A study on tracheal disease analysis using breath signal processing

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Abstract— **Breath tests are the noninvasive methods for clinical diagnosis of the tracheal diseases. The tracheal sound signal can be processed using several techniques for diagnostic information. Computerized analysis can facilitate the detection of changes in tracheal sound and storing. This may help in the diagnosis of tracheal disorders and treatment for a patients suffering from various tracheal diseases. This paper is intended to describe the potential applications of breathe pressure and sound signals measured using acoustic sensor from nostrils in diagnosing tracheal diseases using feature extraction and pattern recognition.**

Keywords— **Breathe sound signals, Feature extraction, Pattern recognition.**

I. Introduction

Research, product development, and new applications of breath signal processing have all advanced dramatically in the past decade. It has, potentially, two great advantages over other means they are, complete noninvasiveness and virtually limitless repeatability with respect to frequency, access, and cost. Most of the pulmonary diseases causes breathe disorders. Characterizing of breathe sound signals helps in the diagnosis of breathe disorder. Diagnosis of breathe disorder by breathe signal processing is a subjective process. The limitation of it can be overcome by using digital signal processing techniques [3], [4]. The quantification and analysis of noise free breathe sound signal will be helpful for better diagnosis. Artifact suppression is needed for automatic diagnosis of breathe disorder. Recording of breathe sound signal and signal processing techniques are needed for automatic diagnosis of breathe disorder. Artifact suppression is done using frequency domain and adaptive filtering technique and the characterization of tracheal sound signal is done using spectral analysis and power density spectrum.

II. Process

Each and every person has their own breathe pattern. The pressure variation from each person is different but lies in a certain range for the normal persons and the persons who have breathe problems.

The acoustic sensor is placed near the nostrils; an acoustic sensor is capable of sensing both the pressure and sound variations. A common symptom in all the tracheal disease patients is shortness of breath. The pressure variations and the sound from the nostril is recorded using the combination of acoustic sensor and a USB (Universal Synchronous Bus) sound card, a 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 breathe signal patterns were taken from ten randomly selected subjects, for each separate breathing disorder. A breathe sound recorder instrument was used for recording the breathing sound signal. A microphone based developed sensor was used for recording breathe signals of normal and diseased persons. Two signals were taken into account one signal with breathing and other is signal without breathing. From this an average pattern and frequency for each time instant is obtained and the respected values is stored in the database. The breath signal values calculated from patients at real time is then compared with the average calculated values from the database and the respected decision is given in the display unit.

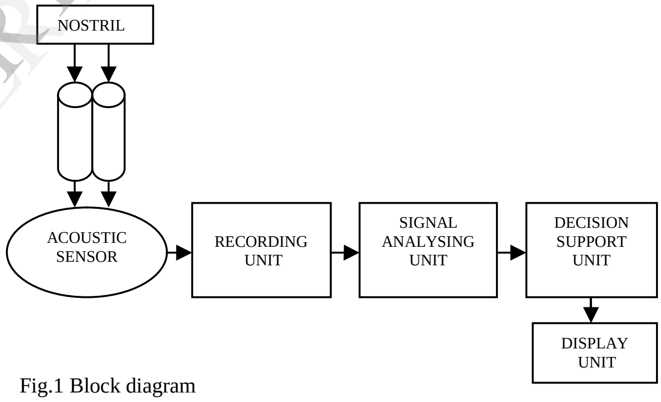

Fig.1 Block diagram

A. *Acoustic sensor*

A sensor is used to measure (sense) an environment and convert this information into a digital or analog data signal that can be interpreted by a computer or an observer. An acoustic wave sensor is an electronic device that can measure sound and pressure levels. It produces electrical charges as a result of mechanical stress. The signal is then recorded in the computer using the USB sound card.

B. *Recording unit*

Here we use digital recording, digital recording and reproduction converts the analog sound signals picked up by the microphone to a digital form by a process of digitization because digital signals can be easily interpreted by computer programs such as MATLAB (Matrix Laboratory) for noise reduction and Artifact suppression.

C. *Signal Analysing Unit*

The Signal analysing unit is used to analyse the recorded signal and to suppress the artifacts using the combination of adaptive and frequency domain filtering. There are three main components in the combination method they are, the input or primary signal, the noise signal (heart signal & other muscle artifact) and the filtered output signal. In this technique the recorded signal during normal breathing of normal person or diseased patient is the primary input and the signal recorded with normal breathing is a reference input signal. Breathe sound is considered as the primary signal for analysis, a partial overlap between the breathe signal and the heart signal is provided as the primary input for the adaptive noise cancellation technique. The heart sound signal is taken as the reference input signal and the artifact mixed breathe signal is taken as the primary input. The noise signal consists of the heart signal and other artifact noises. To remove the high frequency artifact noises FIR (Finite Impulse Response) filtering is applied to both the signals. The output is the signal which is determined by subtracting the reference signal from the primary signal.

$$e(n) = b(n) - m(n) \quad (1)$$

Where "(1)", b(n) is the breath sound, m(n) is the heart sound and other high frequency artifact noises and e(n) is the denoised breath sounds[5].

We also observe the signal patterns, we study the relationships between 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 using pattern recognition.

D. *Decision Support Unit*

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

III. ALGORITHM IMPLEMENTATION

Breathe sound signals are difficult to process due to the interference of the heart sounds and the various high frequency artifacts. This is removed by the combinational method of adaptive and frequency domain filtering. The processing of these signals was done in MATLAB. The IFFT (Inverse Fast Fourier Transform) of the signals were plotted using MATLAB to observe the different frequency ranges of the signal. Power spectrum verses frequencies, of the filtered tracheal sound signals were plotted. Peak of the waveform was found at the maximum value of the power density. The frequency value was calculated and depending upon this frequencies from various subjects the reference database values are calculated and the abnormalities in breathe sound signals are decided.

IV. RESULTS AND ANALYSIS

The results shown below are the simulation output of the input signals from various subjects without heart sounds and other muscle artifacts from the combination method of adaptive and frequency domain filtering using MATLAB simulation software.

The waveform for a sample obtained from a person who doesn't have any breathe related problems using MATLAB is shown below,

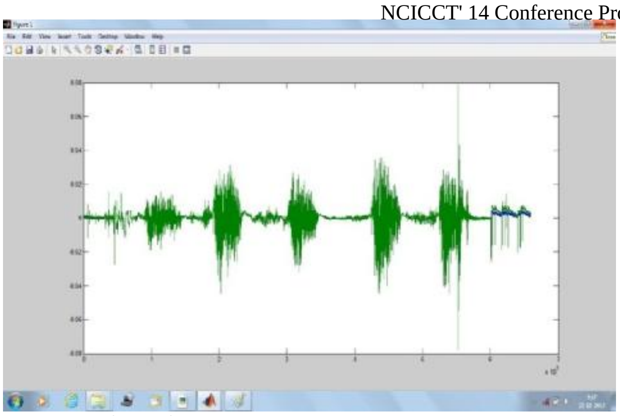

Fig. 2 Waveform of normal person with no breathing problems

From "Fig.2", the frequency range of a normal person who doesn't have any breathe related problems, is found to be in the range of (-0.05-0.05) hertz.

The IFFT waveform for a sample obtained from a person who doesn't have any breathe related problems using MATLAB is shown below,

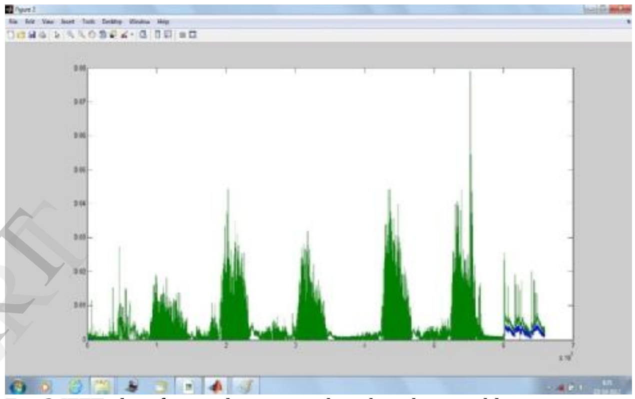

Fig. 3 IFFT plot of normal person with no breathing problems

From "Fig.3", the IFFT plot the frequency range of normal person with no breathing problems is found to be in the range of (0-0.05) hertz.

The waveform for a sample obtained from a person with wheezing problem in the normal condition using MATLAB is shown below.

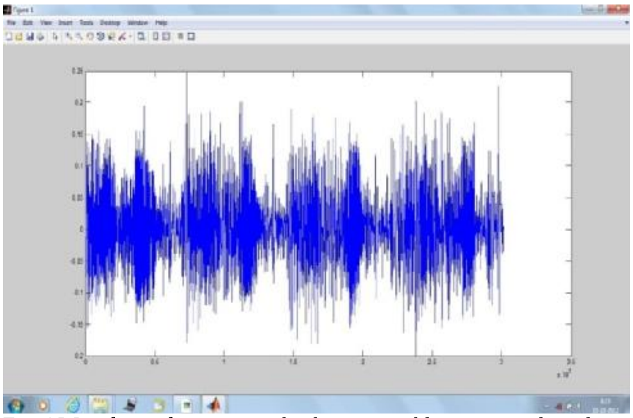

Fig. 4 Waveform of a person with wheezing problem in normal condition

From "Fig.4", the frequency range for a sample obtained from a person with wheezing in the normal condition is found to be in the range of (-0.2-0.2) hertz.

The IFFT waveform for a sample obtained from a person who has wheezing problem in his normal condition using MATLAB is shown below

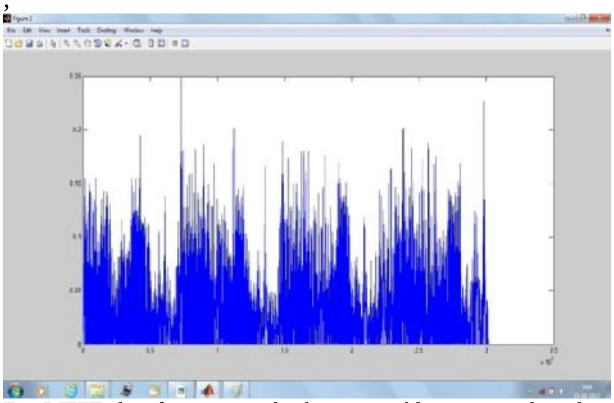

Fig. 5 IFFT plot of a person with wheezing problem in normal condition

From “Fig.5”, the IFFT plot the frequency range of a person with wheezing problem in normal condition is found to be in the range (0-0.2) hertz.

The waveform for a sample obtained from a person who has wheezing problem during wheezing using MATLAB is shown below,

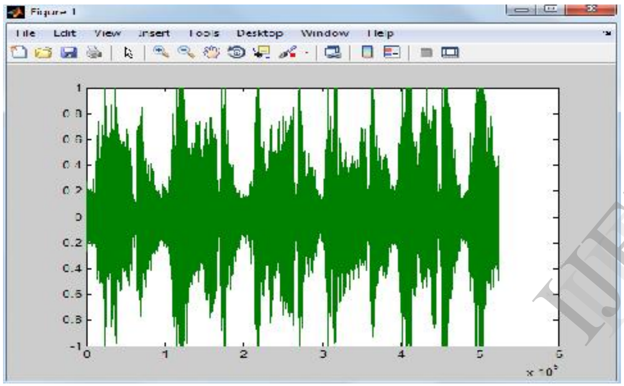

Fig. 6 Waveform of person with wheezing problem during wheezing

From “Fig.6”, the frequency range of a person with wheezing problem during wheezing is found to be in the range of (-1.0-1.0) hertz.

The IFFT waveform for a sample obtained from a person who has wheezing problem during wheezing using MATLAB is shown below,

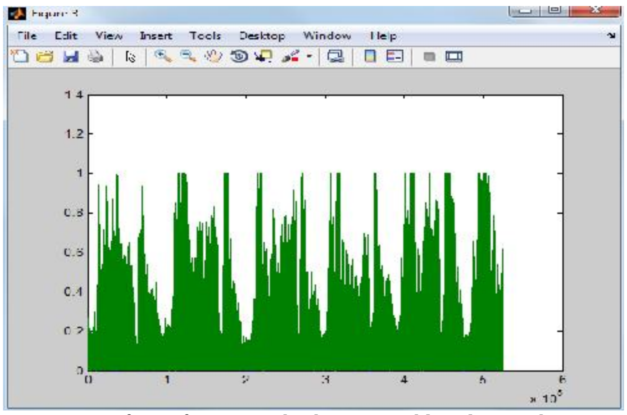

Fig. 7 IFFT waveform of person with wheezing problem during wheezing

From “Fig.7”, the IFFT plot the frequency range of a person with wheezing problem during wheezing is found to be in the range of (0-1.0) hertz.

The waveform for a sample obtained from a person who has cold using MATLAB is shown below,

Fig.8 Waveform of a person having cold

From “Fig.8”, the frequency range of a person with cold is found to be in the range of (-0.15-0.1) hertz.

The IFFT waveform for a sample obtained from a person who has cold using MATLAB is shown below,

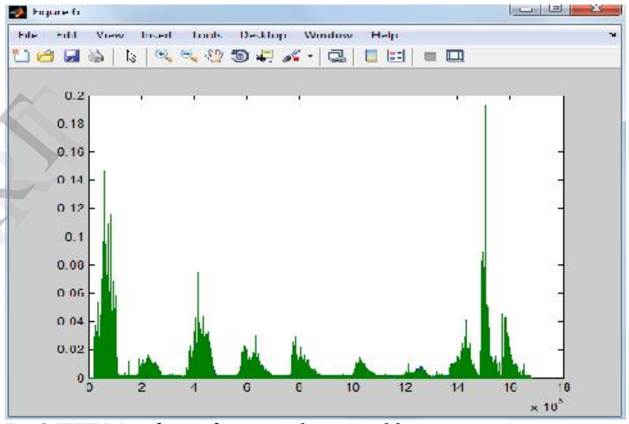

Fig.9 IFFT Waveform of a person having cold

From “Fig.9”, the IFFT plot the frequency range of a person with cold is found to be in the range of (0-0.15) hertz.

V. CONCLUSION

The results we have obtained are after eliminating the heart sound and the other muscle artifacts. By comparing the MATLAB simulation result for the prestored breath signals of a wheezing patient in their normal and abnormal states with the simulation result obtained for the prestored breath signal of a normal person and a cold patient, 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 and cold 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 and the cold patients breathing frequency lies in the range of (-0.1-0.1). From this it is clear that each tracheal disease patients have distinct breath pattern and frequency range. Hence, if the process is further refined tracheal diseases can be identified noninvasively and treated effectively. This would eliminate the expensive tests used for diagnosing the tracheal diseases such as the Bronchitis, Sinusitis, Pneumonia and Gastric problem's etc.

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REFERENCES

[1] R. A. Sovijarvi, J. Vanderschoot, and J. E. Earis, "Standardization of Computerized tracheal Sound Analysis," Eur Repair Rev, vol 10 (77), pp. 58, 2000.
[2] J.E. Earis, B. M. G. Cheetham, "Current Methods used for Computerized Tracheal Sound Analysis," Eur Repair Rev; vol 10 (77), pp. 585-590, 2000.
[3] Z. M. K. Moussavi, "Respiratory Sound Analysis," IEEE Engineering in Medicine & Biology Magazine 0739-5175, 2007.
[4] Z. M. K. Moussavi, "Separating heart sound from lungs sounds," IEEE Engineering in Medicine & Biology Magazine, 2007.
[5] Z. M. K. Moussavi, "Fundamentals of Respiratory Sound Analysis," Morgan & Claypool, First Edition.
[6] W. F. Ganong, "Review of Medical Physiology (Seventeenth Edition), New Jersey, Prentice Hall, 1995.
[7] Guyton & Hall,"A textbook of Medical Physiology", Tenth Edition, printed in India at Gopsons Paper Ltd., Noida 201 301.
[8] Johnson, L.R.,"Essential Medical Physiology (Second Edition). Philadelphia, Lippincott Williams & Wilkins, 1998.
[9] MedicineNet.com, article.htm.
[10] T.E. Ayoob Khan, Dr. P. Vijayakumar, "Separating Heart sound from lung sound using LavView", International Journal of Computer and Electrical Engineering, Vol. 2, No. 3, June, 2010 1793-8163.
[11] Rahman Jamal, Mike Cerna, John Hanks Designing Filters Using the Digital Filter Design Toolkit.
[12] Emmanuel. C. Ifeachor, Barrie. W. Jervis, Digital Signal Processing.
[13] Edward P. Cunningham, "Digital Filtering An Introduction", John Wiley & Sons, Inc.1995.
[14] Haykin S, Adaptive Filter Theory, 2nd Edition, United Stated of American: Prenticem Hall, Inc. 1991.
[15] KristerLandernas, "Implementation of Digital Filters Using Digital-Series Arithmetic's, Department of electronics", Licentiate thesis No. 23, 2004.

[16] HTTP://WWW.DSPTUTOR.FREEUK.COM/DFILT2.HTM ACCESSED ON 2008-11-22.
[17] http://www.intersil.com/data/AN/an9603.pdf Accessed on2008-11-21.
[18] Cedric Keip, "Design of a Finite Impulse Response Filter Coefficients Computation tool using Evolutionary Strategies and Extension to Filter Bank Design", 2004.
[19] Terrell, Trevor J. Introduction to Digital Filters. Second Edition, London: Macmillan, 1980.
[20] THOMAS J. CAVICCHI, JOHN, DIGITAL SIGNAL PROCESSING, WILEY & SONS, INC 2000.
[21] "Pressures generated during nose blowing in patients with nasal complaints and normal test subjects*"Peter Clement and Hana Chovanova, Department of ENT, H&N Surg, Free University Hospital Brussels (AZ-VUB), Laarbeeklaan 101, 1090 Brussels, Belgium, Rhinology, 41, 152-158, 2003.