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Estimation of Ensembles in an Adventitious Wave by EMD and EEMD Techniques

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Abstract:- The Empirical Mode Decomposition (EMD) is a basic building block of Hilbert-Huang Transformation. The main principle behind EMD is to decompose a sound wave into its intrinsic mode function (IMF). The time domain analysis is fairly described with EMD breaking down. The basis is derived from the same sound wave only. The analysis is useful for affected respiratory sound waves, which are non-linear and non-stationary in nature. Huang and Wu established another milestone in the area of EMD called Ensemble Empirical Mode Decomposition (EEMD). The EEMD is now can be used to interpolate a sound wave from the affected waveform. The EEMD specify a certain TRUE IMF components as an ensemble mean, every component consists of a sound wave in addition to Gaussian Noise of certain amplitude. In this paper, the mean and standard deviation at a different instance of the affected wheezing respiratory wave is discussed. The comparison between crackle wave and the wheezing wave is listed with respect to mean and standard deviation. The results specified in the table shows that the EEMD is an efficient technique for minimizing noise affected with abnormal lung waves.

Keywords:- CAS, DAS, EEMD, EMD, EXTREMA, MINIMA.

I. INTRODUCTION

Analysing and estimating a wheezing sound wave that is degraded by additive Gaussian noise is a primary problem in signal analysis. Usually, sound wave denoising is used to achieve the estimates of the crackle and wheezing waves which are discontinuous adventitious sounds (DAS) and continuous adventitious sounds (CAS) respectively. The estimated signal must be much closer to normal breathing sound wave while retaining the very fine details. Many methods for estimation of the affected adventitious wave have been reported in the survey ranging from linear to nonlinear methodologies. Wiener filter and wavelet transform thresholding techniques are one among them [1]. However, the wavelet transforms based denoising exhibits problem in selecting the wavelet base, threshold function, and its value. In order to minimize these limitations, Huang experimented EMD and Huang and Wu established a new era in EMD by formulating Ensemble EMD. The overall analysis achieves the higher ranking in order to analyse the non-linear and non-stationary wheezing respiratory sound waves.

II. PROPOSED WORK

The two different decomposition techniques are proposed to nullify the noise and to detect the number of ensembles present in the adventitious wave.

A. Empirical Mode Decomposition

The Empirical Mode Decomposition is a basic building block of the Hilbert–Huang transform (HHT) [5]. The HHT can be used to acquire instantaneous frequency spectrum of non-linear and non-stationary adventitious sound waves. These waveforms can also analyse with the help of empirical mode decomposition. The major benefit of EMD is that it is completely due to adventitious wave information itself. The main role of EMD is to decompose an adventitious sound wave into its intrinsic mode function (IMF). Compare to wavelet transformation, the EMD is a superior analysis technique, in which fundamental functions are fixed and thus matching of the real wheezing waves not compulsory[2]. If the following functions are satisfied then it Is called an IMF of adventitious [7].

- In the entire adventitious sound wave, the total number of extrema and the number of baseline crossings must be same or vary at the most by single variation.
- At any adventitious sound wave, the mean is represented by the local maxima and its envelope represented by the local minima is zero.
- The method of identifying an IMF is called sifting.

The sifting procedure is as below.

- Labelling and locating all the extrema in an adventitious sound wave.
- Interpolating all the thus localized maxima to form the upper envelope.
- Same steps may be repeated for localized minima to form a lower envelope.

The EMD technique is explained as below [1].

- Extraction of every localized point of minima and maxima of the adventitious sound wave.
- Formation of Upper and lower envelope by a cubic spline connection of the extrema value formed in the step(1).
- Calculation of the mean and standard deviation of thus formed envelopes.

B. Ensembled Empirical Mode Decomposition

Ensemble empirical mode decomposition (EEMD) is an important modified version of EMD to reconstruct a lung wave from the developed Gaussian noise contaminated wave. EEMD is very much helpful in order to decompose an adventitious sound wave into several intrinsic mode functions (IMFs). Ensemble EMD (EEMD), intern calculates the true IMF components as the mean of an ensemble of trials, every component consisting of adventitious wave and a Gaussian noise of finite magnitude. This is the ensemble approach, occupies the scale naturally without any selection procedure [4].

The EEMD algorithm can be described as below [3].

1. Initialization of the number of ensemble Q, the magnitude of the additive Gaussians noise, and q=1.
2. Add a Gaussians noise to the specified adventitious sound wave, $xq(no)=x(no)+nq(no)$.
3. Apply EMD to the adventitious sound wave $xq(no)$ to derive a set of IMFs $cp,q(no)$ ($p = 1,2,...,n$) and residues $rq(no)$, where $cp,q(no)$ denotes the pth IMF of the qth trial, and n is the number of IMFs [6].
4. Repeat steps (1) and (2) until $q>Q$.

III. RESULTS

The same adventitious waveform of continuous and discontinuous type wave is analysed using both the techniques Empirical Mode Decomposition and Ensemble Empirical Mode Decomposition, the original adventitious waveform is same but the final outputs are different. Total, 14 IMF's along with residual are calculated IMF'S has been calculated. The first step is to set the initial value equal to the original adventitious sound and now exterma of the adventitious sound can be found. Next, establish a connection between all maxima with spline functions to form an upper envelope and also interconnect all the minima with spline functions to form the lower envelope. Now mean and standard deviation can be calculated for both the envelope. Finally, subtract this mean from the input wave. Residual sound wave is calculated and displayed at the end.

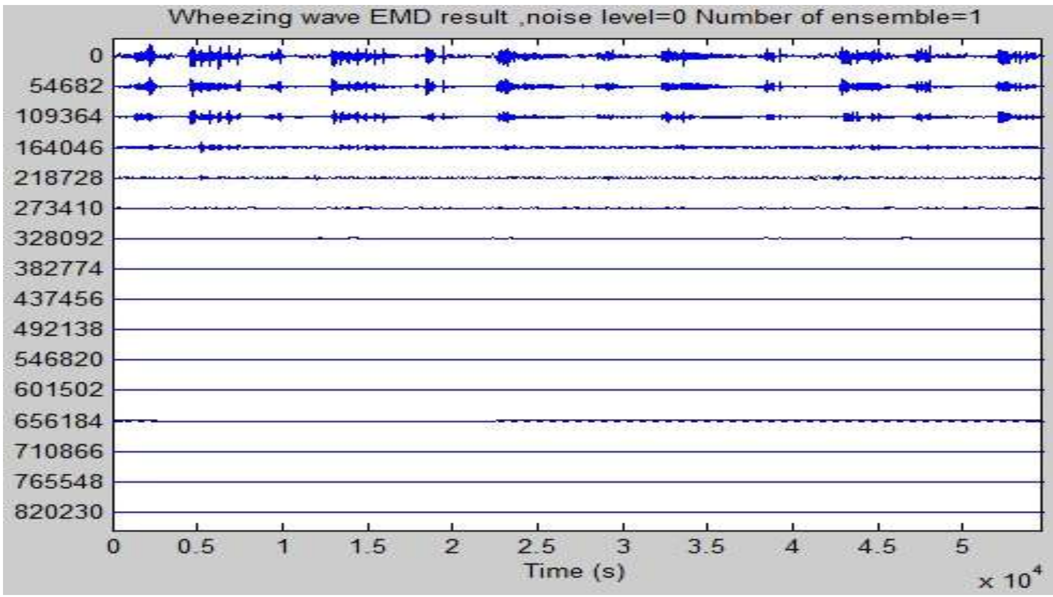

Figure 1.The EMD IMFs of the correlative CASRSW: the variations by the wheezing wave can be seen in the almost regular amplitude variations in the first three IMFs (from the top down)

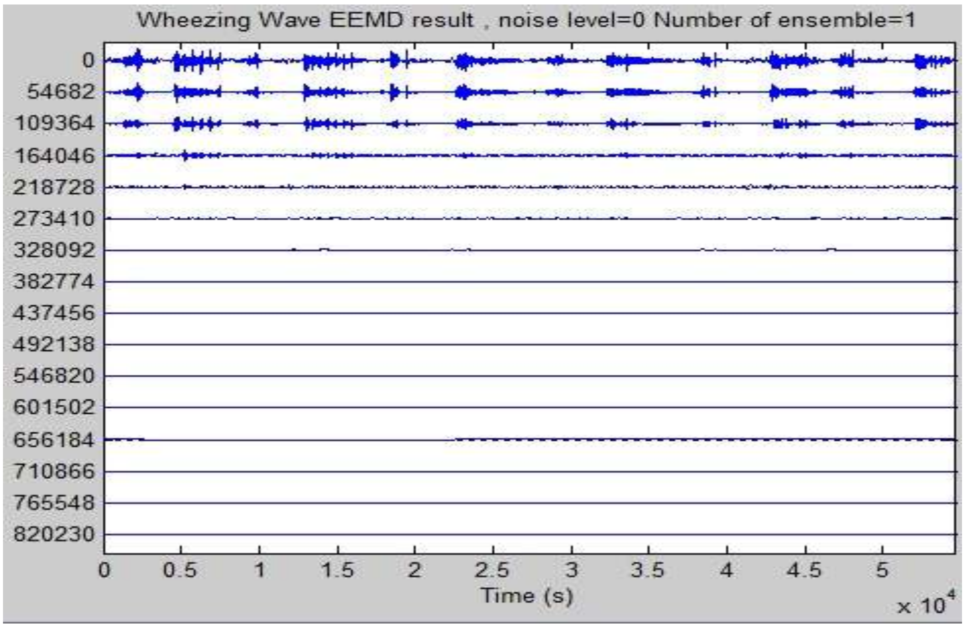

Figure 2. The EEMD IMFs of the correlative CASRSW: the variations by the wheezing wave can be seen in the almost regular amplitude variations in the first three IMFs (from the top down).

The mean and standard deviation at different instance of wave is observed and listed in the below tables

```
Column 0          mean: 316.318830        sd: 116.467019
Column 1          mean: 848.776372        sd: 346.492988
Column 2          mean: 2591.745202       sd: 361.313958
Column 3          mean: 3776.036850       sd: 431.216165
--------------------------------------------------------------
Statistics of CASRSW computed between 0.0 and 2.809251700680272
(n=276)
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The above statistical result gives the sample standard deviation for CASRSW is 136.77 and Mean (Average) of 313.5. The below statistical result gives the sample standard deviation for DASRSW is 208.62 and Mean (Average) of 183.5

IV. CONCLUSIONS

The primary task of the article is to find out a number of IMF's with residual. The minimizing the noise level and extracting the number of ensembles in an adventitious sound wave is the next process. The comparison between EMD and EEMD at different SNR values in an asthmatic patient is analyzed and observed similar kind of wave pattern and also gives the same amount of ensembles in both the cases. However, the mean and standard deviations for continuous and discontinuous wave pattern gives the distinguishable data. Experimentally, It is noticed that the EEMD technique is a suitable for both the type of adventitious respiratory sound waves.

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