",*International Conference on BioMedical Engineering and Sciences IEEE December 2012.*

[7] Ibtihel Nouira, Asma Ben Abdallah, Mohamed Hédi Bedoui, and Mohamed Dogui,"A Robust R Peak Detection Algorithm Using Wavelet Transform for Heart Rate Variability Studies",*International Journal on Electrical Engineering and Informatics - Volume 5, Number 3, September 2013.*

[8] Md. Wasiur Rahman, Manjurul Ahsan Riheen "Compatibility of Mother Wavelet Functions with the Electrocardiographic Signal", *IEEE 2013.*

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