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Design Electronic Stethoscope for Cardiac Auscultation analyzed using Wavelet Decomposition

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ABSTRACT

Stethoscope become standard equipment used medical personnel to perform initial checks on patients. Stethoscope in general has a function for auscultation, which is listening to the sounds that occur in the body. The sound produced by the biological activity of the body's organs, like the heart, lungs and digestive system. The heart is one organ that plays a role in the circulatory system. Contraction of the heart that can cause pulsation felt in the arteries in some places. Instrument used for the detection of clinically sound heart is an acoustic stethoscope. Acoustic stethoscope has a weakness, depending on the hearing of each physician. Diagnosis of each physician may vary. Sensitivity of the ear of each doctor is different. Noise signals generated in the electronic stethoscope will be analyzed using Wavelet. In this research, recognition of heart sounds using a stethoscope sound signal based on wavelet decomposition. Heart sound signal is decomposed up to level 8 using Daubechies3 wavelet (db3). Energy of each subband is calculated spectogram. Analysis of cardiac auscultation signals with wavelet daubachies, system can calculate the value of heartrate with 78% for heart sound pattern of early and late systolic murmur, 63% Diastolic heart sound patterns Rumble and 85% for normal heart sound patterns.

Keywords: *Wavelet, Stetoschope, Heartrate.*

1 INTRODUCTION

The stethoscope is an instrument used to detect sound. One sound that can be detected is the sound associated with heart pumping activity. These voices claimed indications in heart rate and rhythm of the heart. These sounds are also useful to provide information about the effectiveness of the pumping activity of the heart and heart valves. Heart sounds are diagnostic correlated with the physical propert-ies of the heart itself. Until now, the instrument clinicaly used for detection of heart sounds is acoustic stethoscope. Acoustic stetho-scope has a weakness, depending on the hearing of each physician. Diagnosis of each physician may vary though slightly. This is due to the sensitivity of the ear of each doctor is different. Medical auscultation capabilities depend on the ability of hearing and sound clinical experience to analyze the organs in the body. Does not have a conventional stethoscope signal processing system, the acoustic signal generated organ sounds like it is because there is no signal amplification. This often led to some problems in analyzing the acoustic signal, among others, the difficulty in detecting the presence of some kind of noise and noise from outside which makes the sound auscultation difficult to detect.

Medical auscultation capabilities depend on the ability of hearing and sound clinical experience to analyze the organs in the body. This often led to some problems in analyzing the acoustic signal, among others, the difficulty in detecting the presence of some kind of noise and noise from outside which makes the sound auscultation difficult to detect. Since 1991, many researchers have shown that continuous wavelet analysis can provide an adequate representation of the primary heart sounds.calculation this approach is done based on digital one dimension signal processing using DWT.

2 AUSCULTATION

In medicine, the technique to hear sounds that occur in the body is called auscultation. In doing auscultation a common tool used is the stethoscope.

Auscultation is used to examine the cardiovascular system, respiratory system and gastrointestinal system.

During the movements performed by the heart muscle and blood flow that occurs in the heart, can be heard the sound kind of sound caused by closing the valves passively. In the normal heart sounds, there are two kinds of sounds are heard. The first sound is longer and second sounds is short and thus as "lup" and "dub".

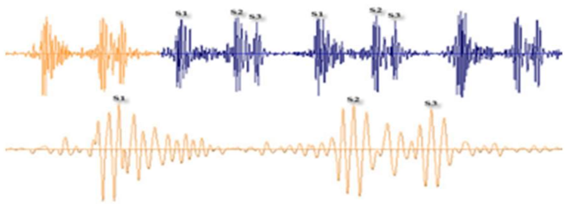

Fig. 1. Heart Sound Signal

The first heart sound also called S1 in medicine or "lups" caused atrio-ventricular valves shut mitral and tricuspid, at the beginning of ventricular contraction or systole. When the pressure in the ventricles exceeds the pressure rises to the atria, these valves close to prevent regurgitation of blood from the atria to ventricle. The second heart sound also called S2 or "dub" caused by pulmonary and aortic valves close it at the end of the contraction of the ventricles.

3 WAVELET

A wave is usually defined as an oscillatory function of time or space, for example, a sinusoidal wave. A wavelet is a short wave or small wave whose energy is concentrated in a time interval to provide transient analysis capabilities, non-stationer, or the phenomenon of time-varying. Wavelet can be used as a tool to perform mathematical decomposition of a signal into components of different frequencies, so that each component can be studied using the appropriate scale of resolution.

Therefore, the wavelet is known as a tool to perform analysis based on the scale.Short waves have the advantage when compared to Fourier style shift methods in analyzing non-stationary signals. A wave is normally defined as an oscillation function of time such as sinusoidal waves. Fourier analysis is a wave analysis where this analysis expands signals or function of a sinusoidal wave having a periodic phenomenon, not changing time (time invariant), and stationary. Continuous Wavelet Transform (CWT):

$$\gamma(s,\tau) = \int f(t)\psi^*_{s,\tau}(t)dt$$

Explanation:

$\gamma(s,\tau)$: Signal Function,

s : Scale

τ : (translation) as new dimension.

f(t) : Input Signal.

$\Psi^*_{S,T}(t)$: Basic Function Wavelet,

* : Complex Conjugate.

The continuous wavelet transform maps a one dimensional time signal to a two dimensional time scale joint representation. The time bandwidth product of the continuous wavelet transform output is the square of that of the signal the use of the discrete wavelet transform (DWT) can reduce the time bandwidth product of the wavelet transform output. Performing a wavelet transform consist of convolving the signal with time shifted and dilated. The result of wavelet transform will be a set of coefficients, which are function of time and scale.

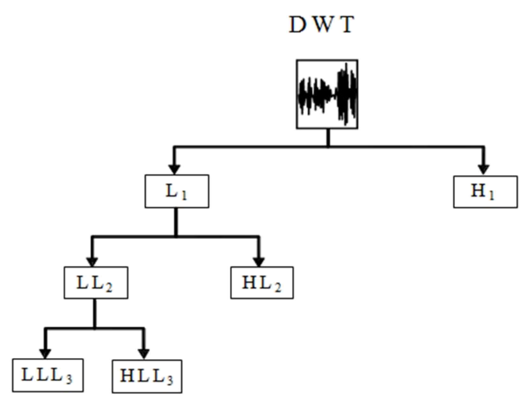

Fig. 2. Filter bank for wavelet decomposition

4 IMPROVED SECURE - DYNAMIC SOURCE ROUTING

4.1 Methodology

Heart Sound Signal received and serves to capture the sound of the heart in patients. Sounds arrested the head of the stethoscope is then converted into electrical signals by a microphone. The electrical signals become inputs for the hardware. A hardware signal processing circuit comprising amplifiers and filters for heart sound signals as well as power amplifier. This circuit functions to process the voice signal from the signal receiver so it can fit into a PC soundcard. On the PC there is a wavelet software that will process the signal from the soundcard to produce output on the monitor display wavelet analysis . Signal processing software includes heart rate filtering the signal using wavelet decomposition. The software also stores data recorded voice signals

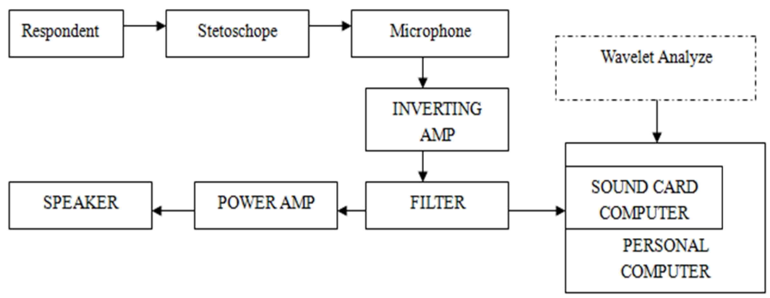

Fig. 3. Procedure of wavelet analysis for electronic stethoscope

Design electronic stetoschope uses input circuit with 100Hz frequency and 50 mVp-p amplitude. From this circuit we have 110mVp-p output.So we know that this design had an amplification 2,2. With Sallent-Key Butterworth Low Pass Filter. Testing is done by providing input sine signal with 200 MVP-p amplitude of the function generator.

4.2 Data Description

All data has been collected from respondent using digital stethoscopes built at electronic laboratory health polythenic surabaya. The heart sound data using a 4096 Hz sampling frequency. Representation of heart sounds subjects. For analysis we use spectrogram. Spectrogram is used since long time for one dimension signal recognition. Spectrogram is a time-varying spectral representation that plots the variation of spectral density with respect to time. Spectrogram is a two dimensional graph, where horizontal axis represents time and vertical axis represents frequency. A third dimension indicating amplitude of a particular frequency is represented by the intensity or color of each point in the image. For analog one dimension signal processing, approximation as a filter bank that results from a series of band pass filters and calculation from the time signal using the Short Time Fourier Transform (STFT) are adopted for spectrogram analysis.

5 RESULT ANALYSIS

To verify the applicability of the electronic stetoschope, The heart signals were normalized in energy into different amplification. We determine the wavelet decomposition in daubechies3 coefficients (dB3) at level 8. The frequency band is divided into equal interval of length 32 Hz. Each level covers 32 Hz for a frequency band. For example the 1st level cover the frequency range 0 to 32 Hz, the second level covers the frequency range 32 to 64 Hz and so on.

5.1 Normal Heart Sounds

Normal heart sounds with a stethoscope contained the original signal from the noise after the db3 wavelet analysis, details the importance of the level 4 heart sound signals S1 and S2 are clearly visible and without any other additional signals.

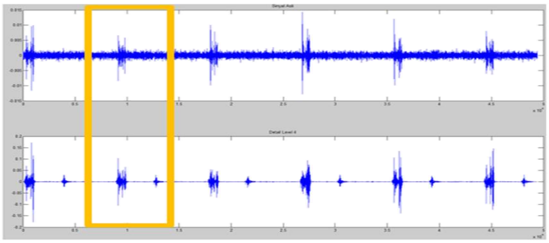

Fig. 4. Details Normal Heart Sounds

Wavelet decomposition in the normal heart signals on a scale to 64 also showed the absence of the spectrum other than voice signals S1 and S2.

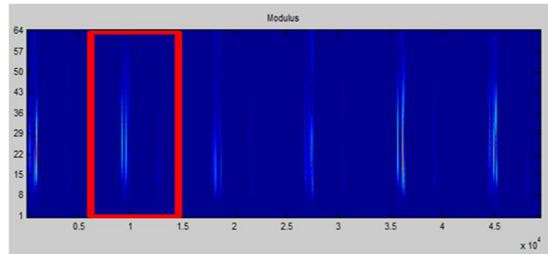

Fig. 5. Wavelet Decomposition Normal Heart Sounds

Table 1: Mean Normal Heart Sounds

Stetoschope	H.R	X1	X2	X3	X4	X5	Mean	Error %	StDev	Ua
NST	92	85	101	98	89	91	92,8	-0,8696	6,573	2,93
Software	92	77	82	72	98	94	84,6	8,84	11,08	4,95

5.2 Early Systolic Murmur Sounds

Abnormal heart sounds that early systolic murmur with a stethoscope original signal from the noise is still there. Shape of the signal and the noise signal is still not able to show any abnormalities. After the db3 wavelet analysis, details the importance of the level 4 heart sound signals S1 and S2 are clearly visible. This signal is different from normal heart signals because the sound signal S1 there are two signals that arise.

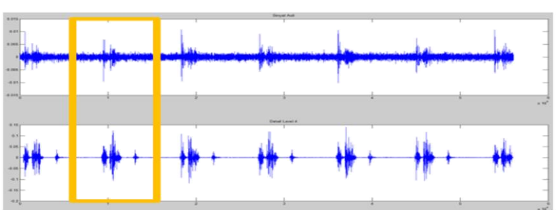

Fig. 6. Details Early Systolic Murmur Sounds

Wavelet decomposition to signal early systolic heart murmur on a scale to 64 showed a wide spectrum of other on the S1, in addition to voice signals S1 and S2.

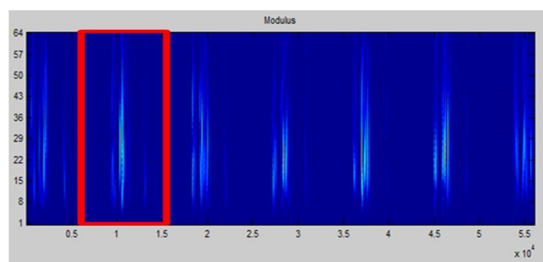

Fig. 7. Wavelet Decomposition Early Systolic Murmur Sounds

Table 2: Mean Early Systolic Murmur Sounds

Stetoschope	H.R	X1	X2	X3	X4	X5	Mean	Error %	StDev	Ua
NST	77	77	78	80	77	74	77,2	0,1	2,168	0,97
Software	77	111	101	121	108	143	116,8	-51,3	16,32	7,3

5.3 Late Systolic Murmur Sounds

Abnormal heart sounds late systolic murmur with a stethoscope original signal from the noise is still there. Shape of the signal and the noise signal is still not able to show any abnormalities. After the db3 wavelet analysis, details the importance of the level 4 heart sound signals S1 and S2 are clearly visible. This signal is different from normal heart signals because the voice signal S2, there are two signals that arise.

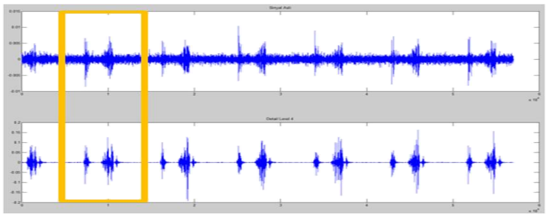

Fig. 8. Details Late Systolic Murmur Sounds

Wavelet decomposition at the heart of late systolic murmurs signal on a scale to 64 showed a wide spectrum of other voices besides signals S1 and S2. Broad signals at S2.

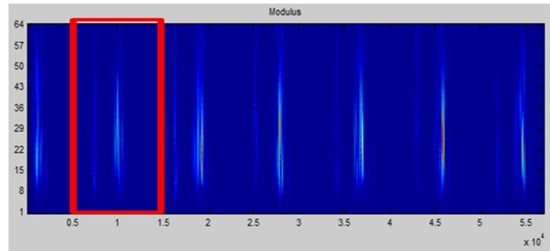

Fig. 9. Wavelet Decomposition Late Systolic Murmur Sounds

Table 3: Mean Late Systolic Murmur Sounds

Stetoschope	H.R	X1	X2	X3	X4	X5	Mean	Error %	StDev	Ua
NST	88	74	70	118	105	73	88	0	21,99	9,8
Software	88	70	57	73	64	69	66,6	24,318	6,269	2,8

5.4 Diastolic Rumble Sounds

Heart sounds abnormal diastolic rumble with the original signal from the stethoscope still be noise. Shape of the signal and the noise signal is still not able to show any abnormalities. After the db3 wavelet analysis, details the importance of the level 4 heart sound signal. Mixing sound signals occurs not only signals S1 and S2, but there is an additional signal that was clearly visible that there are 3 periods in a heart sound signal.

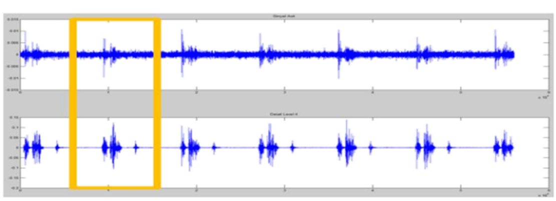

Fig. 10. Details Diastolic Rumble Sounds

Wavelet decomposition CWT on Diastolic heart signal Rumble on a scale up to 64 shows another spectrum appears there are 3 signals.

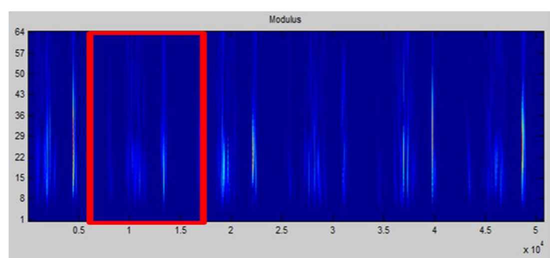

Fig. 11. Wavelet Decomposition Diastolic Rumble Sounds

Table 4: Mean Diastolic Rumble Sounds

Stetoschope	H.R	X1	X2	X3	X4	X5	Mean	Error %	StDev	Ua
NST	98	115	100	101	76	98	98	0	14,02	6,26
Software	98	63	70	96	78	82	77,8	20,612	12,54	5,6

6 CONCLUSION

After the design of electronic sthetoscope, literature study, planning, experimentation, testing and data collection tools, the authors can conclude that Heart auscultation can be analyze by using wavelet decomposition. From the analysis of the data, system can calculate the value of heartrate with 78% for heart sound pattern of early and late systolic murmur, 63% Diastolic heart sound patterns Rumble and 85% for normal heart sound patterns with the number of data is limited and more is needed to validate the proposed criteria. In a Diastolic signal Rumble, with random sound pattern. Heart sound in one and two are not visible because the phase of the cardiac cycle cannot be known with certainty.

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