Efficient Noise Removal in Images using Adaptive Matched Partial BWT

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Abstract **- Reducing the amount of noise from images affected with Gaussian noise is one of the major problems in image processing besides the issue of dealing with images of unwanted large size. In this paper image compression and denoising is performed using simulated noise images with various characteristics with the help of new biorthogonal filter banks (BFB). The exquisite features of wavelet transforms are utilized in the area of image processing which perform better compared to other transforms. We present a method to design partial biorthogonal wavelet bases and report on their potential for denoising. Simulated noise images are used to evaluate the denoising performance of proposed filters with the help of Bayes Shrink algorithm and Set Partition In Hierarchical Trees (SPIHT) algorithm for image compression along with another wavelet-based denoising like Cohen-Daubechies-Feauveau(CDF 9/7). Experimental results show that the proposed noise removal method outperforms standard wavelet denoising techniques in terms of the PSNR (Peak Signal to Noise Ratio) and the preservation of edge information. Several comparisons of images based on PSNR are done with different filter specifications. Also displaying a slight improvement over the proposed noise reduction technique by adaptive threshold setting for the images according to the image's varied features.**

Index Terms—Wavelet transforms, Biorthogonality, image compression, image denoising.

I. INTRODUCTION

An image is often corrupted by noise when it is obtained and also during when it is transmitted. The purpose of Image denoising is to reduce the additive noise while keeping intact as much as possible important features of the image. In the recent years there has been some amount of research on wavelet thresholding and threshold selection for signal de-noising because wavelet provides an appropriate method for separating noisy signal from the image signal. Wavelet transforms are used in the field of image processing because of their varied advantages.

They have proved to perform much better than other transforms .A very outstanding property of wavelet transforms is its tree structure which helps in the area of image compression as it achieves a high degree of picture resolution. Orthonormal wavelets are known to have a criterion called preservation of energy. However they have their limitation sin the area of image processing. Biorthogonal wavelets do not have energy preserving criteria but have other advantages. So when we combine both the features of orthonormal and borthogonal wavelets we can get partial biorthogonal wavelets which are energy preserving. These new BFBs have perfect reconstruction (PR) property and are QMF with FIR .They are applied to test images to check on compression and noise reduction.

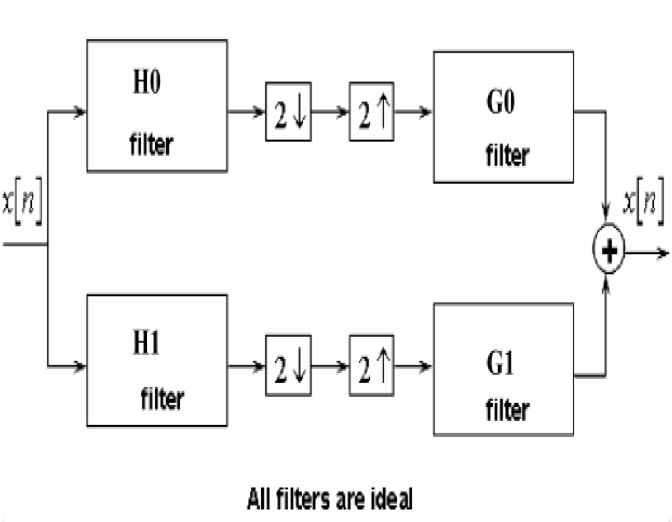
The rest of the paper is arranged as follows. In Section 2
We discuss about wavelet based denoising. In section 3 we deal with the wavelet based compression of images. In section 4 the proposed method is discussed. The conclusion and references are given in sections 5 and 6.

II. WAVELET BASED DENOISING

The wavelet transform is an efficient tool in the context of reducing noise from images. Wavelet transform has been a widely used tool in image denoising because of:

a) High energy compaction
b) Multi resolution properties [4]

Perfect reconstruction is a process by which a signal is completely regained after being split into its low frequencies and high frequencies. Below is a block diagram of a perfect reconstruction process which uses ideal filters. The perfect reconstruction process requires four filters, two low pass filters (H0 and G0) and two high pass filters (H1 and G1). In addition, it requires a downs ampler and ups ampler between the two low pass and between the two high pass filters. [5]

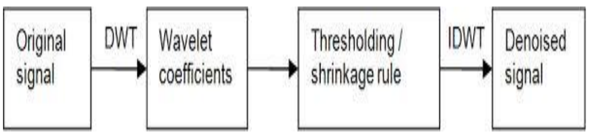


For Image denoising using wavelets:

a) Calculate the DWT of the image.

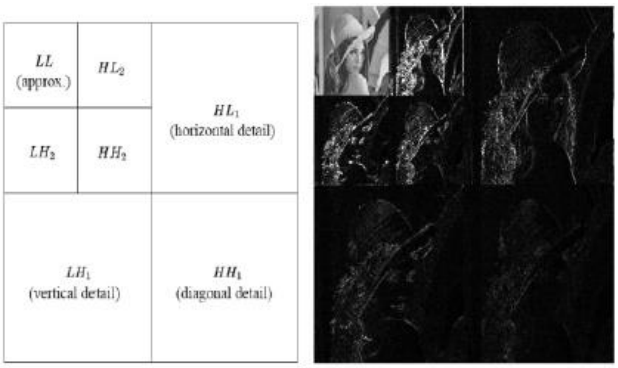
b) Threshold the wavelet coefficients. The threshold may be universal or subband adaptive.

c) Compute the IDWT to get the denoised estimate.



1: Block diagram of image denoising

The wavelet decomposition of an image is done as follows: In the first level of decomposition, the imageis split into 4 subbands,namely the HH,HL,LH and LL subbands. The HH subband gives the diagonal details of the image;the HL subband gives the horizontal features while the LH subband represent the vertical structures. The LL subband is the low resolution residual consisiting of low frequency components and it is this subband which is further split at higher levels of decomposition.



2.(a): Decomposition Structure (b) Decomposed Image

Soft thresholding is used in the different thresholding methods to get visually more pleasing images. Wavelet denoising attempts to remove the noise present in the signal while preserving the signal characteristics, regardless of its frequency content. Smoothing is different from wavelet denoising, smoothing removes the high frequency components and retains the lower frequency components. Denoising performance show variations with type of signal under consideration and wavelet chosen. The principal work on denoising is done by Donoho, which is based on thresholding the DWT of the signal. The method sticks on the fact that noise commonly manifests itself as fine-grained structure in the signal, and WT provides a scale-based decomposition. Thus, most of the noise tends to be represented by the wavelet coefficients at finer scales. Discarding these coefficients would result in a natural filtering out of noise on the basis of scale. Because the coefficients at such scale also tend to be the primary carriers of edge information, the method of Donoho thresholds the wavelet coefficients to zero if their values are below a threshold. These coefficients are mostly those associated to the noise. The edge related coefficients of the signal on the other hand, are usually above the threshold. An alternative approach to hard thresholding is the soft thresholding, which leads to less severe distortion of the signal of interest.[6].Here we are using the Bayes Shrink method which is a type of soft thresholding for reducing noise in images.

III. WAVELET BASED COMPRESSION

Wavelet compression is a form of data compression well suited for image compression. The method is as follows:

a) First a digital wavelet transform is applied. This produces as many coefficients as possible as there are pixels in the image.

b) These coefficients are coded into bit stream using SPIHT algorithm.

The wavelets bring us to a new vision of signal processing. It tactically avoids the problem that Fourier analysis encounters. Its implementation is simple. We need some designed filters to do the task. [3]. Here we are performing compression on test images using the SPIHT algorithm by decomposing the image into 5 levels. The decoding procedure is the reverse of the encoding steps. The performance of the wavelets using CDF and the different BFBs are compared.

IV. ADAPTIVE MATCHED PARTIAL WAVELETS IN DENOISING

Our requirement of matching is based on enlarging the projection of signal characteristics into the scaling subspace rather than the wavelet subspace based on the features of the noise.Such a matching criteria will deliver a higher SNR in the

roughest approximation when a noisy signal is decomposed .The adaptive wavelets method on images is as follows.An image is given as input to a system, divides into segments of the image, and allocates each segment to a wavelet transform filter chosen from a bank of filters for the required transformation. The filter bank constitutes of filters adapted for various types of the image details , eg. Sharp edges, smooth areas etc. Each filter produces coefficients for each segment .The selected coefficients for each segment are combined which is similar to the single wavelet coefficient of the entire image, even though different filters are used to create different parts of the coefficient image

V. CONCLUSION

Wavelet tansforms are used in many applications of image processing like image inpainting, water marking .In this paper we observe that the image denoising algorithm has used soft thresholding to achieve better details of edges and provide smoothness. We have compared denoising and compression performances of the existing CDF 9/7 and different BFBs according to their energy preserving criteria (EP) .Results show that BFB 15/13 with condition EP3 performs best for image compression and BFB 17/15 with condition EP2 performs best for image denoising.

We have also looked into the use of image –matched biorthogonal wavelets for noise reduction. The main idea of these wavelets is that most of the energy of the image is projected into the scaling subspace and not the wavelet subspace.In the paper we have compared denoising performances of the matched wavelets with the older methods like CDF and several recently constructed BFBs.The outcomes have displayed that the adapted wavelets performed better in terms of PSNR.

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