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# Mapping Of One-Dimensional ECG Abnormalities in Spatial coordinates using Wavelet Transform for Telediagonostic Purposes

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## Abstract

*The paper discusses a unique methodology of connecting one dimensional images of time domain ECG to the spatial coordinate image. The wavelet has been used for non stationary waveform of the ECG while abnormalities are pronounced here , a multiresolutionary method needed to visualize the discrepancies of the heart.ECG with abnormality may not be periodic and have transients of distortions of very short duration. The short time duration signal can also be analyzed with Fourier Transform method with average results .Wavelet provides detailed pictorial view of the ECG time domain signal .Eventually, the approach leads to direct mapping to beating heart discrepancy.The paper facilitates telediagonostic purposes by compressed data transmissions over net.*

## 1. Introduction

An electrocardiogram (ECG or EKG, abbreviated from the German Elektrokardiogramm) is a graphic produced by an electrocardiograph, which records the electrical activity of the heart over time. The signal is constructed by measuring electrical potentials between various points of the body using a galvanometer. ECG is generated by depolarization and repolarization of the atria and ventricles. Understanding the various waves and normal vectors of depolarization and repolarization is very important to obtain useful diagnostic information.

The online telemedicine diagonostic procedures are increasing day by day. The wavelet transform can facilitate this in a special manner by reducing the bandwidth, eventually less memory requirement in the system. This is an additional facility to send encrypted data of ECG on the internet anytime-anywhere in real time mode.

Currently one dimensional time domain data has been encrypted and the same could be enhanced to the level of direct mapping of actual beating heart images. The deformities in one dimensional ECG will lead exact replica in two dimensional images of heart in beating mode. Wavelet transform is the best method for such nonstationary images.

A typical ECG tracing of a normal heartbeat (or cardiac cycle) consists of a P wave, a QRS complex and a T wave. Fig.1 shows an example of a normal ECG trace.The P wave is the electrical signature of the current that causes atrial contraction; the QRS complex corresponds to the current that causes contraction of the left and right ventricles; the T wave represents the repolarization of the ventricles and finally the small U wave although not always visible, is considered to be a representation of the Papillary Muscle .The presence or lack of presence of QT interval and PR interval are meaningful parameters in the screening and diagnosis of cardiovascular diseases.

Generally, the condition of a heart can be determined by extracting features from the ECG signal. These features include the amplitudes of the waves and the intervals between them. A normal ECG signal has the following amplitudes values [2]:

P-wave 0.25 mV,
R-wave 1.6mV,
Q-wave 25% of the R-wave,
T-wave 0.1 to 0.5mV;

the time interval values: PR-interval 0.12-0.2s,
QRS complex 0.04 to 0.12s,
QT interval <0.42s

and the heart rate of 60-100 beats/min . Any change in the above said values indicates the abnormality of the heart.

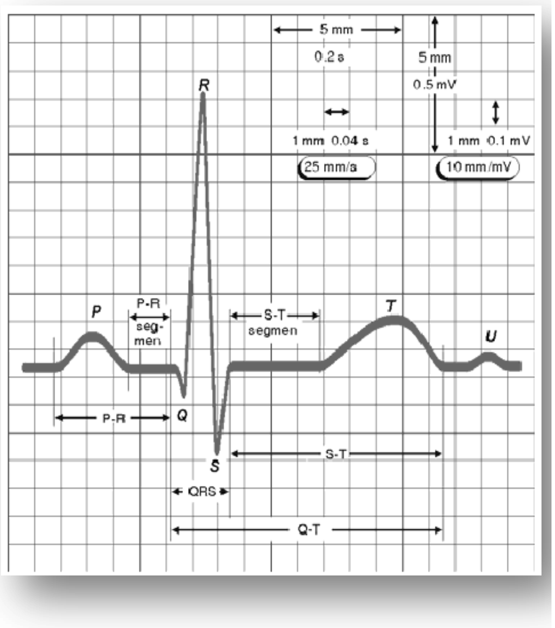


Figure.1 The Ecg signal

The benefit of the wavelet based ECG approach is that T-wave abnormalities can be assessed without the need for T-wave end point identification. Most of the time the desired ECG signals are either corrupted or embedded in noises. Thus wavelet analysis is an effective tool for the analysis of non-stationary signals, because it provides an alternative to the classical Short-Time Fourier Transform (STFT) . STFT uses a single analysis window whereas, the WT uses short windows at high frequencies and long windows at low frequencies. If the function $\psi(t) \in L^2(R)$(square integrable space) and meets $\int_{-\infty}^{+\infty} \psi(t)dt = 0$, then it is known as the mother wavelet or the basic wavelet. The basis function of Wavelet Transform is known as the wavelet. The basis function of Wavelet Transform is known as the wavelet function, for short wavelet, which is expressed by $\psi_{a,b}(t)$generated by the basic wavelet ψ(t), after companding and moving parallelly, as shown in the formula(1), where *a* is the companding factor and *b* is the moving parallelly
factor and $a \neq 0$ , *a* and *b* are the continuous quantities [4].

$$\psi_{a,b}(t) = \frac{1}{\sqrt{|a|}}\psi\left(\frac{t-b}{a}\right)$$

Wavelet transforms are classified in two different categories: the continuous wavelet transforms (CWT) and the discrete wavelet transforms (DWT).
Continues wavelet transform (CWT) is defined as the sum over all time of the signal multiplied by scaled, shifted versions of the wavelet function ψ(t), which is a time function with finite energy and fast decay called the mother wavelet. The results of the CWT are wavelet coefficients C, which are a function of scale and position. Multiplying each coefficient by the appropriately scaled and shifted wavelet yields the constituent wavelets of the original signal f (t ) [1].

$$C\,(\text{Scale, Position}) = \int f(t)\,\Psi(\text{Scale, Position},t)\,dt$$

(2)

$$CWT(a,\tau) = \frac{1}{\sqrt{a}}\int s(t)\,\psi\left(\frac{t-\tau}{a}\right)dt$$

(3)

In this equation, the parameter "a" is the scaling factor that stretches or compresses the function. The parameter τ is the translation factor that shifts the mother wavelet along the axis. It is often desirable to work with discretized signals. DWT is defined by the following equation [1]

$$DWT(m,n) = 2^{-\frac{m}{2}} \sum_{k} s(k) \psi\left(2^{-m} k - n\right)$$

(4)

Often, Discrete Wavelet Transform is also referred to as decomposition by wavelet filter banks [3]. This is because DWT uses two filters, a low pass filter (LPF) and a high pass filter (HPF) to decompose the signal into different scales. The output coefficients of the LPF are called approximations while the output coefficients of the HPF are called details. The approximations of the signal are what define its identity while the details only imparts nuance. Furthermore, the decomposition process is iterative. The approximation signal may be passed down to be decomposed again by breaking the signal into many levels of lower resolution components. This is called multiple-level decomposition and may be represented in wavelet decomposition tree. Only the last level of approximation is save among all levels of details, which provides sufficient data to fully reconstruct the original signal using complementary filters.

Conventionally, ECG feature extraction is preceded by a bandpass or a matched filter to suppress the P and T waves and noises before sending the signal for characteristic detection. By using discrete wavelet transform, frequency domain filtering is implicitly performed, making the system robust and allowing the direct application over raw ECG signals. Discrete wavelet transform is also referred to as decomposition by wavelet filter bank.

The Discrete Wavelet Transform in 2-D of a function f(x,y) of size M x N is [6]:

$$W_{\psi}^{i}(j,m,n) = \frac{1}{\sqrt{MN}} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y) \psi_{j,m,n}^{i}(x,y), i = \{H,V,D\}$$

where H represents the Horizontal components, V the vertical components and D the Diagonal components.

## 2. Analysis Method

First the ECG signal is decomposed using three level wavelet decomposition. For analysis, any of the wavelets among wavelet family can be used. For example Daubechies, symlet, haar, coiflet etc. can be used. The high frequency components of the ECG signal decreases as lower details are removed from the original signal. As the lower details are removed, the signal becomes smoother and the noises on the T and P waves disappears since noises are marked by high frequency components picked up along the ways of transmission. The detection of the QRS complex is the last step of feature extraction. The R peaks have the largest amplitudes among all the waves, making them the easiest way to detect and good reference points for future detections.

However for the detection of the QRS complex, only details up to level 2 were kept and all the rest removed. This procedure removed lower frequencies considering QRS waves have comparatively higher frequency than other waves. In a Normal ECG rhythm is regular, 60 to 100 times per minute. In abnormal ECG, like Bradycardia heart beat is slower i.e < 60 bpm, in Tachycardia heart beat is faster i.e.> 100bpm.In this paper, wavelet transform is applied to two dimensional ecg of these syndromes in heart using symlet2 wavelet.

Deformities mappings are discussed here:

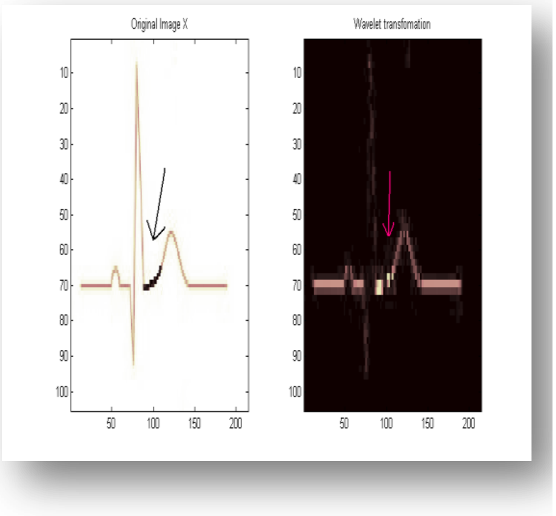


Figure 2. Normal ECG waveform

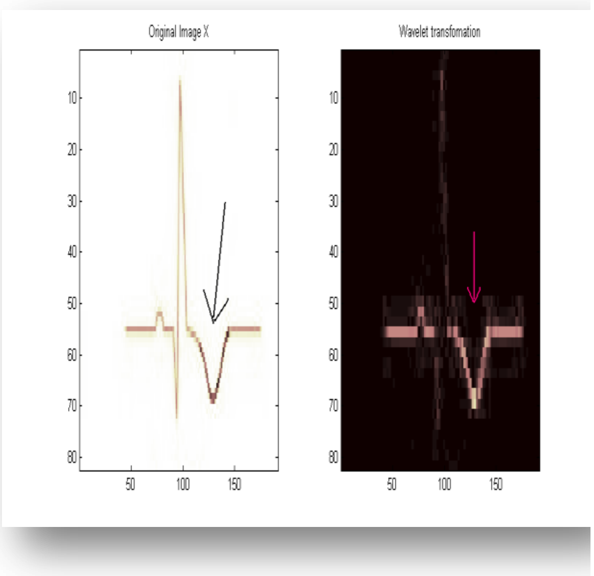


Figure. 3 Inverted T-wave

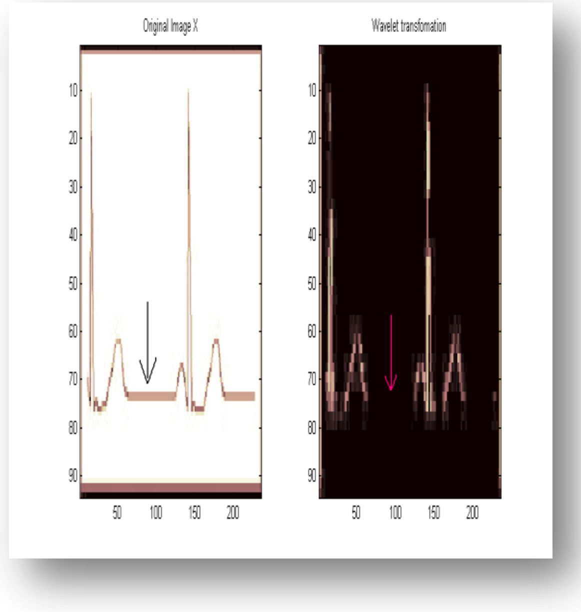


Figure 4. Bradycardia

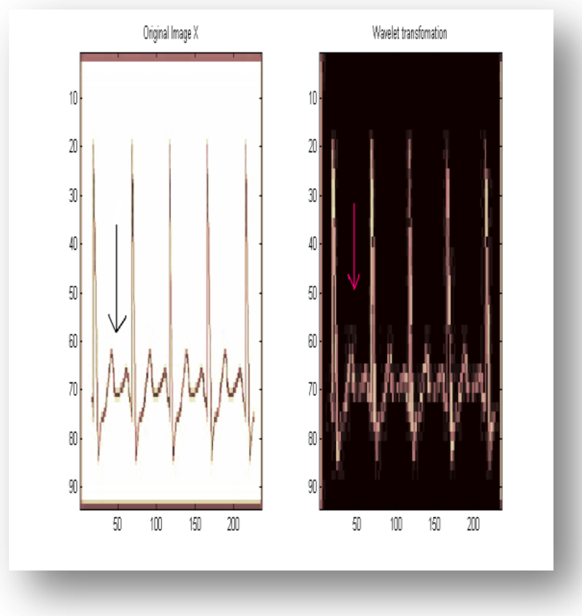


Figure 5. Tachycardia

## 2. Conclusion

Ailments of the heart are perpetual and become epidemic in SARC countries where medical facilities of diagonostics are inadequate. Thus, it is imperative to use modern communication technique for the faster, easier and accessible methods by 'common people'. Sometimes one dimensional ECG interpretation is quite embarrasing. In such circumstances two dimensional image mapping will lead to an easier process in which heart deformities can easily be seen once as the thumping heart image. Wavelet transform provides unique encryption and detailed information in time as well as in frequency domain. For instance, Bradycardia**,** a slow heart movement of ECG must map into a sluggish heart beating image. Images thus, are obtained through direct mapping of ECG waveform.

## 4. References

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