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Transform Domain Techniques for Denoising of Signals: A Review

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ABSTRACT

One of the important research areas in signal processing is removing noise from noisy signals. Denoising of signal addresses the problem of removing noise from noisy signal. This paper reviews various transform domain techniques for denoising of noisy signals. An over view on DFT, DCT and DWT are also presented in this paper. Simulation results are carried out using MATLAB by considering various signals. From the results it is observed that the significant amount of noise is removed from the noisy signals.

KEYWORDS: *Denoising of signals, DFT, DWT*

INTRODUCTION

Audio is mixed with different types of noise during transmission of audio. Removing of the noise which is mixed with audio signal is called denoising. The main aim of this technique is to remove noise without modifying the audio signal. The DWT, DFT, DCT techniques are used to remove the noise from the audio signal using MATLAB. There are different types of systems which are useful to remove the unwanted noise from speech signals One of the important system is Audio reduction system. This is classified into two types namely complimentary and non complimentary techniques. Non complimentary technique is used to compress the noise of recorded Audio signal And complimentary technique is used to compress the noise of live recording Audio signal .

Noise is classified into two types namely "External Noise" and "Internal Noise"

EXTERNAL NOISE :- External noise is also known as Manmade noise or Natural noise

- Natural noise : noise gets generated due to either natural phenomenon or atmospheric actions like Solar flares,Electronic storms, Radiation from space etc…
- Manmade Noise : The noise which is made by human beings like vehicle sounds, Electric motors, High-current circuits etc.. This is also known as Industrial Noise.

INTERNAL NOISE: It is generated from Electronic equipment involved in the system itself. Internal noise is classified into few types.

- Thermal noise:-
  This is due to the random movement of the Electrons.
- Transits time noise :-
  It is also known as High-frequency noise. This noise is generated due to delay in time.
- Shot Noise :-
  Shot Noise occurs when the finite number of particles that carry energy, such as electrons in an electronic circuit or photons in an optimal device.

APPLICATIONS:-

- These are used in Mobile Communication.
- These are used in data communication
- Remote sensing
- Almost all communication applications

In this paper, in order to remove noise from the corrupted signals, we have discussed the techniques using DCT, DFT and DWT. This paper is organized into 5 sections. Section II presents about literature survey. An overview on DFT, DCT and DWT is presented in section III. Simulation results are presented in section IV. Finally, the conclusions drawn from this work is presented in section V.

LITERATURE REVIEW

Recovering the desired speech or sound signals corrupted by Additive White Gaussian Noise has been of interest to many researchers during the last few years [1]. The technique for removing of AWGN is difficult as it preserves at all the frequencies in the signal. The popular methods of denoising signals are based on either adaptive filter algorithms or based on transform domain techniques. Spectral audio denoising methods usually make use of the magnitudes of a time-frequency representation of the signals discussed in paper [1]. The scheme requires to minimize a cost function composed of a diagonally weighted quadrature data term. The performance and the influence of the parameters through experiments on Wavelet based algorithm for audio denoising is presented in paper [2]. Their work focused on audio signals corrupted with white noise. White noise is especially hard to remove because it is located in all frequencies. The authors used Discrete Wavelet Transform (DWT) to transform noisy audio signal in wavelet domain. It was assumed that signal is represented by high amplitude DWT coefficients and noise is represented by low amplitude coefficients. To get audio signal with less noise, thresholding of coefficients are used and they are transformed back to time domain. The authors proposed modified universal thresholding of coefficients which results with better audio signal. This denoising algorithm worked better for lower noise signals but for higher noise signals higher threshold must be set.

OVERVIEW ON DFT, DCT AND DWT

Signal denoising is carried out using DFT, DCT and DWT. Hence, brief overview on these transforms is given in this section.

a)Discrete Fourier Transform

Discrete Fourier Transform (DFT) is one of the most important tools in digital signal processing and digital image processing[1,2,3]. It is used to derive a frequency-domain (spectral) representation of the signal. Fast Fourier Transform is used to compute DFT electively by reducing the number of computations.

The N-point DFT Xk of a signal xn is given by

$$X_k = \sum_{n=0}^{N-1} x_n e^{-j2\pi kn/N} \qquad k = 1, 2, \ldots, N$$

And inverse DFT is given by

$$x_n = \frac{1}{N} \sum_{k=0}^{N-1} X_k e^{j2\pi kn/N}$$

b) Discrete Cosine Transform

Discrete Cosine Transform of signal f(x) of N points is given by

$$C(u) = a(u) \sum_{x=0}^{N-1} f(x) \cos\left[\frac{(2x+1)u\pi}{2N}\right]$$

$$u = 0,1,\ldots,N-1$$

$$a(u) = \begin{cases} \sqrt{\frac{1}{N}} & u = 0 \\ \sqrt{\frac{2}{N}} & u = 1,\ldots,N-1 \end{cases}$$

c) Discrete Wavelet Transform

In wavelet analysis, the Discrete Wavelet Transform (DWT) decomposes a signal into a set of mutually orthogonal wavelet basis functions [1]. These functions differ from sinusoidal basis functions in that they are spatially localized. Further, wavelet functions are dilated, translated and scaled versions of a a common

function ϕ, known as the mother wavelet. The discrete wavelet transform has a large number of applications in science, engineering, mathematics and computer science. It is widely used for signal coding, data compression and denoising applications

The expressions for Continuous wavelet transform [2] is given by

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

The expressions for Continuous wavelet transform is given by

$$T_{m,n} = \int_{-\infty}^{\infty} x(t)\, \psi_{m,n}(t)\, dt$$

Wavelet transforms are broadly divided into three classes namely continuous, discrete and multiresolution based wavelet transforms[7].

SIMULATION RESULTS

This section presents simulation results of denoising techniques using DFT, DCT and DWT. MATLAB is used to carry the simulations. In the first simulation, we have generated a 20 Hz sinusoidal signal. This signal is corrupted by random noise of variance 0.8. DFT of the corrupted signal is computed using FFT. From DFT, power spectrum is computed. Select the significant frequency components using thresholding technique. Make all the non significant frequency components to zero. Reconstruct the signal with the significant frequency components. Since higher frequency components are removed. Noise is filtered out. The results are shown in Fig.1.

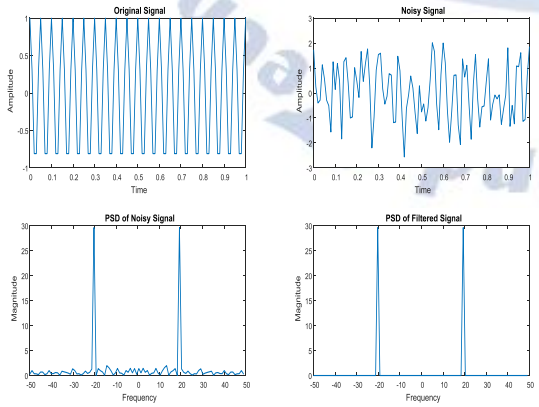

Fig. 1. Denoising of noisy signal using DFT technique

In the second simulation experiment, we have generated a sinusoidal signal of 10 Hz and it corrupted by noise of variance 0.5. 'sym8' wavelet is used to decompose the signal at level 5. High frequency components are removed and reconstruction is done with the low frequency components. The results are shown in Figs.2 and 3.

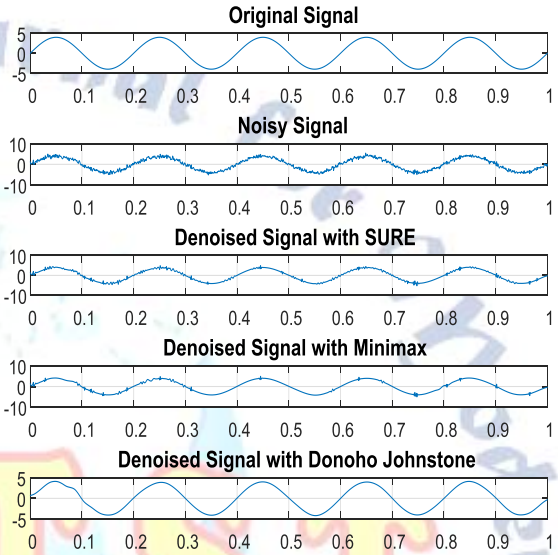

Fig.2. Results of denoising using DWT

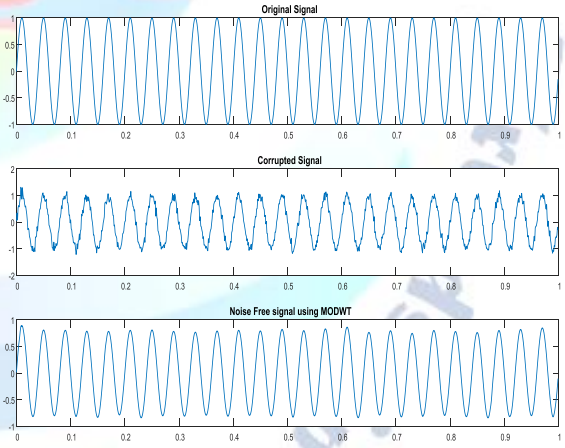

Fig.3. Results of denoising using MODWT

CONCLUSIONS

This paper presents a review on transform domain techniques for denoising of signals corrupted by amount of noise. Overview on DFT, DCT and DWT techniques reviewed in this paper. Simulation results are carried out using the techniques with DFT and DWT. From the results it is observed that significant amount of noise is removed. Our future work will be towards real time denoising of signals.

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