Breathe signal processing in diagnosis of respiratory diseases

Aadityavelava.V.A[#1], M.Vanithalakshmi[*2], R.Radhika[#3]

[#] *Communication systems, S.A.EngineeringCollege, Chennai, India.*

[1] gowthamaaditya@gmail.com

[3] radhi.jazz21@gmail.com

[*] *AssistantProfessor, Department of PG studies, S.A. Engineering College, Chennai, India.*

[2] vanithahitesh08@yahoo.co.in

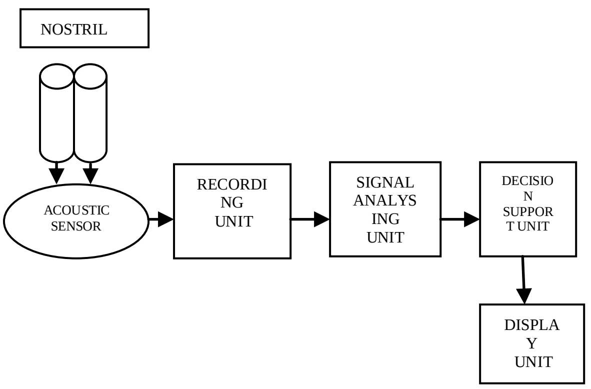
Abstract— **Breath tests are the non-invasive methods for clinical diagnosis of the respiratory diseases and monitoring patients from environmental pollution exposure assessments. This paper is intended to describe the potential applications of breathe pressure and sound signals measured using acoustic sensor from nostrils in diagnosing respiratory diseases using feature extraction and pattern recognition. This method overcomes the current expensive techniques used for diagnosing the respiratory diseases. It is cost effective and can be operated by anybody.**

Keywords— **Non-invasive, Acoustic sensor, Feature extraction, Pattern recognition.**

I. INTRODUCTION

Research, product development, and new applications of breath signal processing have all advanced dramatically in the past decade. Research into new methods of breath analysis and enhancement of existing approaches has proceeded at a fast pace. Exhaled breath analysis holds great promise for the development of non-invasive disease diagnostics and monitoring. It has, potentially, two great advantages over other means of diagnosis, including blood, urine, biopsy, endoscopy, and imaging: Complete non-invasiveness and Virtually limitless repeatability with respect to frequency, access, and cost .Breath analysis is inherently non-invasive, one potential application of breath analysis is SPIROMETER which is used for the monitoring lung functions.Breath analysis could have many more potential applications in the clinical diagnosis of various breath disease monitoring.

II. BLOCK DIAGRAM



A. *Acoustic sensor*

A sensor is used to measure (sense) an environment and converts this information into a digital or analog data signal that can be interpreted by a computer or observer. An acoustic wave sensor is an electronic device that can measure sound and pressure levels. Practically all acoustic wave devices and sensors use a piezoelectric material to generate the acoustic wave. Piezoelectricity essentially means electricity resulting from pressure. It refers to the production of electrical charges as a result of mechanical stress. Piezoelectric acoustic wave sensors are relatively cheap, rugged, very sensitive, reliable, and can be used passively (without a power source) and wirelessly.

B. *Recording unit*

Sound recording and reproduction is an electrical or mechanical inscription and re-creation of sound waves. The two main classes of sound recording technology are analog recording and digital recording, here we use digital recording. Digital recording and reproduction converts the analog sound signal picked up by the microphone to a digital form by a process of digitization, allowing it to be stored and transmitted by a wider variety of media. Here we use USB sound cards for recording the input sound signals. A sound card (also known as an audio card) is an internal computer expansion card that facilitates the input and output of audio signals to and from a computer under control of computer programs.

C. *Signal Analysing Unit*

Signal analysing unit is used to analyse the recorded signal using the used algorithms. The algorithms used are,

1. Least mean square algorithm
2. Pattern recognition

The signal recorded using the combination of Acoustic wave sensor and the 3D USB sound card is analysed using the algorithms. The required features for determining the diseases is acquired from the signal using this.

LMS algorithm is used to minimize the mean square error. It is used to reduce the error during the transmission and to find the least mean square

$$w_{n+1} = w_n + \mu E\{e(n)\boldsymbol{x}^*(n)\}$$

This is the weighted equation of LMS algorithm. The LMS algorithm requires one multiplication and one addition.$\mu e(n)$has to be found once and can be used for all the coefficients. LMS adaptive filter having (p+1)coefficients

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require(p+1) addition and (p+1)multiplication to find the filter coefficients.

1. P = Filter order
2. μ= Step size
3. w _0 = 0

For n = 0,1,2,….

a) $y(n) = (w_n)T\, x(n)$

b) $e(n) = d(n) – y(n)$

c) $w_{n+1}= w_n + \mu e(n)\, x^*(n)$

First initially n is assumed to be 0 and it is updated automatically till the error reaches the desired value.

We observe the signal patterns, we study the relationships between the various signal patterns, we study the changes in situations and come to know about the events, we study events and thus understand the law behind the events and using the law, we can predict future events.

D. *Decision Support Unit*

The estimated mean, frequency range and the waveform pattern in the signal analysing unit is given to this decision support unit. In this unit the estimated value is compared with the previously calculated and stored values from the collected data base from various patients with various diseases. After comparing it the desired output is given in the display unit.

III. PROCESS

The acoustic sensor is placed near the nostrils, a sensor is used to sense all the variations around it, an acoustic sensor is capable of sensing the pressure and sound variations. A common symptom in all respiratory diseased patient is shortness of breath. The pressure variations and the sound from the nostril is recorded using the combination of acoustic sensor and 3D USB sound card, a 3D USB sound card is an internal computer expansion card which facilitates the input and output to and from a computer under control of computer programs.

A database of breath patterns from patients with various respiratory problems is collected, from this an average pattern and frequency for each time instant is obtained and the respected values is stored in the decision support unit. Then the breath signal values calculated from patients at real time is then compared with the average calculated values from the database and respected decision is given in the display unit.

The values for a normal breathing person and a wheezing patient is shown below,

Each and every person has their own respiratory pattern. The pressure variation from each person is different but lies in a certain range for the normal persons and the persons who have respiratory problems. The differentiation between the normal and the diseased are shown below using which the respiratory diseases can be diagnosed and with further refining of the work the current expensive techniques used for diagnosing the respiratory diseases can be overcome with cost effectiveness.

The frequency range of a normal person at normal condition , the breathing waveform is found to be from (-0.05-0.05) hertz.

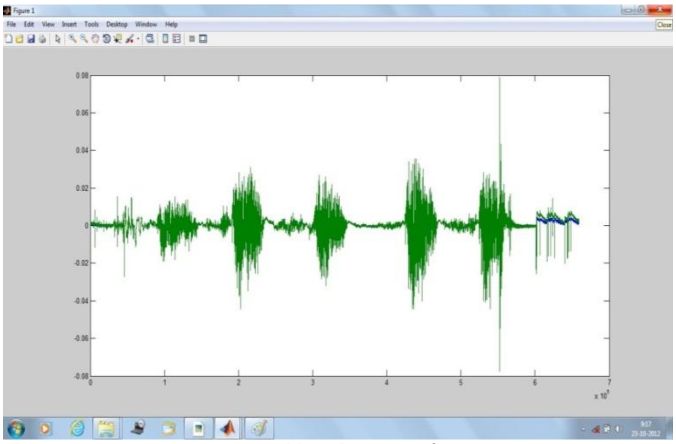

Fig. 1Normal breathing waveform

The IFFT plot of a normal person at the normal condition, the normal breathing waveform is shown below,

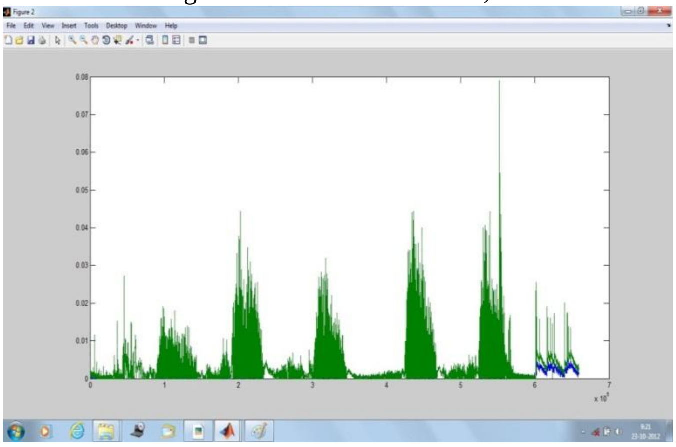

Fig. 2 IFFT plot of normal breathing waveform

From the IFFT plot the frequency range of normal breathing waveform is found to be from (0-0.05) hertz.

The frequency range of a person with wheezing in normal condition is found to be from (-0.2-0.2) hertz, it is shown below,

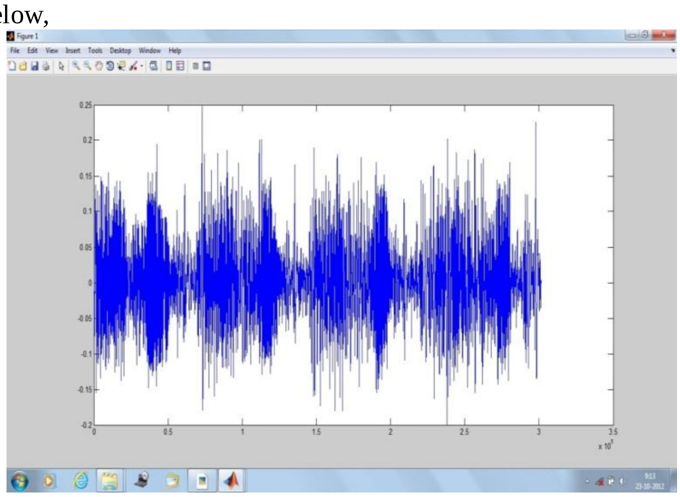

Fig. 3 Normal wheezing waveform

The IFFT plot of a person with wheezing in normal condition , the normal wheezing waveform is shown below,

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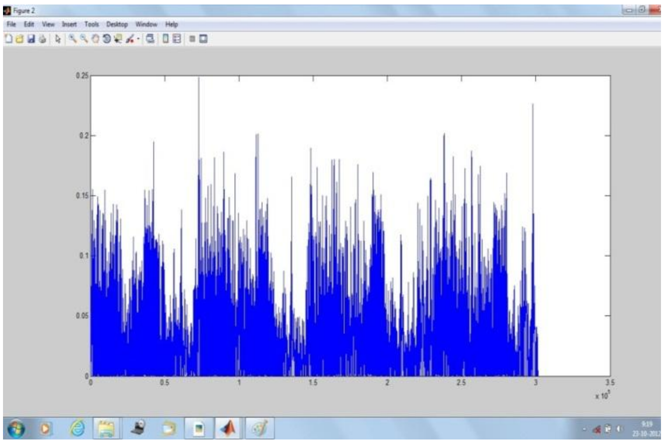

Fig. 4 IFFT plot of normal wheezing waveform

From the IFFT plot the frequency range of a person with wheezing in normal condition is found to be from (0-0.2) hertz.

IV. CONCLUSION

In recent years, interest in breath analysis for clinical purpose has been increased rapidly. Patients are also interested in Non-invasive methods rather than the invasive methods.One potential application of breath analysis is Spirometer.Few types of breath tests have been successfully used as diagnostic tools in clinical analyses, such as the, Urea Breath Test (UBT) in the diagnosis of Helicobacter pylori infection and the, Nitric Oxide (NO) breath test in the diagnosis of airway inflammation.

From the results we have obtained by comparing the simulation result obtained for the pre-stored breath signals of a wheezing patient in their normal and abnormal states with the simulation result obtained for the pre-stored breath signal of a normal person, it is clearly seen that there is a heavy frequency variation in the signals obtained from a normal person compared to that of a wheezing patient. A normal person's breathing frequency lies in the range (-0.05 – 0.05) hertz, a wheezing patients breathing frequency in normal condition lies in the range (-0.2 – 0.2) hertz and in severe condition lies in the range of (-1.0 – 1.0) hertz. From this it isclear that each respiratory diseased patient's have distinct breath pattern and frequency range.Hence, If the process is further refined respiratory diseases can be identified non-invasively and treated effectively. This would eliminate theexpensive tests used such as CT scan, etc. used to determine the heart problem, sinusitis, pneumonia and gastric problem's etc.

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