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Estimation of Different Thersholding Techniques for Signal Denoising

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Abstract **— In almost every area of science and technology, signals must be processed to facilitate the extraction of information. Thus, the development of signal processing techniques and systems is of great importance. These techniques usually take the form of a transformation of a signal into another signal that is in some sense more desirable than the original. In this paper, when we decompose a data set using wavelet, we use filters that act as averaging filters & others that produce details. Some of resulting wavelet wavelet coefficients corresponds to detail in data set. If details are small, they might be omitted without substantially affecting the main features of data set. Then thresholding is used to set to zero all coefficients that are less than particular threshold. These coefficients are used in an inverse wavelet transformation to reconstruct data set. Hence with the help of WT the noise is removed from the signal.**

Keywords **— DT, SNR, PSNR, ST, HT.**

I. Introduction

Digital Signal Processing, a field which has its roots in 17^{th} and 18^{th} century mathematics, has become an important tool in a multitude of diverse fields of science and technology. The field of digital signal processing has grown enormously in the past decade to encompass and provide firm theoretical backgrounds for a large number of individual areas.

The term “digital signal processing” may have a different meaning for different people. For example, a binary bit stream can be considered a “digital signal” and the various manipulations, or “signal processing”, performed at the bit level by digital hardware may be construed as “digital signal processing”. But, the viewpoint taken in this thesis is different. Implicit in the definition of digital signal processing (DSP) is the notion of an information-bearing signal that has an analog counterpart. What are manipulated are samples of this implicitly analog signal. Further, these samples are quantized, that is represented using finite precision, with each word representative of the value of the sample of an (implicitly) analog signal. These manipulations, or filters, performed on these samples are arithmetic in nature – additions and multiplications. The definition of DSP includes the processing associated with sampling, conversion between analog and digital domains, and changes in word length. Digital Signal Processing is concerned with the representation of signals by sequences of numbers or symbols and the processing of these sequences. The purpose of such processing may be to estimate characteristic parameters of a signal or to transform a signal into a form which is in some sense more desirable.

II. Literature Survey

2.1. Based on Discrete Wavelet Transform (DWT):

In 2005, Gordan Cornelia used wavelet transforms as tool for processing non stationary signals like ECG signals. R. F. Von Borries developed two channel filter banks to remove effectively the base line drift and S. Z. Mahmoodabadi demonstrated the filtering of ECG signal by using Db4 and Db6 at higher scales to preserve various components of ECG signal. The distortion of R morphology occurs in classical wavelet approach and this drawback is removed by A Choukari by applying their algorithm on detail coefficients of both noise free ECG signal and ECG signal corrupted with WGN. The authors claimed that the performance of their algorithm is superior compared to classical wavelet transform in restoring P and T waves without distorting R morphology. But the limitation is that it heavily depends upon the presence of the R waves in the first level of approximation of the noisy ECG signal.

Again in 2006, S. A. Choukari used second level decomposition for detecting QRS complex and fourth and fifth level of decomposition for detecting P and T waves. They compared the performance of their algorithm with db5, db10, coif5, sym6, sym8, biorth5.5 by calculating MSE and SNR. This algorithm works effectively at low SNR to remove various noises but the main limitation is the presence of huge base line wonder .A robust QRS detection algorithm can be used for removing baseline wonder.

In 2007, M. Kania studied the importance of the proper selection of mother wavelet with appropriate number of decomposition levels for reducing the noise from the ECG signal. The authors claim that they obtained good quality signal for the wavelet db1 at first and fourth level of decomposition and sym3 for fourth level of decomposition.

In 2008, C. Saritha have identified different types of abnormalities using daubechies wavelets in MATLAB environment. D.T Ingole used Dyadic wavelet Transform for extraction of ECG features, which is robust, highly efficient, accurate and reliable. Fayyaz A. Afsar proposed a method which is robust to noise based on DWT and PCA for classifying six different types of beats from the ECG. The merits of this algorithm are less complexity, good accuracy and time saving.

In 2009, Tan Yun-fu used Daubechies and symlet wavelets for the removal of various kinds of noises present in the ECG signal and reconstructed ECG signal with minimum distortion at faster rate. Abed Al Raof Bsoul

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used two mother wavelets namely Haar for the detection of QRS morphology and db2 for the detection of P and T waves at fourth decomposition level to obtain high accuracy.

In 2010, Abdel-Reman used the high pass filtering for noisy signal before reconstruction by inverse discrete wavelet transform (IDWT).This algorithm is very robust for noise removal and it does not smoothens QRS complex. Ruchitha Goutham have demonstrated the application of DWT for QRS complex detection. Naregalkar Akshay demonstrated the application of UWT for base line wonder removal and QRS morphology detection in LABVIEW environment. Antonio used wavelet transform to detect the R-wave and wavelet segmentation approach for the extraction of ECG features.

2.2 Based on Fast Wavelet Transform (FWT):

In 2008, Rizzi proposed and implemented an algorithm called R-point detector based adaptation of fast parallelized wavelet transforms for the detection of R-wave in the presence of different types of noises. The algorithm gives high degree of noise immunity and predictivity.

2.3 Based on Multiwavelet Transforms:

In 2009, Jeong Yup Han proposed a new translation invariant method called multiwavelet transform to filter the noise from ECG without significant distortion of ECG morphology and characteristic features.

2.4 Based on Shrinkage and Threshold Methods:

In 2005. Donghui Zhang demonstrated the application of DWT and level dependent thersholding methods for removal of low frequency base line wander and high frequency noise interferences respectively. S. Poornachandra proposed a new modified hyper-shrinkage function for analysis of complex biosignals.

In 2008, proposed an efficient wavelet based shrinkage method to filter out the power line frequency. According to the authors the proposed algorithm is simple to implement in real time application, involves less computational complexity and gives better visual display. I Motoki Sakai treated EEG signal as noise component and applied wavelet shrinkage algorithm to remove the EEG from ECG signal. In 2009, Yang Ying proposed a new shrinkage function for denoising ECG signal and compared the results with various shrinkage functions. Their proposed method gives better results they claimed. In 2010 L. N. Sharma have proposed ECG processing method based on higher order statistics at different wavelet sub bands to analyze the statistical nature of the signal in time- frequency domain. The kurtosis and energy contribution of the sub bands combined to assess the noise quantity in the signal and Zaffery Z.A have evaluated the performances of four different threshold estimators rules in the application of denoising the ECG signal in the MATLAB7 environment .The simulated results show that the universal method performs better at all SNR.

III. De-Noising Procedure Principles

The general de-noising procedure involves three steps. The basic version of the procedure follows the steps described below.

1. Decompose
   - Choose a wavelet, choose a level N. Compute the wavelet decomposition of the signal s at level N.
2. Threshold detail coefficients
   - For each level from 1 to N, select a threshold and apply soft thresholding to the detail coefficients.
3. Reconstruct
   - Compute wavelet reconstruction using the original approximation coefficients of level N and the modified detail coefficients of levels from 1 to N.

Two points must be addressed: how to choose the threshold, and how to perform the thresholding. Following threshold estimators on the denoising of ECG signal.

(a) Universal Thresholding:

This is proposed by Donoho. The threshold value T is given by

$$T = \sqrt{2 * \log(n)}$$

where, n is the number of samples in the signal.

(b) Hard Thresholding:

In 1995 Donoho developed the hard shrinkage function & given by formula

$$\hat{Y} = \begin{cases} 0 & |Y| < T \\ Y & |Y| > T \end{cases}$$

Hard thresholding is the simplest method. Hard thresholding can be described as the usual process of setting to zero the elements whose absolute values are lower than the threshold. Soft thresholding is an extension of hard thresholding, first setting to zero the elements whose absolute values are lower than the threshold, and then shrinking the nonzero coefficients towards 0, the hard procedure creates discontinuities at Y = ±T

(c) Soft thresholdling:

In 1995 Johnston developed the soft shrinkage function & given by formula

$$\hat{Y} = \begin{cases} 0 & |Y| < T \\ Y - T & Y > T \\ Y + T & Y < T \end{cases}$$

In soft thresholding, in addition to that the remaining coefficients are also reduced linearly. Soft thresholding is an extension of hard thresholding, first setting to zero the elements whose absolute values are lower than the threshold, and then shrinking the nonzero coefficients towards 0.

(d) Firm Thresholding:

The derivation of standard soft shrinkage function is not continuous. Both hard and soft shrinkages have advantages and disadvantages. The soft shrinkage estimates tend to have a bigger bias, due to the shrinkage of large coefficients. Due to the discontinuities of the shrinkage function, hard shrinkage estimates tend to have a bigger variance. In other words, it will be sensitive to small changes in the signal. To overcome the drawbacks of hard and soft shrinkage, a firm shrinkage function was introduced by Gao and Bruce & given by the formula

$$\hat{Y} = \begin{cases} 0 & |Y| \le T_L \\ sgn(Y)\left[\frac{T_{H(|Y|-T_L)}}{(|Y|-T_L)}\right] & T_L < |Y| < T_H \\ Y & |Y| < T_H \end{cases}$$

Where, T2 is decided by formula (1), the scope of T1 is 0~T2. According to the previous experiments when T1 equals 2/3T2, the denoised results would be better. The shrinkage function is continuous and approaches the identity line as |Y| increase. The firm shrinkage function provides a good compromise between the hard and the soft shrinkage function.

The firm shrinkage is less sensitive than hard shrinkage to small fluctuations and less biased than soft shrinkage.

(e) Yasser thresholding:

In 2006 Yasser presented an improved threshold shrinkage function as formula (5). (named Yasser shrinkage function) & given by formula

$$\hat{Y} = \begin{cases} Y & |Y| \ge T \\ sgn(Y).\frac{|Y|^{\gamma}}{T^{\gamma-1}} & |Y| < T \end{cases}$$

Where, the value of T is decided by formula given by Donoho. The Yasser shrinkage just shrinks the wavelets coefficients which are lower than threshold and it keep the continuing of function. γ=3 was used to finish the speech signals denoising and obtained good results.

The shrinkage expressed by firm & Yasser, combined the advantages of hard shrinkage with soft shrinkage, possess better results in signal denoising. But it wasn't designed for ECG signal specially and could not obtain the best result in denoising processing. For firm shrinkage, the denoised result of ECG signal is closely to hard shrinkage when contamination is slight. For Yasser shrinkage, the denoised signal can't be smooth enough when contamination is serious.

IV. Conclusion

The denoising effects for clangorous graph signal mistreatment totally different functions were compared here. The results show that the shrinkage operate planned during this work is incredibly sensible at signal denoising. Not solely will it get the very best SNR, however additionally keep the similarity and smoothness of denoised signal. In fact, this operate can also be used for every kind of signals denoised. the advance of signal to noise quantitative relation for planned methodology proves that this can be powerful technique for denoising of non-stationary signals like graph signals. The planned threshold and shrinkage operate is helpful whereas process the graph signal and to boost S/N (SNR) for getting clean recordings and preserve the initial form of signal, particularly the peaks, while not distorting the waves and segments. the most task is to recover a real graph signal from clangorous recording and with success achieved by the planned methodology.

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