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Comparative Study of Wavelet Packet Algorithm for Image Denoising with Edge Detection

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Abstract: **An image is a two dimensional function represented as F(x,y),it can be defined as an artifact that depicts or records visual perception for example two dimensional picture that has a similar appearance to some objects. All digital images contain some degree of noise. Often we suffered with noise in image that is occurred due to the sensor and circuitry of a scanner or digital camera during image acquisition and/ or transmission. In this Paper, noise removal technique is presented through the Wavelet packet algorithm along with the edge detection. Wavelet packet provides more accurate method of signal analysis. Since wavelet packet is able to divide the band into multilayer classification to further decomposition in both high & low frequency also, thus it provide more extensive application value than wavelet analysis. At the same time to preserve the features of an image such as edge information we will apply edge detection on the image. By comparing the different wavelet packets, we will find the best among them based on parameters such as PSNR (Peak signal to Noise Ratio) value, MSE (Mean Square Error) and SSI (Structural Similarity Index).**

1. INTRODUCTION

Image denoising plays an important role in digital image processing. There are so many kind of denoising process which provides the denoised image but the only procedure is best which not only denoise the image but also remains its features like edges, contrast level etc. In image processing wavelet transform are widely used now a days. Here we proposing a denoising technique which is based on wavelet packet transform. Here in order to preserve the edges of the image we are going to use canny edge detection algorithm. Since edges are one of the most important features of image which is used for object recognition and also other important application in image processing field.

Wavelet Packet: The wavelet packet method is a generalization of wavelet decomposition that offers a richer signal analysis. Wavelet packet atoms are waveforms indexed by three naturally interpreted parameters i.e. position, scale (as in wavelet decomposition), and frequency. For a given orthogonal wavelet function, we generate a library of bases called wavelet packet bases. Each of these bases offers a particular way of coding signals, preserving global energy, and reconstructing exact features. The wavelet packets can be used for numerous expansions of a given signal.

Wavelet Packet Decomposition: The orthogonal wavelet decomposition procedure splits the approximation coefficients into two parts. After splitting we obtain a vector of approximation coefficients and a vector of detail coefficients both at a coarser scale. The information lost between two successive approximations is captured in the detail coefficients. Then the new approximation coefficient vector is split again. In the wavelet packet approach, each detail coefficient vector also decomposed into two parts as in approximation vector splitting.

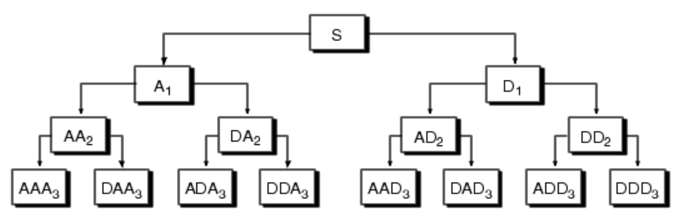

Figure1. Wavelet packet decomposition (in approximate A & detail part D of signal S)

2. RELATED WORK

2.1 Wavelet Packet Denoising Algorithm Based on Correctional Wiener Filtering.

In this paper, in order to improve the quality of the degraded images, based on wavelet threshold denoising algorithm put forward by Donoho, the theory of Wiener filtering is analyzed and a denoising method using wavelet packet transforms based on the Wiener filtering is proposed. Firstly, the noisy image is processed by the correctional Wiener filtering and the noise standard deviation is calculated by the remaining signal of Wiener filter to regard as the threshold of wavelet packet transforms. Then the image is decomposed into the low frequency part and high frequency part by using wavelet packet transform and the wavelet packet tree coefficients are processed with soft threshold by using the level dependent adaptive threshold. Finally, the denoising image is acquired by using wavelet packet inverse transform.

2.2 Denoising of an Image Using Discrete Stationary Wavelet Transform and Various Thresholding Techniques.

The problem of estimating an image that is corrupted by Additive White Gaussian Noise has been of interest for practical and theoretical reasons. Non-linear methods especially those based on wavelets have become popular due to its advantages over linear methods. In this paper they had applied non-linear thresholding techniques in wavelet domain such as hard and soft thresholding, wavelet shrinkages such as Visu-shrink (non- adaptive) and SURE, Bayes and Normal Shrink (adaptive), using Discrete Stationary Wavelet Transform (DSWT) for different wavelets, at different levels, to denoise an image and determine the best one out of them.

2.3 Edge-preserving wavelet thresholding for image denoising.

In this paper, it provides a general setting for wavelet based image denoising methods. The denoised image f is obtained by minimizing a functional, which is the sum of a data fidelity term and a regularization term that enforces a roughness penalty on the solution. The latter is usually defined as a sum of potentials, which are functions of a derivative of the image. It considers new potential functions, which allows preserving and restoring important image features, such as edges and smooth regions, during the wavelet denoising process. Since important edges are characterized by high gradient magnitude, an efficient edge preserving denoising method must reduce shrinkage at points where the magnitude of the gradients exceeds certain thresholds, while shrinking coefficients corresponding to small values of the gradient, that are probably due to noise.

2.4 Thresholding based Wavelet packet Methods for Doppler Ultrasound Signal Denoising.

This paper presents a threshold based wavelet packet denoising method, which preserves useful high frequency components and offers higher signal-to-noise ratio (SNR) compared with straight forward wavelet based denoising methods. To improve the selection of the threshold they propose several algorithms which are adaptive in the sense of coefficients obtained from different decomposed levels using the characteristics of the wavelet transforms. Wavelet packet denoising methods are quite applicable in Doppler Ultrasound signals because they have comparatively high frequency components dependent on flow velocity.

2.5 A New Wavelet Packet Based Method for Denoising of Biological Signals.

This paper introduces a new thresholding filter for the purpose of thresholding in denoising of EEG signals using wavelet packets. The functioning of the filter is examined and compared with that of hard and soft filters by applying this filter in denoising of EEG signals corrupted with white Gaussian noise. From the results, it is found that the new filter works better than hard and soft filters in addition to contain their features.

3. METHODOLOGY

Wavelet Packet Transform (WPT) is now becoming an efficient tool for signal analysis. To denoise the image the wavelet packet transform is used and the proposed methodology is shown in given flow chart. Wavelet Packet Transform (WPT) is now becoming an efficient tool for signal analysis. Compare with the normal wavelet analysis, it has special abilities to achieve higher discrimination by analyzing the higher frequency domains of a signal [1-2]. The frequency domains divided by the wavelet packet can be easily selected and classified according to the characteristics of the analyzed signal. So the wavelet packet is more suitable than wavelet in signal analysis and has much wider applications such as signal and image compression, denoising and speech coding [10]. We preserve the edge of the image by applying the edge detection technique [6]. First of all we add different kind of noise in the color image. After that the image will be decomposed by wavelet packet technique where we have to set the level, entropy thresholding and other parameters. We plot the wavelet packet tree and image on different node. By finding the best node, we have to denoise the wavelet packet and then display the image. Here we are going to calculate the different parameters like PSNR, MSE and SSI index and comparing them for the best wavelet packet for image denoising.

The methodology for denoising the image using wavelet packet transform is shown below:

The steps for image denoising using wavelet packet are described below.

(1) Wavelet packet decomposition. Choose a kind of wavelet to decompose the image using wavelet packet after determining its decomposing layers.

(2) Determine the optimal base of wavelet packet is to calculate the optimal base of wavelet packet according a given standard of entropy.

(3) Do the threshold quantification to the coefficient of wavelet packet. Choose an appropriate threshold for every coefficient of wavelet packet and do the quantitative to corresponding coefficient.

(4) Wavelet packet reconstruction. Do the wavelet packet reconstruction according to the coefficient of the wavelet packet decomposition and the coefficient which is processed by quantification. The flow chart is presented below.

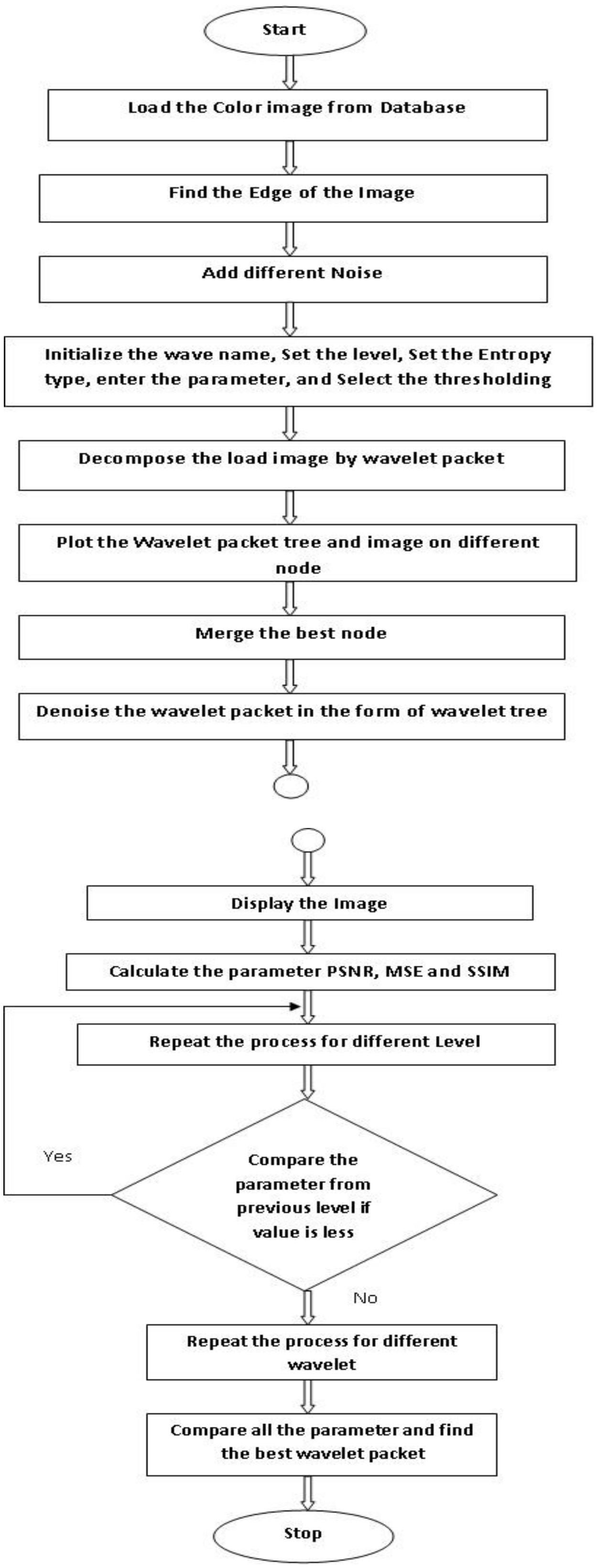

Figure2: Flow chart for image denoising using wavelet packets.

During thresholding period individual pixel in an image is marked as an object pixel. If their value is greater than some threshold value than (assuming an object to be brighter than the background) and as background pixels if their value is less than threshold value.

Here we are going to use soft thresholding. In order to denoised the image, selection of threshold value plays an important role since it affects the denoising quality of an image.

$$\widehat{w}_{j,k} = \begin{cases} sign\,(w_{j,k})(|w_{j,k}| - \lambda), & |w_{j,k}| \geq \lambda \\ 0, & |w_{j,k}| < \lambda \end{cases} \quad (1)$$

Where λ represents the threshold value.

At the time of denoising we perform denoising at various levels. The methodology is applied for 4 kinds of noise ie Gaussian noise, Speckle noise, Poission noise & Salt & Pepper noise. Each level is performed for each of the type of wavelet packet like Haar, Symlets, Coiflet, Daubchies, Biorspline & ReverseBior. The flow chart represents the step by step procedure for denoising of an input image.

4. RESULT ANALYSIS

As per our methodology we apply the wavelet packet algorithm in an image with guassian noise and then calculating the parameter after denoising it. The comparison is shown below. For the same image different wavelet packets are used for denoising it at different levels of wavelet packet tree. We found that Symlet & Reversebior performs well compare to other wavelet packets.

Table 2. Comparison of different wavelet packet based on parameters.

Name of wavelet packet	Parameters			
	SNR	PSNR	MSE	MSSIM
HAAR	7.22	22.61	0.0356	0.715
Symlets	**7.26**	**22.69**	**0.0349**	**0.7208**
Daubchies	7.09	22.35	0.0378	0.6977
Coiflets	7.15	22.46	0.0368	0.7
Biorsplines	7.22	22.6	0.0356	0.7157
ReverseBior	**7.27**	**22.71**	**0.0348**	**0.7217**

As per above result the value of SNR,PSNR,MSE & MSSIM is best for Symlets & Reversebior.

5. CONCLUSION

A denoising process is described above in which various kinds of wavelet packet is used in order to denoise the image. Quality measurement techniques like calculation of various parameters are used. The method provides higher PSNR than adaptive threshold and keeps more edge information & image characteristics while denoising.

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