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Analysis of Enhancement Speech Compression using various Wavelets

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Abstract—Compression plays a important role in communication system. It gives the compact data representation which allows the transmission and efficient storage of signal. Four different speech signals are investigated using Haar wavelet, Biorthogonal wavelet, Discrete approximation of Meyer wavelet, Coiflet wavelet and Symlet wavelet. Spectral subtraction is also performed for enhancement of the signals before using wavelets. On the basis of calculated performance metrics it is found that symlet wavelet gives better results.

Keywords- *Compression; Haar wavelet; Biorthogonal wavelet; Discrete approximation of Meyer wavelet; Coiflet wavelet; Symlet wavelet;*

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I. INTRODUCTION

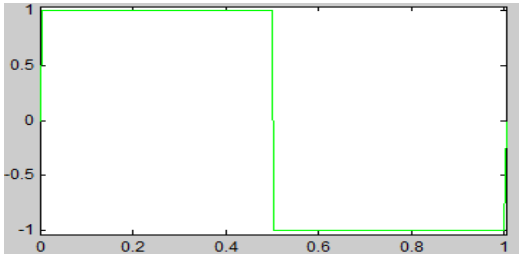
Speech signal contains large number of redundant information, compression of high quality speech at low bit rates is still a important topic to be discussed. Compression helps in reducing the cost for the transmission and required less storage space. By achieving fair amount of compression more number of samples can be transmitted using given bandwidth. The compression should not achieved by degrading the quality of signal. To reduce redundancy and make full use of the human's auditory masking effect by using a variety of source coding techniques, not only can compress the coding rate by many times, but also has the ability to regain high intelligibility and acceptability of speech signals. Therefore a speech compression system focuses on reducing the amount of redundant data while preserving the integrity of signals.[1] [2]
A variety of approaches have been suggested to resolve the various speed related issues. Speech processing involves voice encoding, synthesis, recognition, speaker recognition and verbal language translation. Speech encoding ensures encoded transmission over the channel [3].
Wavelet transform has an excellent resolution in both time and frequency domain. Wavelet transform with detail of signal, decomposes the high-frequency, and the signal was decomposed to the time-frequency space which has a certain correspondence with critical band of speech. The result of wavelet transform is called wavelet coefficients. The coefficients conversion of wavelet can classify into two types, Continuous Wavelet Transform (CWT) and Discrete Wavelet Transform (DWT) [4, 5]. There are some related researches works which have used wavelet transform for speech compression. In [6], author explores the DWT as a tool for speech recognition which studies the recognition of isolated words in Hindi Language speech. The mother wavelets are selected to use 3 families, Daubehies (db), Coiflets (coif) and Discrete Meyer Wavelet (dmey). It is found that Daubechies 10, 5- level decomposition and the Discrete Meyer wavelet give comparable performance, while the Daubechies 8, 3-level decomposition provides the poorest performance. In [7] presents reliable measures of speech compression by detecting the end points of the speech signals prior to compressing them.

Each family of wavelets are wavelet subclasses distinguished by the number of filter coefficients and the level of iteration . wavelets are most often classified within a family by the number of vanishing moments.
Wavelet families have selected for speech compression. These details are followed.

A. Haar wavelet(Haar)

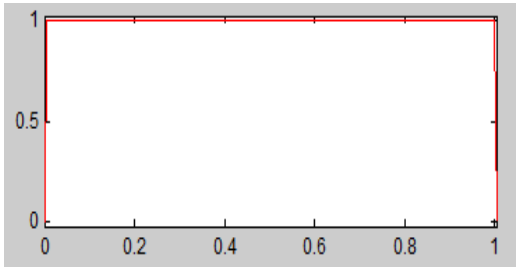
Haar is the compactly supported ,oldest and simplest wavelet . Haar is same as db1. The mother wavelet of haar ψ(x) can be described as the equation[4]

$$\Psi(x)= \begin{cases} 1 & 0< t < 0.5 \\ -1 & 0.5 < t <1 \\ 0 & \text{otherwise} \end{cases}$$



B. Biorthogonal wavelet(Bior)

In Biorthogonal wavelet symmetry and exact reconstruction are possible with FIR filters but in case of orthogonal it is impossible except for Haar.[4]



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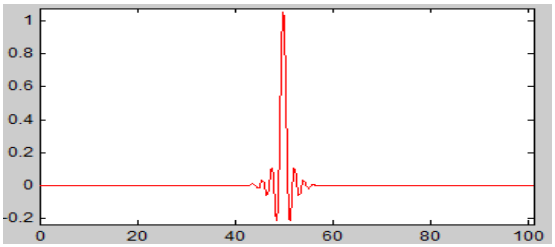
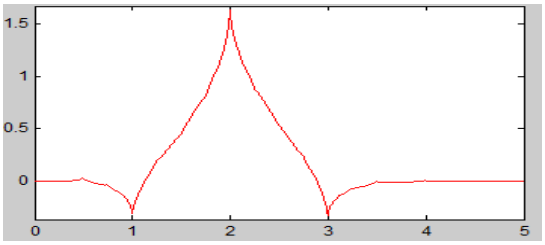
C. Discrete approximation of Meyer wavelet (Dmey)

FIR based approximation of the meyer wavelet. This wavelet is compactly supported. CWT and DWT is possible in this wavelet.[4]



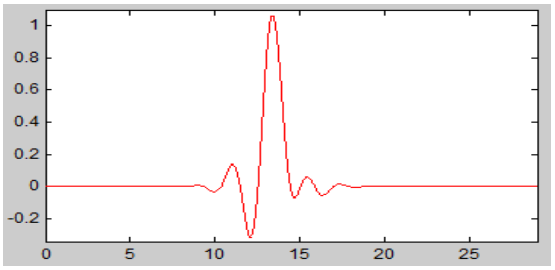
D. Coiflet wavelet(Coif)

Coiflet wavelet is the function which is compactly supported with highest number of vanishing moments for both phi and psi for a given support width.[4]



E. Symlet wavelet(Sym)

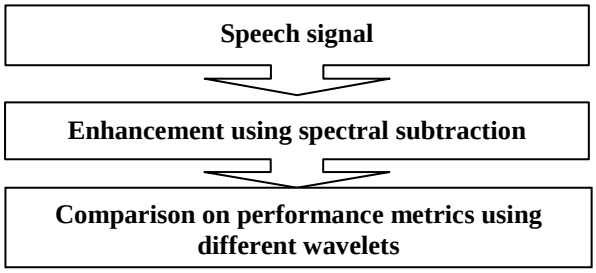
Sym is wavelet function which is compactly supported with least asymmetry and highest number of vanishing moments for a given support width.[4]



II. PERFORM METHODOLOGY

Four different speech signals having different remarks are taken as input. The raw speech signal may contain some type of noise like additive noise or Gaussian noise. It is important to discard this noise because it may effect on signal quality as well on compression ratio therefore spectral subtraction of the speech signals is performed to remove the noisy content. In spectral subtraction, the incoming signal is buffered and divided into segments of *N* samples length. Each segment is windowed, using a Hanning or a Hamming window, and then transformed via discrete Fourier transform (DFT) to *N* spectral samples.The windows alleviate the effects of the discontinuities at the endpoints of each segment.

The enhancement of speech signals using spectral subtraction is performed. There may be some kind of noise present in the signal it is important to discard the noisy portion of the signal before compression with the help of spectral subtraction by using DFT and IDFT. Somewhat compression may also be achieved by removing the more noisy content which is unnecessary.



Speech coders attempt to minimize the bit rate for transmission or storage of the signal to maintain the required levels of speech quality, communication delay, and complexity of implementation. Analysis of the compression is performed by comparing the compressed and decompressed signal against the original signal [7].The adopted techniques are evaluated both objectively and subjectively. Objective analysis is done by evaluating the performance of parameters such as Compression Ratio (CR), Peak Signal to Noise ratio (PSNR), and Normalized Root Mean Square Error Rate (NRMSE) [7]. Subjective analysis is based on hearing the reconstructed signal and making the judgment which is done by Mean Opinion Score (MOS) [8]. These parameter values are very significant in efficient compression algorithms and they are explained below.

A. Compression Ratio(CR)

$$CR = \frac{Length(x(n))}{Length(r(n))}$$

Where x(n) is the original signal and r(n) is the reconstructed signal.

B. Peak Signal to Noise Ratio(PSNR)

$$PSNR = 10\log_{10}\frac{NX^2}{||x-r||^2}$$

Where N is the length of the reconstructed signal, X is the maximum absolute square value of the signal x and ||x-r||2 is the energy of the difference between the original and reconstructed signals.

C. Normalized Root Mean Square Error (NRMSE)

$$NRMSE = \sqrt{\frac{(x(n)-r(n))^2}{(x(n)-\mu x(n))^2}}$$

Where *x(n)* is the speech signal, *r(n)* is the reconstructed signal, and $\mu x(n)$ is the mean of speech signal.

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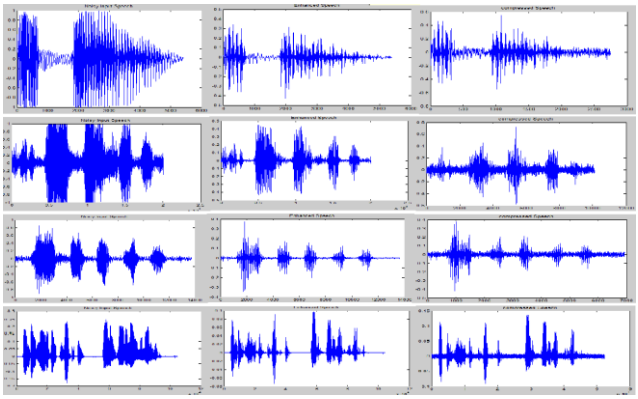

The first column presents the four different types of input signals in this noise is included and the second column presents the noise free signals which is enhanced by spectral subtraction method and the third column presents the compressed signals. compression is performed by using DWT.

III. RESULTS

Results obtained on the basis of performance metrics which are explained above by using different wavelet are shown in figure. The tabular representations and the graphs of the signal obtained after third and final stage are shown. The comparison is made on the basis of Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR) and Compression Percentage.

Performance evaluation based on PSNR

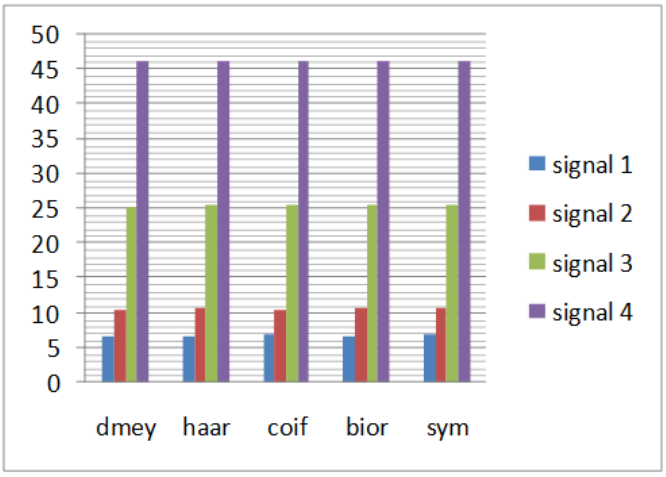

Table 1. Performance based on PSNR

	signal 1	*signal 2*	*signal 3*	*signal 4*
dmey	6.6662	10.6078	25.4279	46.0774
haar	6.683	10.6613	25.4942	46.1899
coif	6.8972	10.5003	25.5076	46.2148
bior	6.6366	10.6553	25.5909	46.2993
sym	6.9338	10.6723	25.61	46.3033

Performance evaluation based on MSE

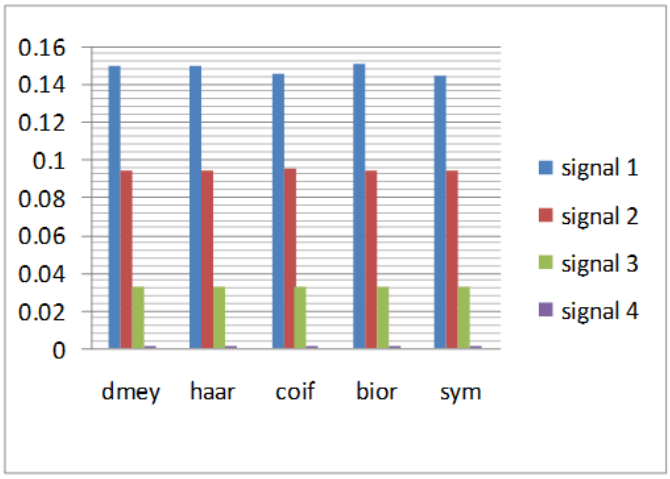

Table 2. Performance based on MSE

	signal 1	*signal 2*	*signal 3*	*signal 4*
dmey	0.15	0.0943	0.0329	0.0012
haar	0.1496	0.0938	0.0328	0.0012
coif	0.145	0.0952	0.0326	0.0012
bior	0.1507	0.0939	0.0326	0.0012
sym	0.1442	0.0937	0.0326	0.0012

Performance evaluation based on compression percentage

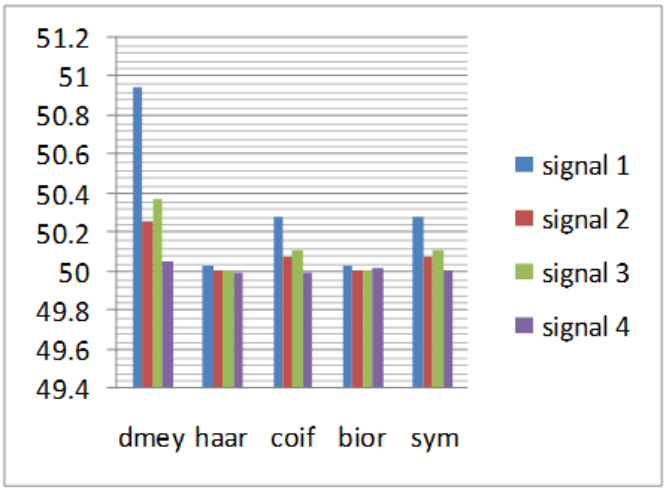

Table 3. Performance based on COMPRESSION PERCENTAGE

	signal 1	*signal 2*	*signal 3*	*signal 4*
dmey	50.9528	50.2563	50.3704	50.0492
haar	50.0278	50.0075	50.0073	50.0014
coif	50.2868	50.0771	50.1089	50.0014
bior	50.0278	50.0075	50.0073	50.0148
sym	50.2868	50.0771	50.1089	50.0038

IV. CONCLUSIONS

In this paper, a hybrid approach is proposed to compress the speech signal. The noise reduction over the signal is done at the first stage and at second level, the signal compression is achieved by using different wavelets. Wavelets which I used are; Haar wavelet; Biorthogonal wavelet; Discrete approx-imation of Meyer wavelet; Coiflet wavelet and Symlet wavelet. Among these wavelets good compression ratio with adaptive PSNR and MSE ratio is obtained by using Symlet as compare to the other wavelets. As there is some loss in the speech quality because it is the lossy compression. In the future, work can be done for the improvisation of the speech quality.

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