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Analysis of Lung Diseases and Detecting Deformities in Human Lung by Classifying Lung Sounds

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Abstract— To analyze lung sound by auscultation method requires substantial clinical experience, a fine stethoscope and good listening skills. The lung itself cannot generate sound if there is no airflow; pressure differences between structures within the thorax. The type of lung sound can be known by listening to the lung sound. The timing, repeatability and shape of crackles are important parameter for diagnosis. In this paper, we aim to detect and classify crackle to find deformities in lungs.

Index Terms—Coarse Crackle, Fine Crackle, Wheeze, Lung Sounds, Vesicular breath sound

1. INTRODUCTION

There are different techniques for lung sound analysis and diagnosis of disease. Lung sound signal is the random physiological signal that occurs during the ventilation process of the human respiratory system with the external environment. Different sounds are present like tracheal breath sounds, vesicular breath sounds, inspiratory and expiratory stridor and stridor[2]. Research broadens the diagnosis purposes to various diseases possibly infects all respiratory sub-systems, specifically the lung organ. A strong database is required to compare the recorded breath sound for processing and separating sounds into lung sound and upper-respiratory sound and to find the disease of the infected patient.

To detect and extract sound different techniques like Auscultation, Bronchoscopy, chest CT or chest scan [1] are present. But due to variation in frequencies it is very important to develop tool which will work with dynamic frequency. Traditionally, Spectrogram (SP) analyses normal and abnormal lung sounds but deals with only non-stationary signals. To diagnosis lung disease effective acquisition, signal processing, and quantitative analysis have particular significance.

2. LITERATURE REVIEW

Murphy *et al.* in 1977,[10] implemented an adventitious sound analysis through the time expanded waveform analysis (TEWA). In TEWA crackles displayed a short and more complex waveform than a sinusoidal sound. Later, Hoevers and Loudon described crackles by time-domain parameters such as the initial deflection width deflection width (IDW), the two cycles duration (2CD) and the largest initial deflection (LDW).

One of researcher proposes the time-frequency representation Hilbert-Huang (HHS) spectrum [17] as an appropriate analysis tool for fine and coarse crackles. HHS is selected after it has been demonstrated in a companion paper that for a signal with similar characteristics in time frequency.

Irina Hossain et al. [19] study the heart-noise reduction technique using wavelet transform which decompose frequency into different components and it is applied to different filters. Results show wavelet transform based filtering reduces the lung sound average power greatly over the whole frequency range.

Tiago H. Falk *et al*. [20] design a modulation filter to improve the separation of heart and lung sounds from breath sound recordings. Le Belvedere *et al*. use adaptive wavelets for lung sounds analysis and successfully detect pathological changes of the lung.

Benjin Wang *et al*. [2] multi-source estimation in the lung sound based on cepstrum. They study the relationship between the lung multi-source vibration and the delay time. From the perspective of digital signal processing, the cepstrum analyzes. Lung sound signal has a variety of superimposed components. Different compositions have their own particular time cycles. At the same time, normal and abnormal lung sounds show appropriate changes in frequency spectrum, time-domain waveform, the signal cycle, and the delay time. The number of multiple sound sources and the time delay contain rich case information, and reflect the physical characteristics of lung diseases. The method of cepstrum analysis in the application of typical lung sound source signal focuses on the relationship between the number of lung source and time delay of multi-source[2].

In the year 1967 Forgacs [18] gives quantitative analysis of crackles. Analysis based on intensity and spectral content of frequency domain signal. There are different techniques used for measurement of lung sound. A stethoscope is used to listen lung sounds directly in Auscultation. To check and view the airway bronchoscope equipment is used in Bronchoscopy. Chest CT scan uses an imaging method that uses x-rays to create cross-sectional pictures of chest/upper abdomen. Routine sputum culture: a test of secretions from the lungs and bronchi tubes that carry air to the lung to look for organisms that cause infection. The advantages and disadvantages of different methods are tabulated below

Table I: ADVANTAGES AND DISADVANTAGES OF LUNG DIAGNOSIS METHOD[1]

Sr no	Method	Advantages	Disadvantages
1	Auscultation	Simple yet long-life and proven method	Requires direct contact with the patients, Depends on the listening skill and judgments of the doctors
2	Bronchoscopy	Sight observation directly to the internal patient body, therefore any infection can be seen	Requires direct contact with the patients, Insertion of bronchoscope equipment into patients airways could cause discomfort
3	Chest CT scan	Accurate diagnosis by sight observation of lung and overall respiratory system	Requires high cost investment.
4	Chest x ray	Accurate diagnosis by sight observation of lungs	Requires high cost investment, and special laboratory to keep the equipment
5	Routine sputum culture	Quite fast and affordable diagnosis method requires only 2-3 days diagnosis time.	This diagnosis requires specific test in a laboratory and requires patient’s sputum transportation to the nearest hospital.

There are some drawbacks by utilizing these methods only. Auscultation which has been recognized as the most common and proven first-hand method, requires direct contact with the patients and cannot be applied when patients are remote from paramedics/doctors/hospitals. The examination also depends heavily on the listening skill and judgments of the doctors alone, therefore bias could exist. Bronchoscopy also requires direct contact with the patient and insertion of bronchoscope equipment into the airways through the nose or mouth could cause discomfort, and usually this is for an advanced diagnosis. Chest CT scan is equipment which can give accurate diagnosis, however this equipment requires high cost investment. Chest X-ray although more common equipment, is also high cost in investment, and requires special laboratory.

Lung sound detection is very important because various diseases possibly infect all respiratory sub-systems, specifically the lung organ. Many researchers propose different techniques to analyse lung sound.

PROPOSED WORK

To detect the deformities in human lungs suffering from various diseases using crackle sounds and to be able to diagnose them.

3. PROPOSED METHOD ON LUNG SOUND ANALYSIS

The proposed method i.e. short time Fourier transforms for lung sound analysis is based on spectrogram analysis of lung sound recordings. The analysis is based on Short Time Fourier Transform.

Short Time Fourier Transform:

Computes the signal energy distribution in the joint time frequency domain.

Algorithm:

• To compute STFT Spectrogram {X}, first computes the STFT of X. To compute the STFT of X, a sliding window is used to divide the signal into several blocks of data.

• Then an N point's fast Fourier transform is applied to each block of data to obtain the frequency contents of each block of data, where N is frequency.
• The STFT aligns the centre of the first sliding window with the first sample of the signal X and extends the beginning of the signal by adding zeros.
• The sliding window moves time steps samples to the next block of data. If the window moves out of X, this VI pads X with zeros.

4. PROPOSED BLOCK DIAGRAM

Proposed system will contain following blocks. In the proposed method, the frequency spectrums of the lung sound signal are analyzed by Short Time Fourier Transforms for lung sound analysis. A lung sound recording was not divided into the frequency bands; instead the frequency peaks were detected for analysis. The minimum duration of crackle in the proposed method is taken as 250 msec. This criterion makes the proposed method more accurate and robust for identifying lung sounds.

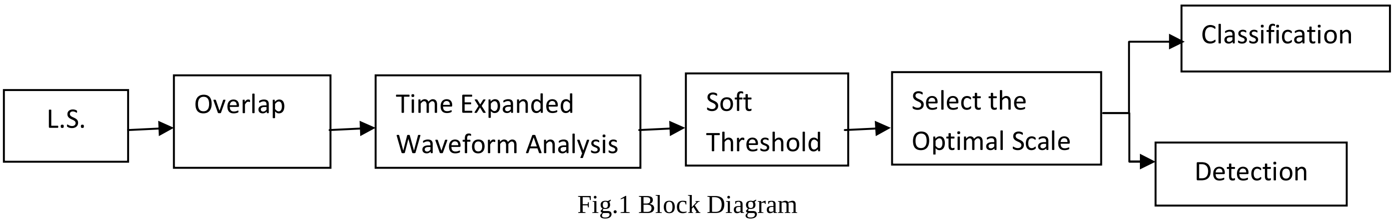

Fig.1 Block Diagram

5. EXPERIMENTAL RESULTS BY PROPOSED METHOD

The result of the proposed algorithm for lung sound analysis is shown in fig. 2-5. It gives idea of the amplitude values of crackle lung sound with respect to normal lung sound. The crackle sounds are repetitive, high pitch as seen in fig.2 & 3 and are mostly associated with obstructive airway diseases like pulmonary fibrosis, pulmonary edema and intestinal lung diseases like asthma, asbestosis etc. Wheezes are mostly associated with acute asthma, chronic emphysema, pneumonia etc.

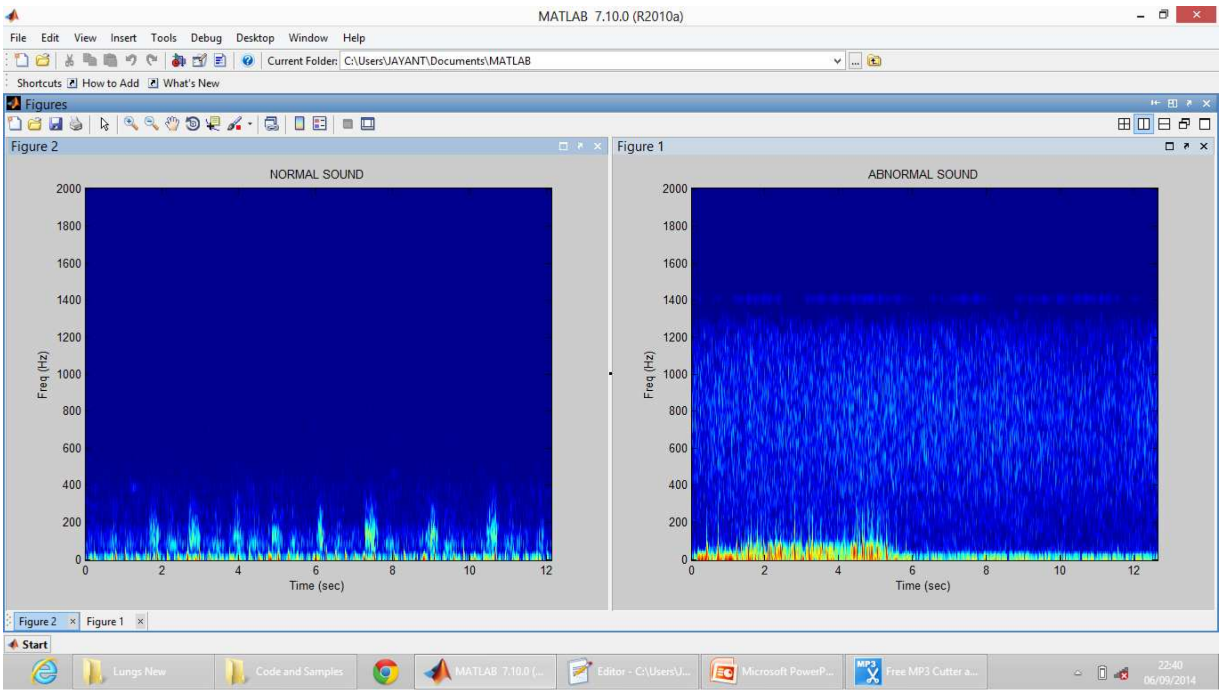

Fig. 2 Comparison of Normal Lung Sounds with Coarse Crackles

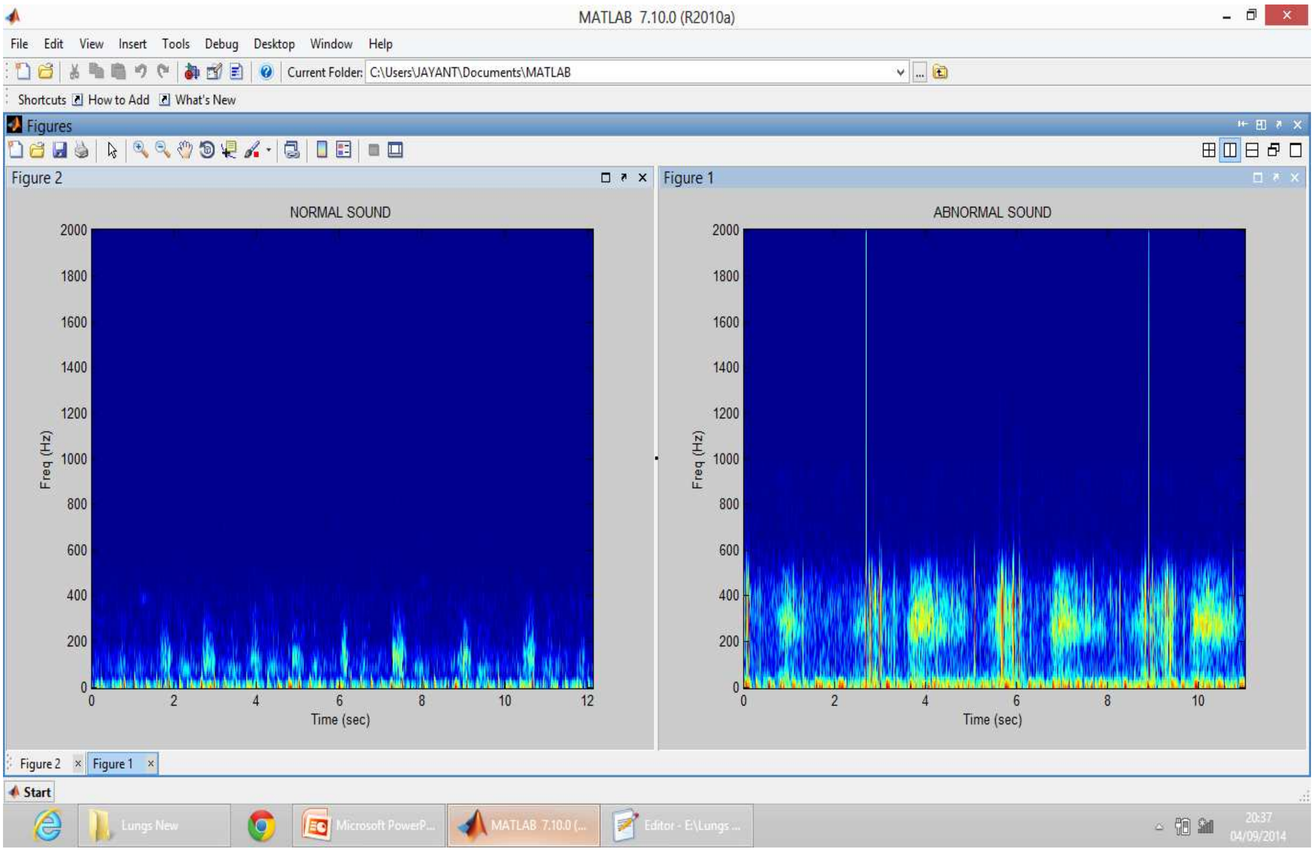

Fig. 3 Comparison of Normal Lung Sounds with fine Crackles

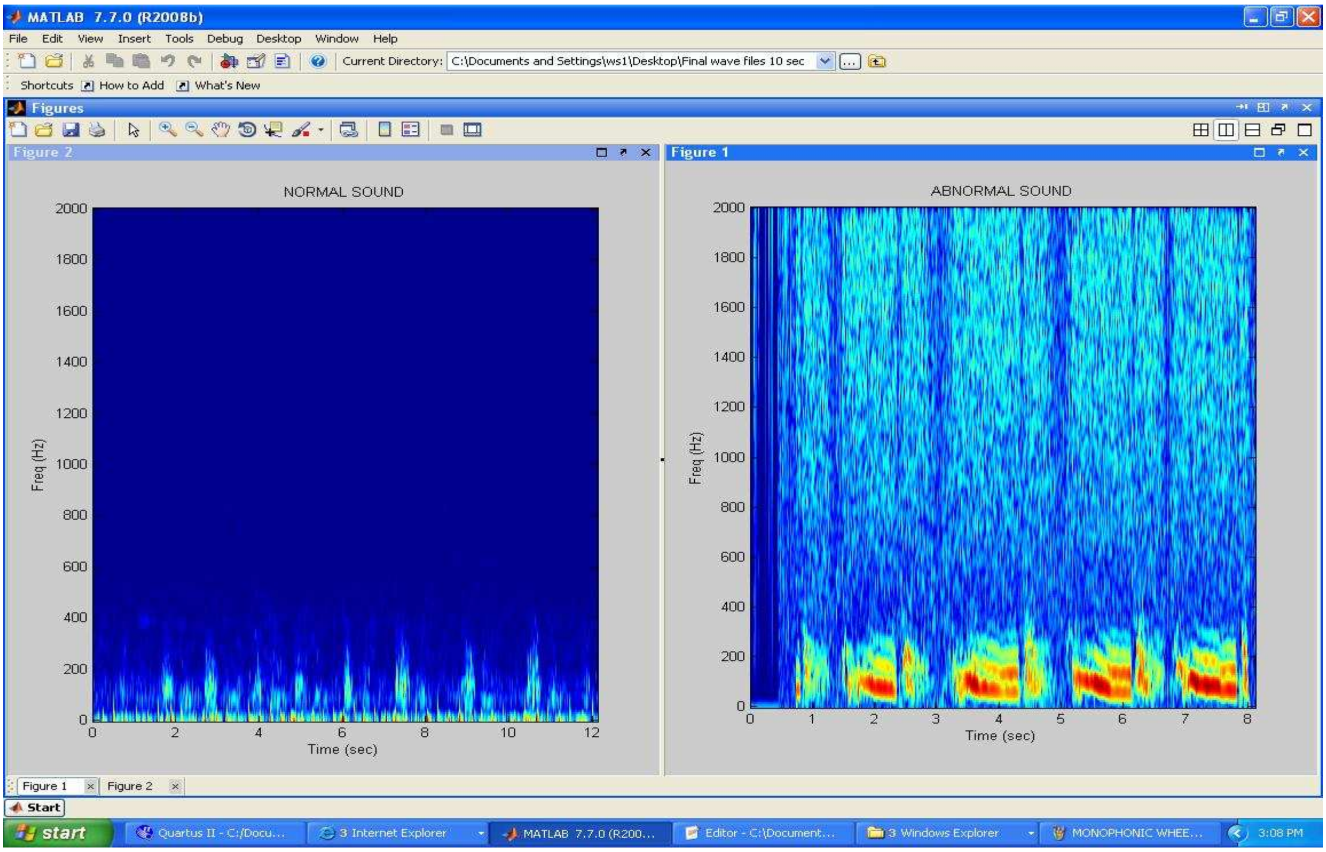

Fig. 4. Spectogram of Normal Lung Sounds & Lung sound with Polyphonic Wheeze

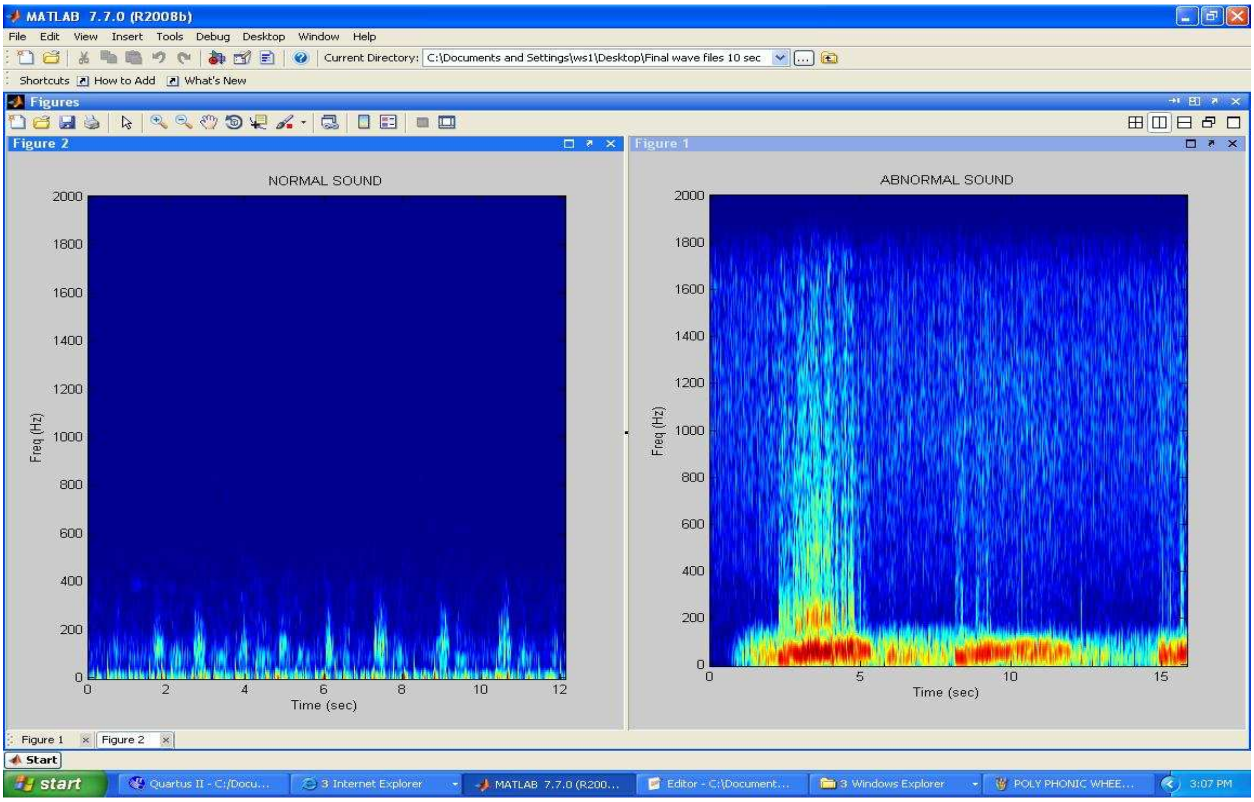

Fig. 5. Spectogram of Normal Lung Sounds & Lung sound with Polyphonic Wheeze

6. CONCLUSION

There is a large variety of normal and abnormal respiratory sounds with their typical characteristics for a disease or for a certain pathological change in the respiratory system. Such deformities can be detected with our proposed method which has the ability to analyze and improve the knowledge of the physiology and pathophysiology of respiratory disorders that can be used in clinical assessment. In our work we concentrated on crackles only instead of using different sounds. Future work includes expanding the type of lung sounds and increasing number of samples.

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