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Comparison of STFT and CWT for Normal subjects and OSA patient

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Abstract*—Obstructive sleep apnea (OSA) is a potentially serious sleep disorder and is caused by obstruction in the upper airway in the presence of the breathing effort. It is characterized by recurrent episodes of upper airway (UA) collapse during sleep due to intermittent relaxing and blocking of the patients airway by the throat muscle. Here noninvasive method of screening OSA patients is proposed. The tracheal breathing sound of the patients with and without obstructive sleep apnea were recorded using the low cost sensor during wakefulness in the supine position. In this study short time Fourier transform (STFT) and continuous wavelet transform (WT) is applied on breathing signal obtained from the normal subject and OSA patient.

Index Terms*—Breathing sounds, Obstructive Sleep Apnea, Short Time Fourier Transform, Continuous Wavelet Transform, Spectral analysis.

I. INTRODUCTION

The obstructive sleep apnea patient suffer from breathing pauses while they are asleep because the airway has been narrowed or partially blocked. It is caused by the muscle and the soft tissue present at the back of the patient's throat collapse inward during sleep. These muscles support the person's tongue, tonsils and soft palate. Once the muscles relax, the airway in the throat can narrow or become totally blocked. This interrupts the oxygen supply to the body, which triggers the brain to pull the person out of deep sleep so that the airway reopens and can breathe normally.

By definition, sleep apnea is the cessation of breathing with respiratory effort lasting greater than 10 seconds. Loud snoring is the noticeable symptoms of sleep apnea and it is caused when the air can't move freely through the nose and throat during sleep. This makes the surrounding tissue vibrate which produces sound. The abnormal respiratory sounds can be classified as wheezing, stridor, rhonchi, rales etc. sleep apnea occur 2 or 3 times in elderly, and also more common in males compared to females.

Full night Polysomnography is currently the accepted Gold Standard diagnostic tool for sleep apnea. The standard PSG consist of recording of EEG, ECG, and EMG to determine sleep stages, nasal airflow, abdominal and thoracic movements.

PSG is high cost, diagnosis time is more and require night long supervision. Typically, full night's sleep is observed before a diagnosis is reached and in some patient a second night's recording is required. To avoid all these inconveniences, we propose a new non-invasive and cost effective way of detecting Sleep Apnea.

Like PSG, most of the existing diagnostic techniques of OSA are invasive, time consuming, costly and causing immense discomfort for the patient. To avoid all these inconveniences, we propose a new non-invasive and cost effective way of detecting Sleep Apnea.

The breathing sound of the subject is recorded during wakefulness in supine position. This is done using Sensory Audio Recorder with the help of the software tool Audacity. Audacity is an open source software which can be used by anyone without licensing.

The recorded sound is then converted into signals by Audacity and are then fed into MATLAB for Continuous Wavelet Transform (CWT) Analysis and Short Time Fourier Transform (STFT) Analysis. At the end of the process, two output spectrums of the breathing signal is generated with which the presence of Obstructive Sleep Apnea in the subject can be detected.

The aim of this paper is to compare the output spectrums of CWT and STFT and determine the most accurate method of the two.

II. SLEEP APNEA

Apnea literally means "Without Breathing". Thus, Sleep Apnea refers to the condition in which breathing is stopped for a considerable amount of time during sleep. This is a very common disease and is hardly diagnosed and treated. If left untreated, Sleep Apnea can cause severe breathing problems during sleep and may cause death of the person in sleep.

The severity of sleep apnea is assessed based on the value of apnea-hypopnea index (AHI), which is the total number of apnea and hypopnea events per sleep hour. If the value of AHI is greater than 15 then it is moderate, and if the value is greater than or equal to

30 then the person suffer from severe sleep apnea.

III. EXPLANATION OF THE TRANSFORMS

In order to clearly understand the signal, it is found that frequency content of the signal is well understood. For the analysis and processing of breathing sound which is recorded by the sensory audio reader (sensor), the Short Time Fourier Transform and wavelet transform is applied to it. And the programs were developed in MATLAB.

A. Short Time Fourier Transform (STFT)

Short time Fourier transform (STFT) is a Fourier related transform which is used to determine the sinusoidal frequency and phase content of the signal which changes over time. The STFT method is used to analyze the non-stationary signal i.e., it has the property that changes with time. Through a moving window process the longer length signal is divided in to shorter segment of equal length and Fourier transform is computed for each shorter segment signal separately. The frequency band activities of the breathing signal is mapped on to frequency time axis using STFT. In the end all the results of the frequency domain are added together. STFT is defined as,

$$STFT\{x(t)\}(\tau,\omega) \equiv X(\tau,\omega) \equiv \int_{-\infty}^{\infty} x(t)\, w(t-\tau)\, e^{-j\omega t}\, dt$$

In the above equation both t and **τ** are variables,

Where, $w(t-\tau)$ is a real window which determines the portion of $x(t)$ that is used in the computation of $X(\tau,\omega)$.

STFT is the function of two variable, a) the time index, t which is discrete and b) the frequency variable ω which is continuous and it can be viewed in two origins 1) time origin tied to the signal x(t) and the time origin tied to the windowed

Signal, $w(t-\tau)$. It has fixed resolution, the signal is represented based on the width of the window size if the length of the window is wide it gives good frequency resolution but poor time resolution, similarly if the width is narrow then the time resolution is good but poor frequency resolution.

B. Wavelet Transform

The wavelet transform was developed alternative to the STFT, and it is developed to overcome some resolution problem in the STFT. This transform gives time and frequency information of the signal simultaneously. The analysis is similar to that of STFT the only difference is that the signal is multiplied with the wavelet function similar to windowed function in STFT, and the computation of transform is done separately for each different segment of the time domain signal.

In case of wavelet analysis, the windowed technique is done with variable sized region. So the local analysis is performed on the signal with longer duration of time. The time frequency region is replaced by time scale region.

The wavelet transform consist of two parts,

1) *Continuous Wavelet Transform (CWT)*
2) *Discrete Wavelet Transform (DWT)*

CWT is used to produce a spectrum of time scale vs amplitude. DWT is used for denoising.

C. 1-D Continuous Wavelet Transform

CWT measures the similarity between the signal and the analyzing function. It divides continuous time function in to wavelet. The CWT is defined as follows,

$$X(a,b;x(t),\psi(t) = \frac{1}{\sqrt{a}}\int_{-\infty}^{\infty} x(t)\psi^{*}\left(\frac{t-b}{a}\right)dt$$

Where, * denote the complex conjugate

ψ(t)- continuous function in both time and frequency domain called as mother wavelet

The wavelet type may also affect the value of the coefficients. By continuously varying the values of the scale parameter a, and the position parameter b, the CWT coefficients X (a, b) can be obtained. By multiplying each coefficient with the scale and shifted wavelet yields the constituents wavelet of the original signal. Normally the output X(a, b) is a real valued function when the mother wavelet is complex, the complex mother wavelet convert the CWT to a complex valued function. Comparing the signal to the wavelet at various positions and scales a function with two variable is obtained. The 2-D representation of the 1-D signal create redundancy i.e. ., the signal which is no longer useful for the analysis. The mother wavelet is the small wave, which is the prototype for generating other window function.

The main two differences between STFT and CWT are,

1) The Fourier transform of the windowed signals are not taken i.e., negative frequencies are not computed.
2) The width of the windowed is changed as the transform is computed for every single spectral component.

Based on what the features of the signal to be detected the wavelet can be selected and it must be closely match the signal behavior.

IV. RESULT AND DISCUSSION

The breathing sounds acquired from the normal and OSA patient during wakefulness is analyzed using STFT and 1-D CWT in Mat lab.

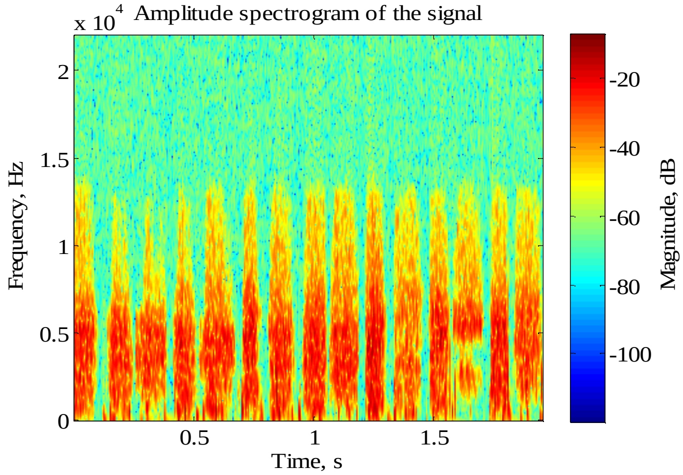

Fig 1 STFT of normal subject

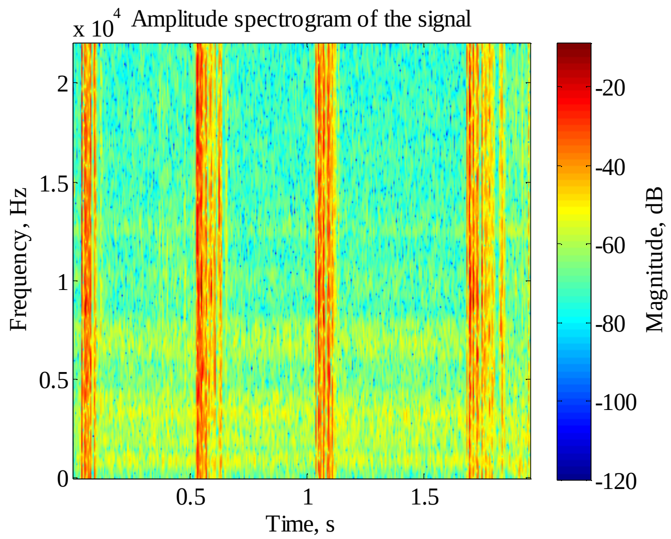

Fig 2 STFT of OSA patient

The STFT represents a comparison between the time and frequency based views of the signal. It provide some information about the when and at what frequency a event of the signal occur. And the information is obtained with the limited precision, and the precision is based on the size of the window.

The drawback is that once we choose particular size for the time window, the size of the window is the same for all frequencies throughout the signal. Many signal require more flexible approach that we can vary the size of the window to determine more accurate either time or frequency we go for CWT.

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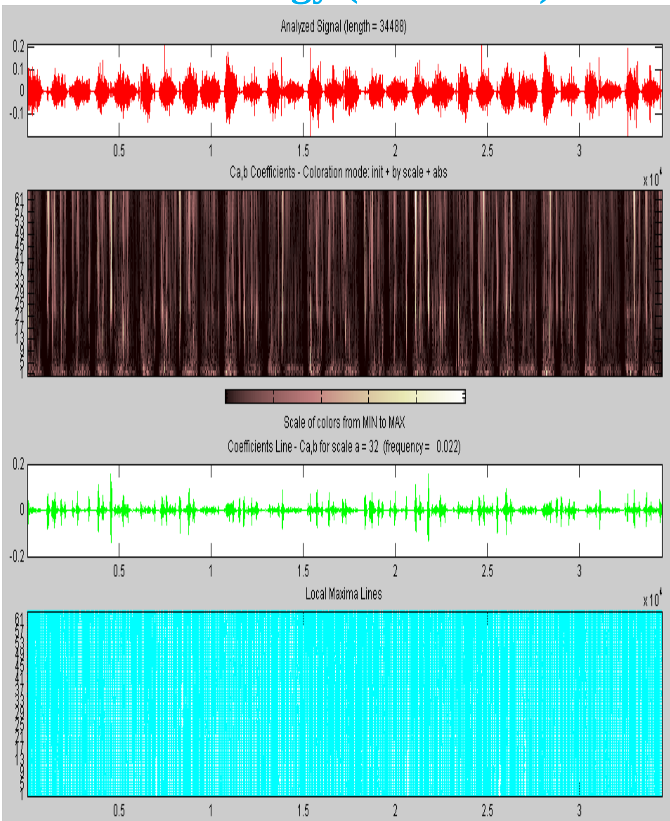

Fig 3 1-D CWT analysis of breathing sound acquired from normal subject

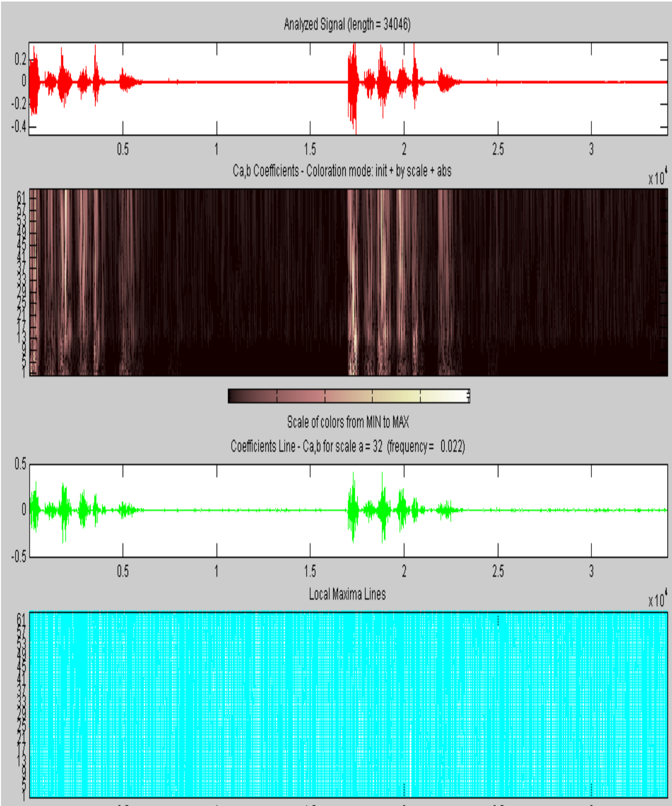

Fig 4 1-D CWT analysis of breathing sound acquired from OSA patient

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In CWT we use windowing technique with the variable sized region. The wavelet analysis does not use the time frequency, but rather a time-scale region is used. The main advantage is that of wavelet is local analysis, it is particularly at making irregularity of the signal. The irregularity may be a discontinuity or a sharp change, the local maxima plot reveal the disturbance in the input data.
The wavelet used was Daubechies 4 and the scale was set to Step by step mode analysis for minimum and maximum levels of 1 and 64 respectively.

V. CONCLUSION

From the results of the application of CWT and STFT on the breathing sounds of the subjects during our study, we can gather ample evidence to conclude that CWT produces better results than STFT when it comes to the analysis of breathing sounds to detect OSA. The main factor that supports this conclusion is the adaptability of CWT. Though the Short-Time Fourier Transform gives uniform resolution in the frequency domain, but this may not be ideal for many applications. The wavelet transform, on the other hand, gives a window that has constant relative error in the frequency domain rather than constant absolute error, at the expense of time resolution. This leads to the conclusion that CWT is better equipped to detect the abnormalities in the breathing sound and thus more helpful in the diagnosis of OSA.

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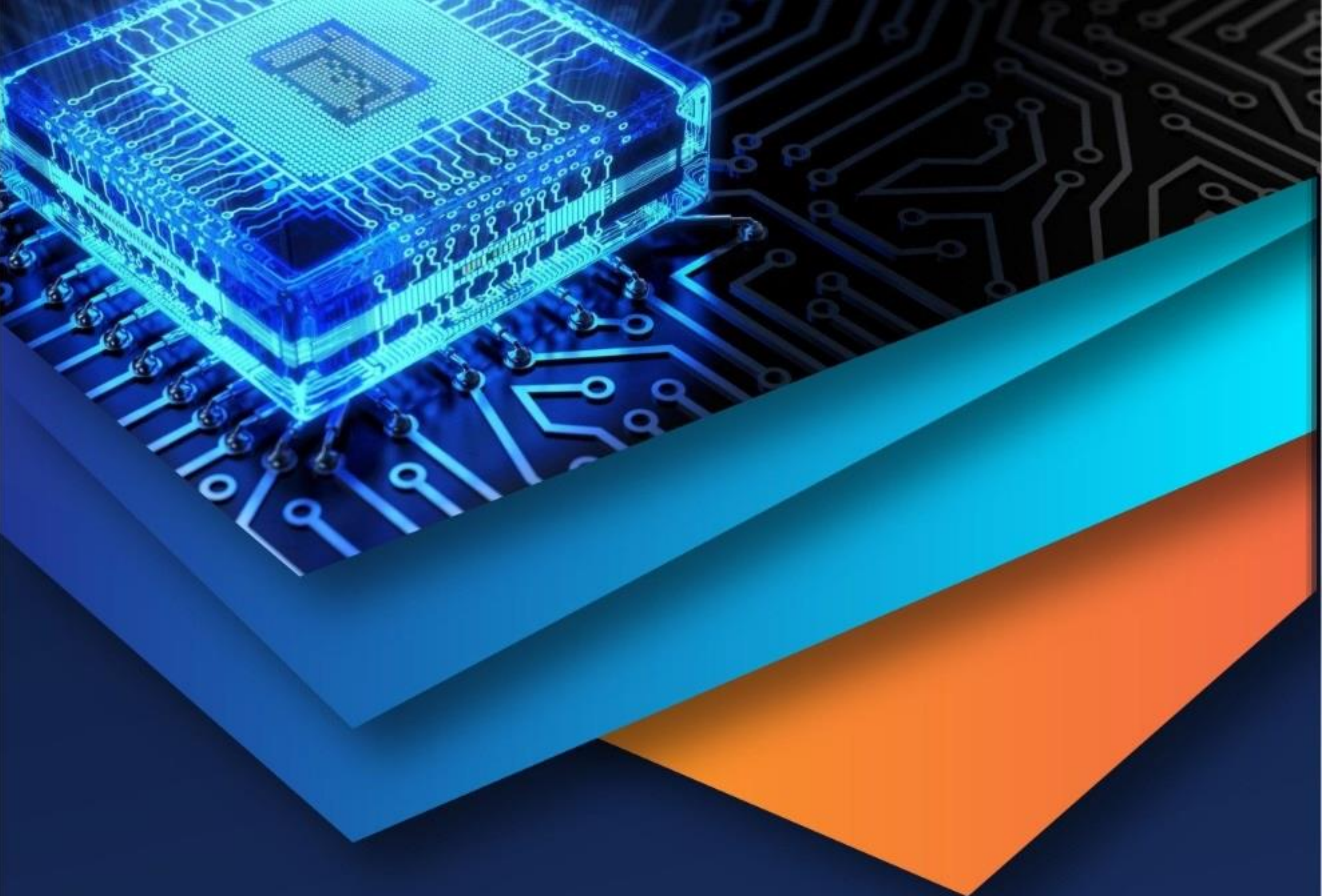
REFERENCES

[1] R. Premkumar, C.Arun,R.Sai Divya, Continuous Wavelet Analysis of the breathing sounds of Obstructive Sleep Apnea Patients and normal subjects during wakefulness, Applied Mechanics and Materials Vol. 622 pp 45-50,2014.
[2] Aman Montazeri, Student Member, IEEE, and Zahra Moussavi, Senior Member, IEEE, Acoustical Screening for Obstructive Sleep Apnea during Wakefulness, IEEE EMBS Buenos Aires, Argentina, August 31 - September 4, 2010.
[3] S de Silva, U R Abeyratne and C Hukins, Impact of gender on snore-based obstructive sleep apnea screening, Physiol. Meas. 33 587–601,2012.
[4] Aman Montazeri, Student Member, IEEE, and Zahra Moussavi, Senior Member, IEEE, Obstructive Sleep Apnea Prediction During Wakefulness, IEEE EMBS Boston, Massachusetts USA, August 30 - September 3, 2011.
[5] Azadeh Yadollahi, Member, IEEE, Ali Azarbarzin,Aman Montazeri, and Zahra Moussavi, Senior Member, IEEE, Acoustical Flow Estimation in Patients with Obstructive Sleep Apnea during Sleep, IEEE EMBS San Diego, California USA, 28 August - 1 September, 2012.
[6] Azadeh Yadollahi, Frank Rudzicz, Aman Montazeri, and T. Douglas Bradley, Variations in Respiratory Sounds in Relation to Fluid Accumulation in the Upper Airways, IEEE EMBS Osaka, Japan, 3-7 July, 2013.
[7] Abdelghani Djebbari, Fethi bereksi reguig, Short-time Fourier transform analysis of the phonocardiogram signal, February 2000.
[8] Patrick J. Wolfe, Short-Time Fourier Transform ES 157/257: Speech and Audio Processing, 2009.
[9] F. J. Nieto, T. B. Young, B. K. Lind, E. Shahar, J. M. Samet, S. Redline,R. B. D'Agostino, A. B. Newman, M. D. Lebowitz, and T. G. Pickering, Association of sleep disordered breathing, sleep apnoea, and hypertension in a large community-based study, J. Amer. Med. Assoc., vol. 283, pp 1829–1836, 2000.



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