Echo cardio graphic Signal Processing Using Wavelets

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Abstract. Various areas like image processing, data compression and time frequency spectral estimation where the Wavelet have been applied. This paper describes another application in the filed of echocardiographic signals from an ultrasound machine. There are two areas of signals from the ultrasound echos - the imaging and the Doppler signals from blood flow in the chambers. Wavelet functions are shown to characterize Ultrasound data in terms of oriented texture component better. It can decorrelate non-coherent speckle noise better in the frequency domain. To determine the velocities of blood particles, the Doppler shift signals, synchronously detected with the base Ultrasound frequency, and called the I and Q signals are obtained. Rather than using the present day technique of CFFT method, the use of Wavelet decomposition of the signals has been made, using standard orthogonal Mallet Wavelet series, for example. Due to the usefulness of the Wavelets in providing better time resolution, particularly adjacent to the opening and closing instants of heart valves, the spectrogram based on Wavelet coefficients was found to be able to give improved resolution of the profiles of the E & A waves as well as in the evaluation of the pressure half-time for assessment of stenosed heart valve's area.

Keywords: Doppler Signals, Myocardial infarction, Wavelet Transform, Ultrasound

1 Introduction

Today, the machines at the high end have scope for real time images. An entire cardiac volume of data may be acquired instantaneously for real-time transducer. No longer requirement for the volumetric reconstruction, as with rotational and freehand Ultrasound acquisition systems for such transducers[1]. Signal processing has long been in the field of waves in biomedical engineering. Bentley PM et al used a simple waveform investigation of the ECG to better bring the time course of the QRS complex [2]. ECG is not a signal generated by many entities because it is a synchronized action. So no more can be put in place for a plain ECG signal for diagnosis. Multi-resolution decomposition of the EEG is very useful for analyzing local pathological patterns. To assist in continuous patient monitoring, a special spike onset (sudden) is detected by spreading to another area. For a particular patient, if a set pattern of spike and wave is detected from its previous ECG records, a wavelet can be formed and used for automatic matching with data[3][4].

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2 Texture Analysis

For almost two decades in echocardiography texture analysis has been used and is based on alternations in composition caused by disease and myocardial tissue structure. The most obvious example of a coronary artery is chronic infiltration with occasional thin, highly echogenic muscle in patients. Documentation of visually less obvious changes can be done using visually less obvious changes, which can be documented using cyclic variation - scatter or its statistical analysis and noise measurement of intensity. Since for routine use, echocardiography clinical analysis are not robust so, these procedures are not common now in it. On transthoracic echocardiography, the acoustic properties of the tissue are greatly influenced by the tissue and s lungs interfering as a pathological process. These methods are also laborious and time consuming [5].
Compression and structure changes of the extracellular matrix by tissue characterization with the promise of determining infarct size and harmonic imaging when the lesion is weeks old. In this paper, for establishing the texture properties, wavelet based texture characterization for echocardiographic two dimensional images have been analyzed along with the relationship with the texture properties and the myocardial viability for accessing the infarcted echocardiograms. It is also possible to study the pathological changes after experimental texture measures for infarcted echo images.

2 Methodology - Data Acquisition

The two dimensional echocardiographic images are retrospectively analyzed by us, which was obtained out after infarction in the intervals of two days, seven days and twenty one days. The images were acquired, captured and recorded with the standard format, on a commercially existing imaging system. All recordings were made by 2 echo cardiographers; to optimize images visually, each was free in adjustment during the recording and to set the time-gain compensation. Depending on the infarcted location, the data acquisition for the diastolic images have been carried out with the apical 4- and 2-chamber views. The resolution of 512x512 pixel and 256-gray-level, the images were recorded in the videotapes. Five samples were used for each patient for the purpose of texture analysis for both infarcted and non-infarcted normal area of the myocardium as shown in figure 1. For a given patient, tissue samples have taken as tissue samples from the same section. For the purpose of the antarctic area, synergistic sections are considered in this work.

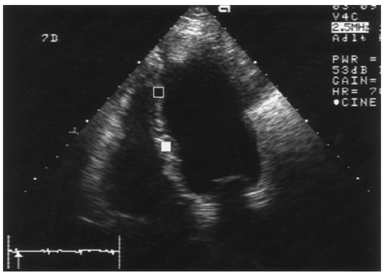

Fig 1. shows the acquired data for the apical 4-chamber view of the transthoracic Echocardiogram sample in use from usual and infarcted myocardium represented as white (normal) and black (infarcted) squares.

Before discharge, in all patients coronary angiography was performed. The assessment was done by using the Thrombolysis perfusion of the infarct-related artery in the Thrombolysis In Myocardial Infarction (TIMI).

3 Texture Analysis

The image decay along the filter banks obtained from the wave functions was done to calculate the given shape dimensions (Fig. 2). Mathematical analysis was performed from the vertical edge image for contour measurements with the selected energy field.A typical two dimensional wavelet decomposision block diagram of the filter bank is shown in figure 2.

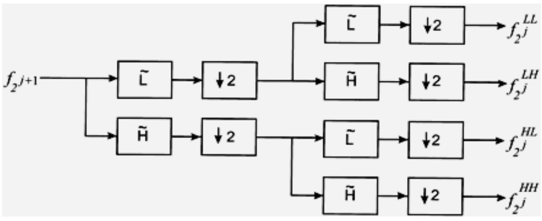

Fig 2. shows a typical two dimensional wavelet decomposision of the filter bank

Tissue samples were taken from five patients, for this area, unaffected by myocardial tissue sections and from myocardial infarcted infarcts for each patient analyzed using the Wavelet method. Power was calculated for each sample. For quantitative measurement of the inequality between 2 tissue groups (normal and infected tissue) using distance D according to eqn (1).

$$D=\sqrt{\frac{(\bar{x}_1-\bar{x}_2)^2}{(\frac{C_1}{n_1}+\frac{C_2}{n_2})}} \qquad (1)$$

Where,

$\bar{x}1$ and $\bar{x}2$ denotes the texture measure mean values for the tissue sample

n1 and n2 denotes the numbers of tissue samples taken.

C1 and C2 denotes the texture measure variances.

When there is a definite inequality in the analyzed models, variables $\bar{x}1$ and $\bar{x}2$ have significantly different distributions and have higher values in the distance between them. D represents a quantitative measure of the similarity between infarcted and normal tissue. Term

D signifies when tits cutoff value is automatically determined. For the infarcted myocardium D is classified as reperfused if it is ≤5.5 or non reperfused, its value would be >5.5. Successful prediction by the wavelet method and also on a follow-up study, a subsequent improvement in regional wall motion was noted in this work.

3 Results and discussions

Texture analysis and features of the inflamed myocardium and the paternity of the infarct-related arterial waves were demonstrated. Figures 3 and 4 describe the Wavelet method for non-recycled and reconstructed myocardial tissue, respectively.

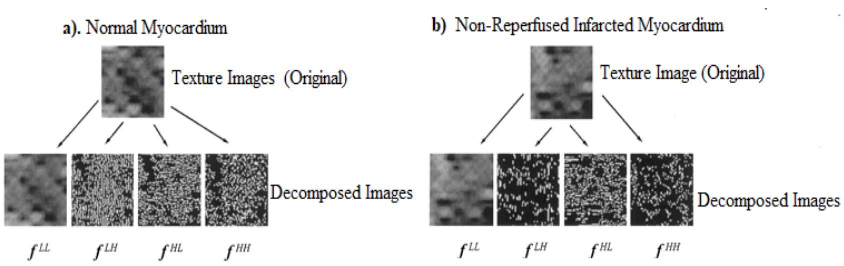

Figure 3 a) Shows the echocardiogram of a patient, wavelet decomposition of normal myocardium should be taken with an occluded infarct-related artery. **3 b)** Shows the echocardiogram of a patient, wavelet decomposition of infarcted myocardium should be taken with an occluded infarct-related artery.

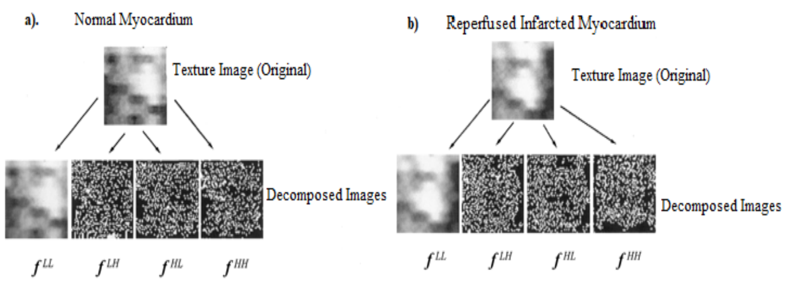

Fig 4. a) From the echocardiogram of a patient, wavelet decomposition of normal myocardium should be taken with an occluded infarct-related artery. b) From the

echocardiogram of a patient, wavelet decomposition of infarcted myocardium should be taken with an occluded infarct-related artery.

4. STUDIES ON DOPPLER SIGNALS WITH WAVELET TRANSFORMS

The other area of signals from the cardiac Ultrasound scanner is the Doppler effect of blood velocities in the chambers. To determine the velocities of blood particles, the Doppler shift signals, synchronously detected with the base Ultrasound frequency, and called the I and Q signals are obtained. Presently, the CFFT of this signal (I + jQ) is taken as a spectrogram plot in time, along with the e.c.g. signal. Methods of evaluating the blood flow jets and therefrom the heart valve pathology are presently done using semi-empirical calculations such as pressure half-time etc. Rather than using the CFFT, the use of Wavelet decomposition of the signals has been made, using standard orthogonal Wavelet series, for example. Due to the usefulness of the Wavelets in providing better time resolution, particularly adjacent to the opening and closing instants of heart valves, the spectrogram based on Wavelet coefficients was found to be able to give improved resolution of the profiles of the E & A waves as well as in the evaluation of the pressure half-time for assessment of stenosed heart valve's area. Fig.5 shows the I & Q signals of Doppler shift are taken form the Ultrasound machine for wavelet analysis.

For the purpose of differentially assessing the wavelet method for Doppler echo signals, around six patient data with mitral stenosis and regurgitation were obtained and processed. The spectrogram using CFFT was used for comparison (Fig.6). The wavelet spectrum as obtained from a MATLAB GUI program showed that essentially, the patterns were same; however, the wavelet pattern showed a clearer E and A wave, leading to a more precise estimation of the pressure half time as well as the valve area, as per Hatle's equation. Further, the better time resolution at the higher frequencies reduced the smear at the top end of the spectrograms. Additional work has to be preformed , of course, with more patients, to examine if the wavelet spectrum could decisively indicate a better assessment of valve function than by mere E/A ratio and Hatle's equation.

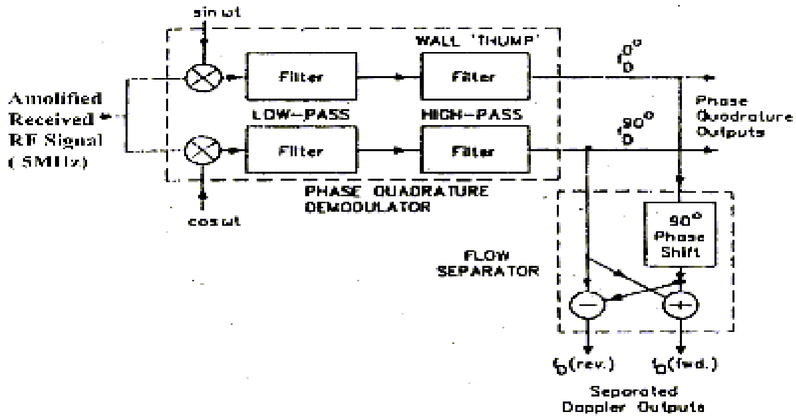

Fig.5. Showing Doppler Signal data acquisition

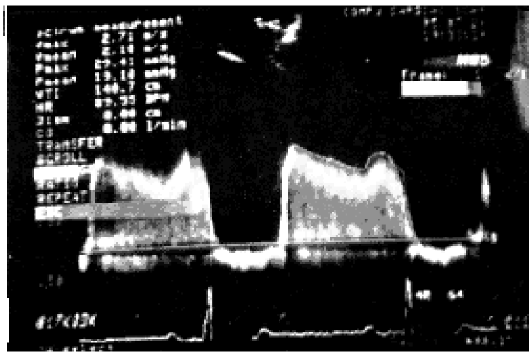

Fig 6. Showing the standard CFFT spectrogram for Doppler signal from a patient with stenosed mitral valve.

5. **Conclusions**

During the early post-myocardial period, a novel approach to the possibility of myocardial infarction represented by myocardial tissue characterization was studied, using the violet image decomposition method. This analysis of the waves on clinical and experimental data suggests that the Wavelet method may be useful in distinguishing between precise myocardial necrosis in the postoperative period with the potential to recover. In the case of Doppler resonance, the wavelet transition shows a good result in time-frequency resolution.

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