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A Review on Image Denoising based on Wavelet Transform for different noises

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ABSTRACT: Due to some technical and environmental problem image get corrupted by different type of noises such as salt and pepper, Gaussian, Poisson or speckle noise during transmission and acquisition. In modern day, Wavelet transform method is used to denoised image which first of all cut up data into different frequency component. There are several advantages of Wavelet transform as compared to other techniques such as wavelet transform has best localization properties. In this paper we have compared different thresholding techniques such as Global threshold, Visu Shrink and Bayes Shrink which is based on the wavelet transform for image denoising. We have also calculated the PSNR and RMSE value for denoised images.

Keywords: wavelet transform, Global threshold, Visu shrink, Bayes shrink

I. INTRODUCTION

Image denoising is the basic method of suppressing the noise in order to enhance the quality of image. Several methods have been proposed till now but discrete wavelet transform method gave best result for image denoising. Wavelet transform can be represented into different frequency band by decomposing signal into several scales [1]. Discrete wavelet transform is basically non linear method [2]. A multiresolution property is used for wavelet thresholding techniques [3][4]. In discrete wavelet transform basically three steps is taken: first of all wavelet transform is taken secondly thresholding techniques is applied at last inverse wavelet transform is applied to reconstruct he image [5]. Mutually orthogonal sets of wavelet is decomposed by Discrete wavelet transform[6]. Discrete wavelet transform is easier to implement than Continuous wavelet transform as it has less computational requirement [7]. Donho and Johnstone established soft and hard thresholding techniques for image denoising [8]. Hard thresholding method with moderate variance yields baised estimate whereas Soft thresholding method with higher variance yields less biased estimate [9]. Earlier in universal threshold method entire Wavelet decomposition tree was used which was proposed by Donho and Johnstone [10]. For image denoising Donho proposed the Visu shrink thresholding techniques using Soft and hard thresholding [11]. The paper is organized in the following ways, section II contain Method used in Wavelet transform. Different thresholding techniques are described in Section III whereas Section IV contains experiment and Result. Finally conclusion is given by section V.

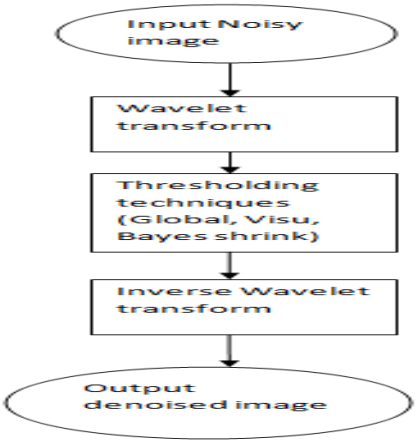

Fig. 1. Image denoising steps.

II. METHOD USED

A wavelet thresholding technique is basically non linear techniques and work on one wavelet coefficients at the time [8]. Let us consider a noisy image is given by:
Y = X + n
Where Y = noisy image
X = original image
n = noisy image

Donho and Johnstone proposed hard and soft threshold method [3].

Hard threshold: In hard threshold method if coefficient value is larger than threshold value than it is kept as it is otherwise set to zero [3].Hard threshold is selected for low error [5]. The Hard threshold is given by:

$$\lambda = \begin{cases} T, \lambda \geq T \\ 0, \lambda < 0 \end{cases}$$

Soft threshold: In soft thresholding techniques, it shrinks the wavelet coefficient value towards zero [3]. In this method absolute value is taken if it is less than or greater than threshold value otherwise set to zero [3][4][11]. Soft threshold is choosed for smoothness [5]. The soft threshold is given by:

$$\Lambda = \begin{cases} T - \lambda, & \lambda \geq T \\ T + \lambda, & \lambda \leq -T \\ 0, & |\lambda| < T \end{cases}$$

III. THRESHOLDING TECHNIQUES

A. Global threshold

This is first wavelet shrinkage method. The universal threshold is given by [2] [5]:

$T = \boldsymbol{\sigma}\sqrt{logM}$

Where $\boldsymbol{\sigma}$ is noise variance and M is total number of pixel in image. In this method coefficient value are shrink according to soft shrinkage rule [2]. When M reaches to infinity it set detail coefficients to zero.

B. Visu Shrink

Visu shrink is also called as universal threshold proposed by Donho and Johnstone [2]. It over smoothen the image [2][6].Visu shrink uses both soft and hard thresholding method [10]. The Visu shrink threshold is given by[4][6][12]:

$T = \boldsymbol{\sigma}\sqrt{2logM}$

In this threshold value is proportional to the standard deviation [12].Based on the median absolute deviation noise level σ is given by [12]:

$\boldsymbol{\sigma} = \frac{median(HH)}{0.6745}$

HH = level of decomposition

C. Bayes Shrink

Chang, Yu and Vetterli proposed the Bayes shrink thresholding techniques [12].To minimize the Bayes risk is main aim of this method [12].The Bayes threshold is given by:

$T = \frac{\sigma X^2}{\sigma N}$

σX^2 = Variance of original image

$\boldsymbol{\sigma}$N = Variance of noise image

$\sigma Y^2 = \frac{\sum_{m=1}^{M} Am^2}{M}$

Am is the coefficients of every wavelet and M is the total number of coefficients in the image [10].

σY^2 = Variance of noisy image

$$\mathbf{T} = \begin{cases} \frac{\sigma X^2}{\sigma N}, & \sigma X^2 < \sigma Y^2 \\ \max|Am|, & \text{otherwise} \end{cases}$$

Bayes thresholding uses soft thresholding method which is adaptive in nature [10].

IV. EXPERIMENT AND RESULT

Table 1. PSNR and RMSE value of Global Hard and soft threshold with different noises for noise level ($\boldsymbol{\sigma}$=15).

Noise (global)	PSNR Hard	PSNR Soft	RMSE Hard	RMSE Soft
Gaussian	24.8166	27.4963	29.3488	21.5578
Salt & pepper	27.5505	29.5800	21.4238	16.9598
Poisson	32.7347	31.7619	11.7946	13.1925
Speckle	30.5171	30.6672	15.6672	14.9645

Table 2: PSNR and RMSE value of Visu shrink Hard and soft threshold with different noises of noise level ($\boldsymbol{\sigma}$=15).

Noise (Visu)	PSNR Hard	PSNR Soft	RMSE Hard	RMSE Soft
Gaussian	26.1178	27.3114	25.2157	21.5204
Salt & pepper	27.7407	29.7004	20.9599	16.7263
Poisson	31.7316	31.1625	13.2385	14.1350
Speckle	30.5103	30.2024	15.2373	15.7870

Table 3: PSNR and RMSE value of Bayes shrink threshold with different noises of noise level ($\boldsymbol{\sigma}$=15).

Noise (Bayes)	PSNR	RMSE
Gaussian	32.9777	0.0843
Salt & pepper	37.4133	0.0764
Poisson	42.9448	0.0394
Speckle	38.4387	0.0541

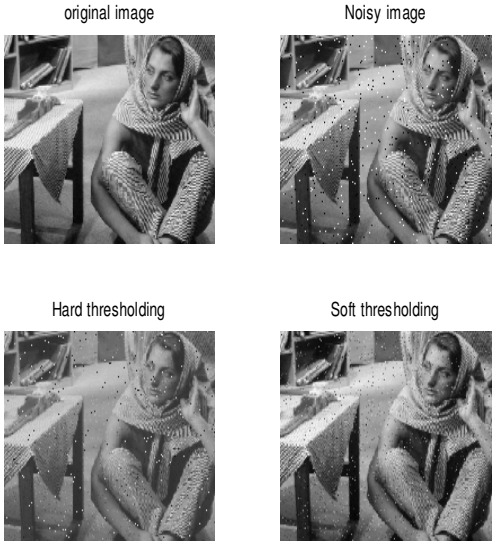

Fig. 2. Denoised Barbara image using Global hard and Soft threshold.

Fig. 3. Denoised Barbara image using Visu hard and soft threshold.

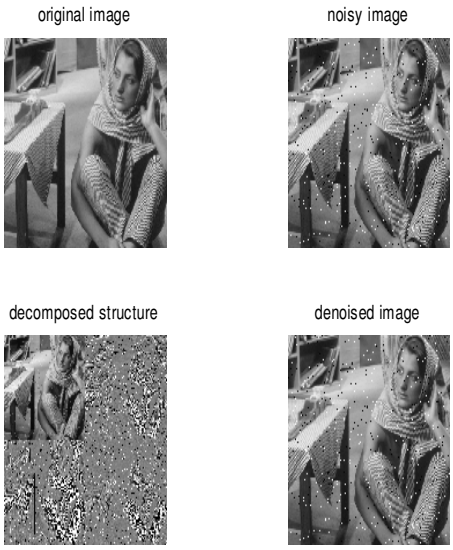

Fig. 4. Denoised Barbara image using Bayes shrink threshold.

V. CONCLUSION

The image is denoised by using Matlab software. The image is Barbara of HAAR of first level of decomposition which gets noisy by different noises such as Gaussian, Salt and pepper, speckle and poisson noise. In this paper we have used Global, Visu shrink and Bayes shrink thresholding techniques for image denoising. We have compared the soft and hard thresholding method for both Global and Visu shrink techniques on the basis of PSNR peak signal to noise ratio) Value and Root mean square error (RMSE). We found that Soft thresholding method gave visually pleasant image. Global and Visu shrink techniques for soft thresholding method gave better PSNR value. We also found that Bayes shrink thresholding gave best PSNR value than Global threshold and Visu Shrink thresholding techniques for different noises. Therefore Bayes thresholding method is best method for image denoising as compared to global and Visu shrink techniques as it also gave minimum root mean square error.

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