Feature Extraction of Lung Sounds Using Daubechies Wavelet

[1]Hupendra Devangan,[2]Nitin Jain,[3]Ajay Roy
[1]M-Tech. Scholar, [2]Associate Professor, [3]Assistant professor
[1]Department of ET&T,
[1]Chouksey Engineering College, Bilaspur , India

***Abstract* - Diagnosis of lung sound using the stethoscope has the many limitation. It depends on the experience and skill of the medical practitioners. Lung sound classification has two parts, first is the feature extraction and second is the classifier used for the classification. Here a biomedical based system is proposed for the feature extraction of lung sound which is done using daubechies wavelet (db10). The features which have been extracted are energy, entropy, standard deviation and variance of the normal lung sound (e.g. vesicular.) and adventitious lung sounds (e.g. crackles and wheezes) and a comparative study has been given between the various features of lung sounds.**

***Index Terms* - Auscultation, Adventitious Lung Sound, Wheeze, Crackles, Vesicular, Entropy, Energy, Variance, Standard Deviation, Daubechies Wavelet, Discrete Wavelet Transform.**

I. INTRODUCTION

The diagnosis of chest diseases is facilitated by pulmonary auscultation using a stethoscope. Auscultation with a stethoscope has many limitations. It is a subjective process that depends on the individual's own hearing, experience and ability to differentiate between different sound patterns [1]. Pulmonary disease is a major cause of ill-health throughout the world. Lungs are the vital component of pulmonary system. There are various reasons which affect the proper functioning of human lungs. For the classification of lung sound, various processes are involved and then, to identify the normal and adventitious lung sound classifiers are needed. During inhalation and exhalation, certain lung sounds can be heard. Lung sounds are described as sounds that are generated by the movement of air as it travels through the bronchial tree. The fluctuations, vortexes shedding and oscillations of tissue allow one to hear the respiratory action, and are used by medical practitioners to assess respiratory health during auscultation. Thus, lung sounds can be classified in terms of sound measurements such as frequency and amplitude. When pulmonary diseases affect the shape and performance of lungs, differences in the respiratory sounds are often observed [2]. There are two types of lung sound normal lung (e.g. vesicular) sound and adventitious lung sound (e.g. Wheezes, Crackles etc.). The abnormal sounds that are caused by anomalies in the lungs and bronchial tubes are termed adventitious sounds [3]. The crackles is a cause of different diseases like Alveolitis, Atelectasis, Pneumonia, Asbestosis, Chronic Bronchitis, Bronchiectasis, Congestive heart failure and wheezes a cause of obstructive lung diseases (e.g. Asthma), Cyctic Fibrosis etc. [4]. There are basically two phases in the lung sound classification first one is the feature extraction and second one is the classification with the help of the various classifiers. This paper deals with the feature extraction process using the DWT. In the proposed work daubechies wavelet (db 10) is used. Using this features like energy, entropy, variance, standard deviation is found and a comparatively study has been done between the features of vesicular, crackles and wheezes.

II. METHODOLOGY

1. INPUT LUNG SOUNDS

There are basically two types of lung sounds normal lung sound and adventitious lung sound. An adventitious lung sound further divided in two parts i.e. crackles and wheeze.

A. NORMAL LUNG SOUND (VESICULAR)

Normal breath sounds have acoustically a soft character. The inspiratory phase is longer than the expiratory phase, with a ratio inspiration / expiration of about 2/1 during tidal breathing. Expiration is nearly silent [5]. Normal breath sound detected over the chest wall [6].

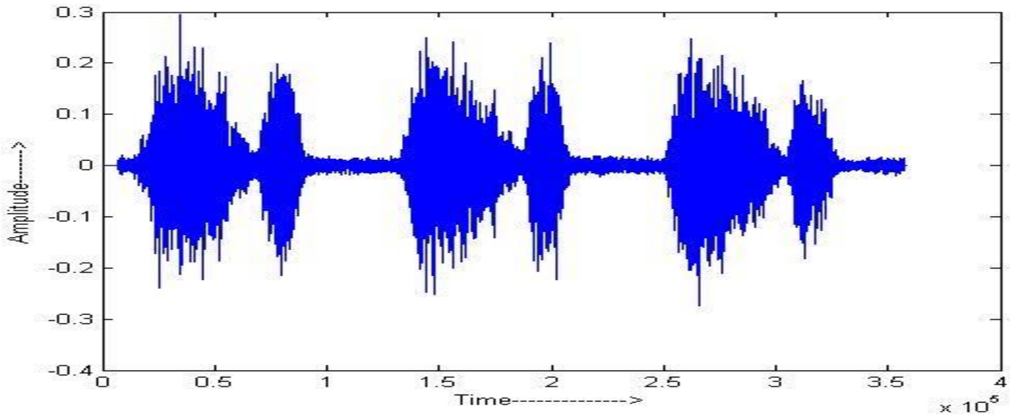

Figure 1: Normal lung sound (Vesicular)

B. ADVENTITIOUS LUNG SOUND

• **Wheeze**: It is a continuous sound having a musical character. Acoustically, it is characterized by periodic waveforms with a dominant frequency usually over 100 Hz and with duration of ≥100 ms, the sound must include at least 10 successive vibrations .If the wheezes contain essentially a single frequency, the wheeze is called monophonic and if it contains several frequencies, it is termed polyphonic wheezes [6]. Wheezes are adventitious sounds associated with airway obstruction [7]

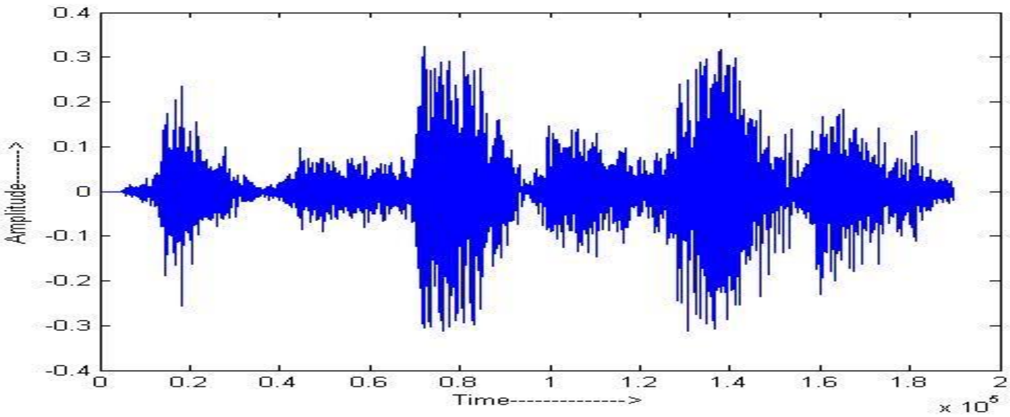

Figure 2: Wheeze

• **Crackles**: Crackles are discontinuous adventitious lung sounds, explosive and transient in nature, and occur frequently in cardio respiratory diseases. Their duration is less than 20 ms, and their frequency content typically is wide [4].

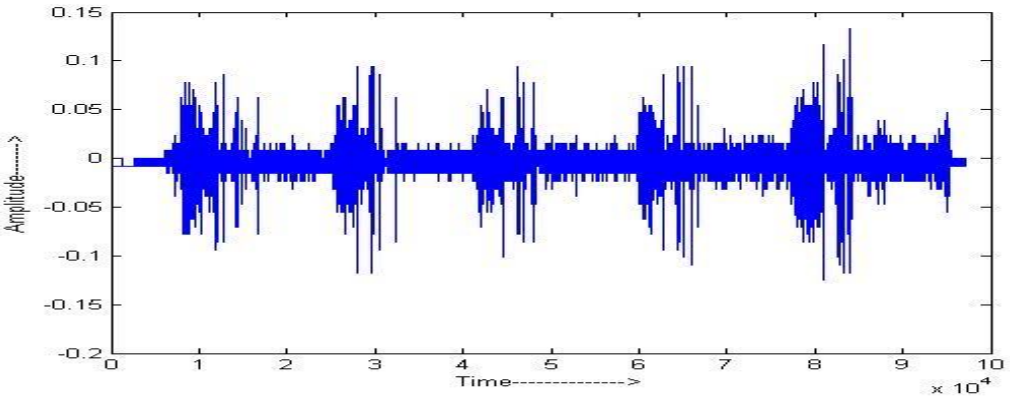

Figure 3: Crackles

2. DISCRETE WAVELET TRANSFORM

Wavelet analysis has practically become a ubiquitous tool in signal processing. Two basic properties, space and frequency localization and multi-resolution analysis, make this a very attractive tool in signal analysis. The wavelet transform method processes perfect local property in both time space and frequency space and it is used widely in the region of vehicle faults detection and identification. The general definition of the wavelet transform is given as:

$$W(a,b)=\int_{-\infty}^{\infty} f(t)\frac{1}{\sqrt{a}}\psi^*\{\frac{t-b}{a}\}dt \quad (1)$$

Where a and b are real and*denote complex conjugate and (t) is wavelet function [8-10]

3. PARAMETERS

A. VARIANCE

Variance is defined as Mean Square value of the signal, computed after the mean value has been removed.

$$\sigma^2=\frac{1}{N}\sum_{i=1}^{N}(Xi-\mu)^2 \quad (2)$$

σ =Variance, N=no of samples, Xi=input heart signal μ= mean

B. STANDARD DEVIATION

Standard Deviation (S) is defined as Square root of the variance i.e. MS value of the signal, computed after the mean value has been removed

$$S=\sqrt{\sigma^2}=\sigma=\sqrt{\frac{1}{N}\sum_{i=1}^{N}(Xi-\mu)^2} \quad (3)$$

C. ENERGY

The energy of the signal can be computed as the squared sum of its spectral coefficients, normalized by the length of the sample window. The energy metric has been used to identify the mode of transport of a user with a single celerometer, respectively walking, cycling, running and driving.

$$Ef=\sum_{-\infty}^{\infty} Ix(n)I^2 \quad (4)$$

D. ENTROPY

Entropy is used to measure a system's level of disorder in physics of thermodynamics. Entropy measurement is an ideal method in order to measure the level of disorder of a non-stationary signal. Besides, entropy is also being used forthe purpose of measuring the average amount of information that an event contains[11].

Entropy = -sum (P*log (*P))…………………………………………………… (5)

P = Probability vector

4. FEATURE EXTRACTION PROCESS

For the feature extraction we use the following process –

i. First of all we collect lung signal in the different format (e.g. .wave, .mp3, .mp4 etc.) from the internet.
ii. Here we are using the MATLAB 2013 so we take the input lung signal in the any format.
iii. We define the sampling frequency, window size, length and the other parameter for the lung sound.
iv. Then we call the various parameters like variance, entropy, energy and variance
v. Then we extract the feature using the daubechies wavelet at level 10.At the last we compare the all the features of normal and abnormal lung sounds.

III. RESULT

The feature that has been extracted using the Daubechies Wavelet Transform is shown in the table below:

1. ENTROPY

Feature (db10)	Normal Vesicular	Wheeze Monophonic	Coarse Crackle
Feature 1	6.32E-05	0.000111718	0.000202457
Feature 2	0.000118847	0.000205905	0.000381973
Feature 3	0.000221734	0.000375057	0.000644278
Feature 4	0.000388783	0.000681333	0.001204564
Feature 5	0.000705783	0.001252683	0.002349882
Feature 6	0.001291732	0.00219727	0.004431631
Feature 7	0.002331511	0.003858765	0.007808397
Feature 8	0.004693893	0.007064117	0.012086815

Table No. 1 – Entropy of the lung sounds

2. ENERGY

Feature (db10)	Normal Vesicular	Wheeze Monophonic	Coarse Crackle
Feature 1	0.000558206	0.001054552	0.002043879
Feature 2	0.001116282	0.002108431	0.004061814
Feature 3	0.002232082	0.004214575	0.008010494
Feature 4	0.004461872	0.008420445	0.009247411
Feature 5	0.008599163	0.016746877	0.014928243
Feature 6	0.013113215	0.029369105	0.014922581
Feature 7	0.020865895	0.0309001	0.014910718
Feature 8	0.020865776	0.048331525	0.014890587

Table No. 2 – Energy of the lung sounds

3. STANDARD DEVIATION

Feature (db10)	Normal Vesicular	Wheeze Monophonic	Coarse Crackle
Feature 1	0.001302957	0.002716109	0.006491483
Feature 2	0.002605843	0.005431529	0.012933119
Feature 3	0.005211974	0.010860523	0.025233846
Feature 4	0.010437348	0.021717178	0.027758013
Feature 5	0.020425234	0.043539481	0.044171048
Feature 6	0.030538106	0.078405342	0.044154294
Feature 7	0.047540915	0.082815421	0.044119194
Feature 8	0.047540644	0.146178768	0.044059626

Table No. 3 – Standard Deviation of the lung sounds

4. VARIANCE

Feature (db10)	Normal Vesicular	Wheeze Monophonic	Coarse Crackle
Feature 1	1.70E-06	7.38E-06	4.21E-05
Feature 2	6.79E-06	2.95E-05	0.000167266
Feature 3	2.72E-05	0.000117951	0.000636747
Feature 4	0.000108938	0.000471636	0.000770507
Feature 5	0.00041719	0.001895686	0.001951081
Feature 6	0.000932576	0.006147398	0.001949602
Feature 7	0.002260139	0.006858394	0.001946503
Feature 8	0.002260113	0.021368232	0.001941251

Table No. 4 – Variance of the lung sounds

The maximum and minimum values shown in the figure below helps in finding the best level so that the feature extracted can be used properly in the stage of classification.

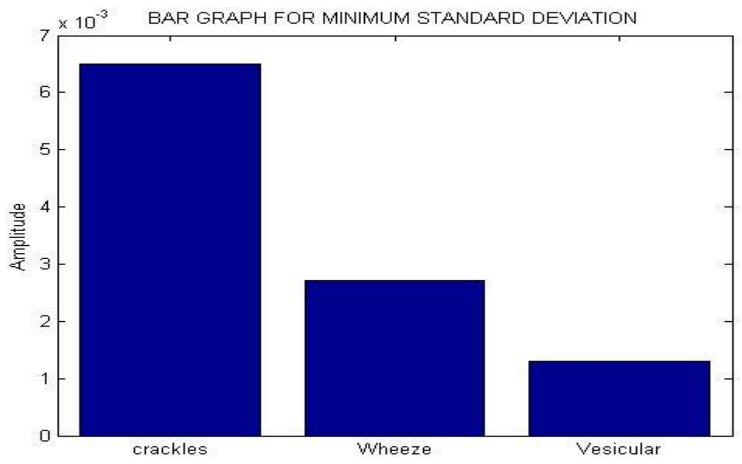

Figure 4: Bar Graph for minimum Standard Deviation

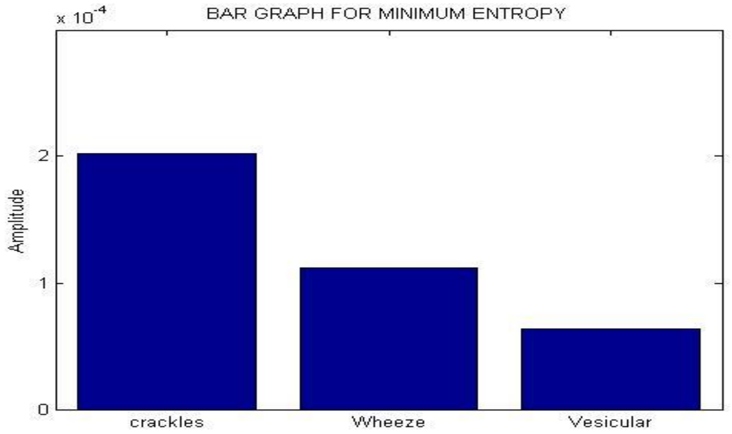

Figure 5: Bar Graph for minimum Entropy

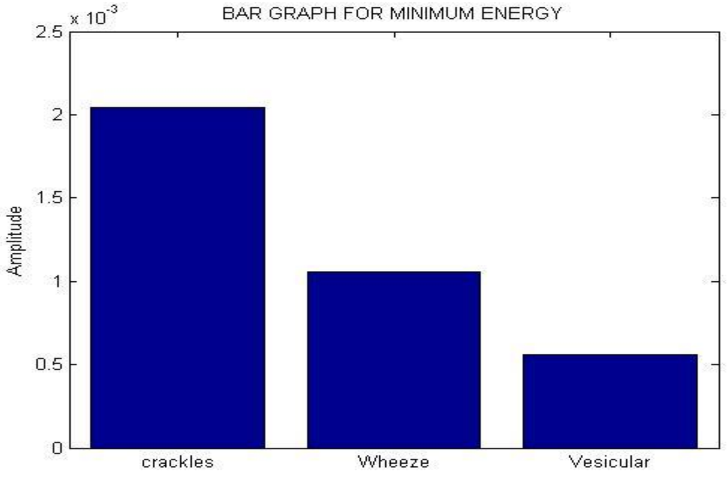

Figure 6: Bar Graph for minimum Energy

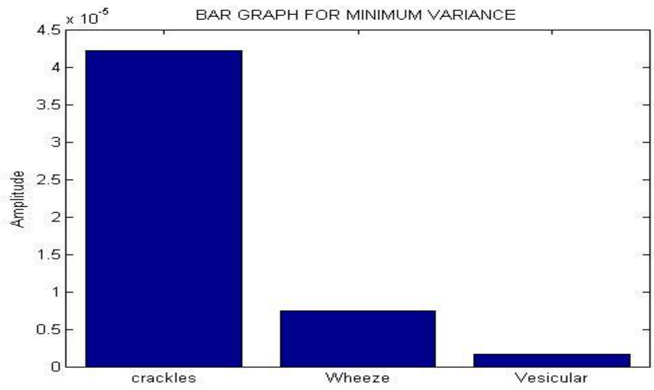

Figure 10: Bar Graph for minimum Variance

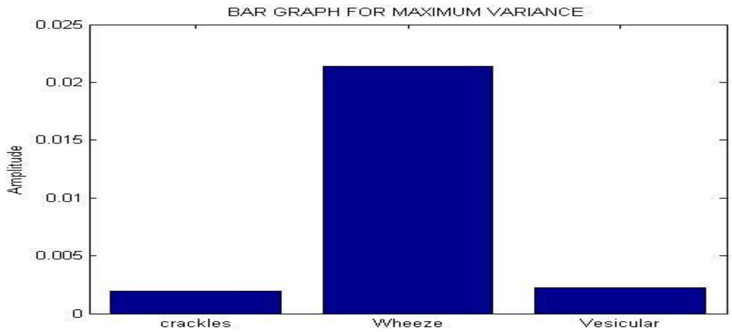

Figure 7: Bar Graph for maximum Variance

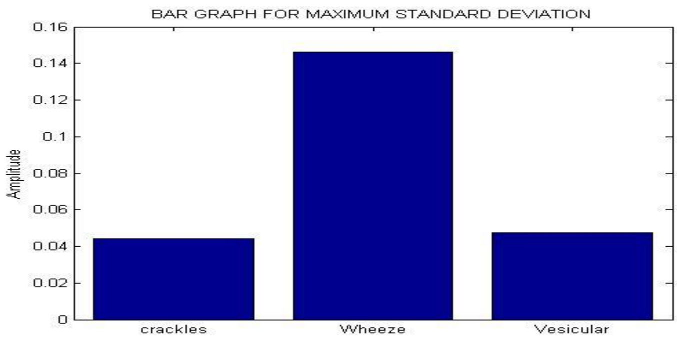

Figure 8: Bar Graph for maximum Standard Deviation

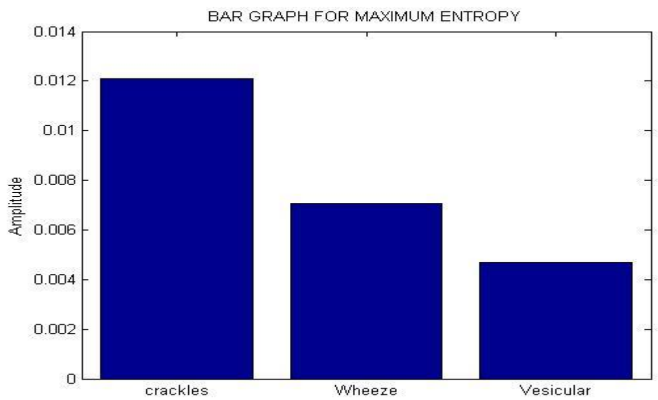

Figure 8: Bar Graph for maximum Entropy

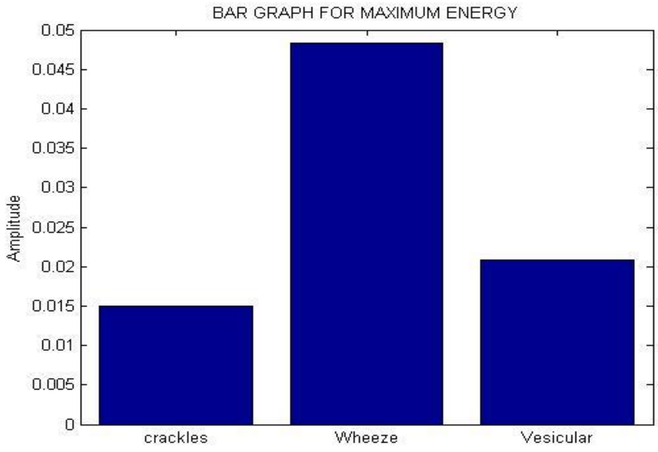

Figure 9: Bar Graph for maximum Energy

IV. CONCLUSION

Here we have proposed a biomedical system for the feature extraction of the various types of lung sound which will be helpful for the classification of the lungs sounds. Here we use the MATLAB 2013 for the experiment which can take the sound input in any format. We extract the four features i.e. energy, entropy, standard deviation and variance using the discrete wavelet transform. An appropriate wavelet is required for the decomposition of the signal because of various dominant frequency components present in the signal. Here we use the daubechies wavelet (db10). At the last a comparison of maximum and minimum features in the vesicular, crackles and wheeze has been given.

REFERENCES

[1] A.R.A. Sovijärvi, J. Vanderschoot, J.E. Earis "Standardization of computerized respiratory sound analysis", Eur Respir Rev, Vol. 10, Issue. 77, 2000.
[2] K.W Becker, C. Scheffer, M. Blanckenberg, "Research into Adventitious Lung Sound Signals Originating From Pulmonary Tuberculosis Using Electronic Auscultation", Department Of Mechanical and Mechatronic Engineering, Stellenbosch University, 2009.
[3] Masaru Yamashita, Masataka Himeshima, and Shoichi Matsunaga "Robust classification between normal and abnormal lung sounds using adventitious-sound and heart-sound models", IEEE International Conference on Acoustic, Speech and Signal Processing (ICASSP), pp. 4451-4455, 2014.
[4] A. Kandaswamya, C. Sathish Kumarb, Pl. Ramanathanc, S. Jayaramana, N. Malmurugana , "Neural classification of lung sounds using wavelet coefficients" Elsevier , pp. 523-537 , 2004
[5] A.R.A. Sovijärvi, L.P. Malmberg, G. Charbonneau, J. Vanderschoot, F. Dalmasso, C. Sacco, M. Rossi, J.E. Earis, "Characteristics of breath sounds and adventitious respiratory sounds", European Respiratory Review, vol. 10, Issue. 77, pp. 591–596, 2000.
[6] A.R.A. Sovijärvi, F. Dalmasso, J. Vanderschoot, L.P. Malmberg, G. Righini, S.A.T. Stoneman, "Definition of terms for applications of respiratory sounds", European Respiratory Review , Vol. 10, Issue. 77, pp. 597–610, 2000.
[7] Kevin E. Forkheim, David Scuse, and Hans Pasterkamp, "A Comparison of Neural Network Models for Wheeze Detection" IEEE WESCANEX '95 PROCEEDINGS, pp. 214-219
[8] Anita Devi , Abhishek Misal , Dr. G.R.Sinha , "Performance Analysis of DWT at different levels for Feature Extraction of PCG Signals", International Conference on Microelectronics, Communication and Renewable Energy (ICMiCR) , 2013
[9] Amjad Hashemi, Hossein Arabalibiek, Khosrow Agin, "Classification of Wheeze Sounds Using Wavelets and Neural Networks", International Conference on Biomedical Engineering and Technology, Vol. 11, pp. 127-131, 2011.
[10] R. Kronland- martinet, J. Morlet ,A.Grossmann , "Analysis of sound patterns through wavelet transform" , International Journal of Pattern Recognition & Artificial Intelligence Vol. 1, No 2, pp.273-302 ,1987
[11] Sergul Aydore, Ipek Sen, Yasemin P. Kahya, M. Kivanc Mihcak, "Classification of Respiratory Signals by Linear Analysis", 31st Annual International Conference of the IEEE EMBS, September 2-6, pp. 2617-2620, 2009.