

Respiratory Sound Identification using Wavelet Multiresolution Analysis

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ABSTRACT: The Respiration sound analysis is important identification method for respiratory diseases. The respiration sound analysis using stethoscope is not reliable method as it is depends on human perception. Thus computerized respiratory sound analysis is more preferable. In this project automatic analysis of respiratory sound is performing by acquiring data using electret condenser microphone placing at the upper respiratory tract. And analysis and identification of the sound is performed in Lab VIEW software using wavelet transform and MRA method.

KEYWORDS: Respiration sound, Signal processing, wavelet transform, MRA, spectrum analysis.

I. INTRODUCTION

Respiratory sound is generated due to movement of air through the respiratory tract. Respiratory sound gives information about the respiratory diseases like asthma, pneumonia etc. So analysis of respiration sound gives us the information about the human health conditions. Every respiratory sound has different characteristics and each sound represents the different respiration condition. The Respiration sound is mainly classified into Normal and Abnormal Sound. Normal sounds are vesicular, bronchial and broncho vesicular etc and abnormal sounds are stridor, wheezing ronchi etc. The characteristics of respiration sounds are as mentioned below:

Name	Continues /Discontinuous	Inspiraory/ Expiratory	Duration (ms)/Frequency (Hz)	Associated conditions
Wheezes	Continuous	Inspiratory or Expiratory	Inspiratory or Expiratory	Asthma
Crackles	Discontinuous	Inspiratory	<20 ms 100 to 200 Hz	Pneumonia, congestive heart failure etc..
Stridor	Continuous	Inspiratory	Low frequency wheezes	Epiglottis etc.
Ronchi	Continuous	Expiratory	>100 ms <300Hz	Bronchitis

Table.1 Characteristics of Respiration Sound

Acquisition of sound using microphone and computerize analysis of acquired sound is called electronic auscultation. In recent years there are changing in perception of analog to digital signal processing graphical analysis of respiratory is more accurate and reliable.

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II. STUDY OF EXISTING METHOD

Respiration sound analysis is mainly divided in to three parts:

a) Acquisition of Respiratory sound

Respiration sound heard at the different parts of the respiratory tract. Respiration sound acquire from the different places of the respiratory tract such as from nose, trachea and also from the chest. Frequency range is shows that the nasal breathing sound frequency is lies between 50-3000Hz. Lungs sound frequency is lies between 100-1200 Hz. And trachea or upper respiratory tract frequency of sound is lies below 1500 Hz. [3] Acquisition of respiration sound is performed using various sensors such as Electret condenser microphone, piezoelectric sensor and accelerometer [7]. Electret condenser microphone senses the vibrations and converts that in to the electrical signal for the further analysis. For respiration sound acquisition range of the sensor is lies between 50-2000Hz. This type of sensor acquire respiratory sensor. Piezoelectric sensor also used for the acquisition of the respiration sound. Piezoelectric sensor converts the one energy form to another energy form. Here the piezoelectric sensor is senses the vibration of the sound from the body and convert it in to the electrical form.

b) Signal Pre-processing

In Respiration sound signal pre-processing butter worth filter is mainly used over the frequency range 100 to 1500 Hz. [1] Due to the filtering of the signal noise such as heart sound interference and external sound is removed from the signal. After filtering the signal is sampled at the 6000-8000 samples per second for analysis of signal. Sampled signal is then converted to the frames for the further analysis. [1][2][3] Once the signal pre-processing is completed signal analysis method is implemented.

c) Signal Analysis Methods

There are various methods for respiration sound analysis has proposed. Among those few methods are as mentioned below:

Fourier spectra is computed on the signal for the analysis of the signal on the frequency range of 100-1300Hz. Spectrogram analysis gives the information about the frequency range of the various respiration sound. In Fast Fourier transform analysis it gives information about the various sound frequency. So using frequency of particular sound identification is possible.[1][2] Short time Fourier transform performed on the signal on the respiration frequency range it gives the information about frequency as well as time duration of the signal. In this method short time is consider for the analysis and it gives the information of frequency with correlation of the short time period over the signal. The cepstrum is technique for finding echo arrival times in a composite signal.[4]Cepstrum is similar methodology as Inverse Fourier Transform. In cepstrum analysis the number of sound sources and time interval of sound sources is accurately calculated. Cepstrum shows a peak when the lung sound contains other sound sources. Cepstrum analysis capture multi-source signal characteristics amount of dieses sources and sound source interval. Cepstrum gives time base spectral analysis of sound and sound sources for identification of respiratory sound various respiratory sounds is identified using Cepstrum analysis.[4]

III. PROPOSED METHODOLOGY

In this paper signal is analyzed from the Wavelet Multiresolution Analysis. For signal identification first requirement is to acquire or recording of the signal. In this methodology acquisition of signal is performed using Microphone sensor ABM-707 of frequency range of 50-16000 Hz. Sensor is attached with the audio-pin for the recording of sound in mobile phone in .wav format which is compatible with the Lab-VIEW software. After that recorded sound files are transferred in to the system for the software base analysis of signal.

A recorded Audio sound file contains noise like environmental noise, swallowing noise, heart sound interference noise etc. For removing sound and for smooth signal processing Band pass filtering over frequency range of 100-1300 Hz and wavelet de-noising is performed on the signal.

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For signal analysis first applying wavelet transform on the signal and Multiresolution Analysis is performed on the various frequency bands such as A3, D1, and D3 for analysis of various respiratory sounds. In MRA method signal is reconstructed as per the frequency band characteristics. Each frequency band reconstructs the signal for particular frequency band. As per the proposed methodology and requirement of the signal analysis three frequency bands are required for the identification of signal. Each recorded signal is passes through the three frequency bands and reconstructed signal represents sound characteristics. Then spectrogram analysis gives information about time and frequency of the signal and identification of sound is performed. For accurate analysis of signal statistical analysis is also performed and compares the results for more than 10 signals.

Multiresolution Analysis

The multiresolution analysis (MRA) is a mathematical construction that characterizes wavelets in a general way. The goal of MRA is to express an arbitrary function $f \in L^2(\mathbb{R})$ at various levels of detail that implies a decomposition of this function in each subspace. Multiresolution will be described first for subspaces V_j and W_j .

V_j = scaling space represent large scale feature , W_j = wavelet space represent small scale feature

For every wavelet Ψ we can consider the following space V_j

$$V_j = \dots + W_{j-2} + W_{j-1}$$

The wavelet space W_j is the difference between V_j and V_{j+1} . The sum of V_j and W_j is V_{j+1} .

Each wavelet is located at a different position on the time axis and its local in the sense that it decays to zero when's is sufficiently far from its center. Any particular local feature of a signal can be identified from the scale and position of the wavelets into which it is decomposed.

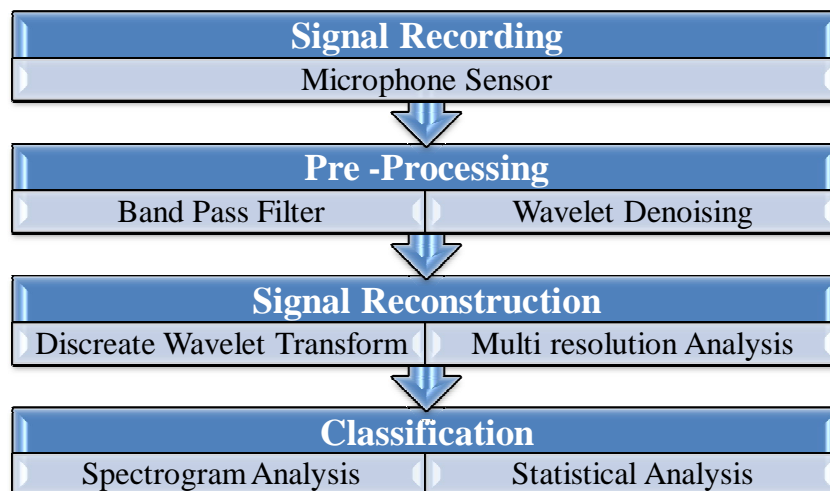


Fig.1 Proposed Method

IV. RESULTS AND DISCUSSION

Respiratory sound recorded from the trachea at the upper respiratory tract and recorded in the mobile phone using the device which is shown in Fig.2. Signal recording is performed using digital stethoscope which is the manipulation of the original stethoscope using the microphone sensor attached at the end of the hollow pipe and microphone sensor is connected to the audio-jack pin. This hardware directly connects the stethoscope with mobile phone for the recording of the respiratory sound from the patient body surface. Microphone sensor which is used for this hardware is electret condenser microphone in that two capacitor plates are fixed for the sensing purpose. Electret condenser microphone senses the air vibration and converts it in to the electrical voltage form. Using the modified stethoscope with audio-jack signal is recorded in the mobile phone for the storage and for the further analysis of signal. Signal is recording in the .Wav format in the mobile phone because .Wav format is the waveform format of signal which is compatible to the Lab-VIEW software. Recorded signal then transmitted to the system for further analysis and pre-processing.

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Fig.2 Acquisition system

Recorded signal transferred to the system for the software analysis. In the Lab-VIEW software where the VI created for the signal analysis. Fig.3 shows the VI for the sound analysis of the wheezing signal. First image in VI shows the original recorded signal with the noise. Second image gives information about where the noise is present in the signal. Red colour represent noise and blue colour represent Filtered signal. After that Wavelet and MRA is performed on the signal and third image represent rejected signal and fourth image represent the reconstructed signal in the VI. Fifth image shows the frequency spectrum of the signal and sixth image shows the time frequency spectrogram for the signal.

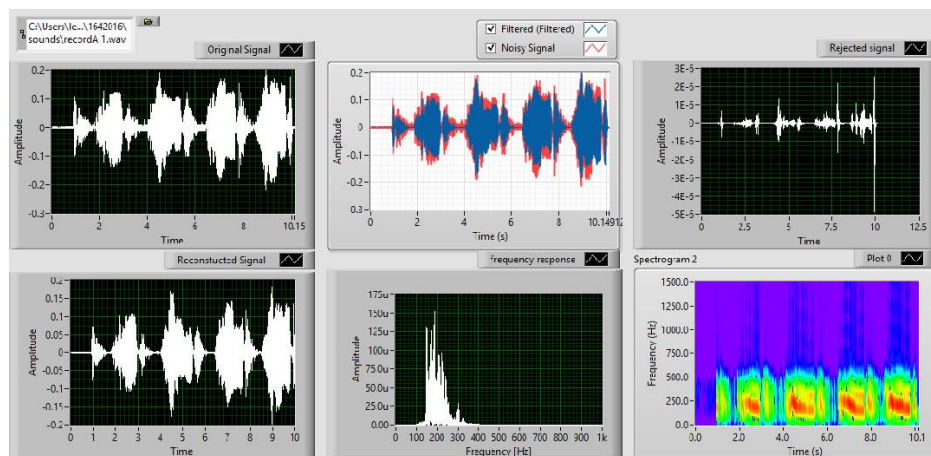


Fig.3 wheezing sound Analysis

For various respiratory sound different frequencies spectrum and different time frequency spectrograms obtained from the above algorithm. And from frequency spectrum and time frequency spectrogram sound is identify accurately. Each sound gives particular time frequency spectrogram and frequency response for identification of sound. Fig.4 shows the analysis vi for the crackles sound. Crackles sound has discontinues property in nature each figure in below VI image shows the frequency information or also the time frequency analysis of signal.

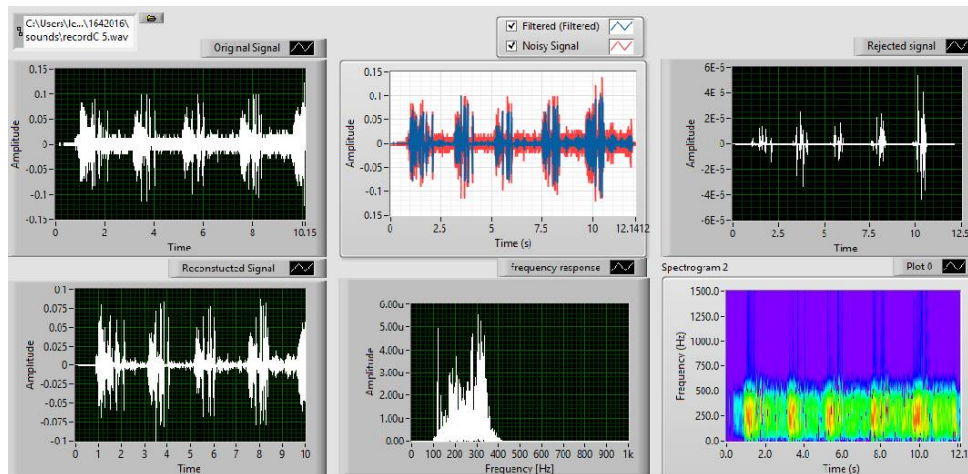


Fig.4 Crackles sound Analysis

For accurate diagnoses of sound algorithm is performed on the more than 43 patients and then the particular characteristics of each sound is determined. From the above algorithm 86% of signals types are identified. When patients condition is very critical they cannot breath properly that time recording of signal and identification of sound is much more complicated that time the sound are not identified properly. Table 2 shows the results after statistical analysis:

Number	Sound	Number of patient	Number of signal Identified
1	Wheezes	12	9
2	Crackles	10	8
3	Stridor	10	9
4	Ronchi	13	11

Table.2 Statistical Analysis

V. FUTURE SCOPE

Respiratory Sound identification using Wavelet multiresolution analysis gives accurate identification of sound. In future there will be need for the real time identification of respiratory sound is much more effective then the recorded signal. Also the accurate analysis of the overlapping frequency which created confusion for sound identification. And develop the algorithm for identify more sounds like cough sound, interrupted breathing sound etc. This provides us detail of every characteristics of the respiration sound. Thus, it leads towards the scope of work in terms of developing reliable sound acquisition system and develop an algorithm which provides time-frequency analysis and as well amplitude and duration of every sound which improves the accuracy and reliability.

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