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NOVEL TECHNIQUE FOR IMAGE DENOISING

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ABSTRACT

Historically, the field of image processing grew from electrical engineering as an extension of the signal processing branch. The massive amount of data required for images is a primary reason for the development of many sub areas ithin the field of computer imaging such as image segmentation and compression. Whatever may be the way of transmission, the data tends to get noisy and thereby the further processing does not lead to good results. Hence, it is very essential to keep the data close to originality. The prime focus of this paper is related to the pre processing of an image. The preprocessing being worked upon is the denoising of images. In this paper, a new threshold estimation technique has been presented along with the standard thresholding and filtering techniques. And a comparative analysis of different denoising methods has been carried out very efficiently. The simulation results show that the proposed threshold estimation technique has superior features compared to conventional methods. This makes it an efficient method in image denoising applications; it can also remove the noise and retain the image details better.

Keywords: *Wavelet-transform; MATLAB; Threshold function; Salt & Pepper noise; Median filter; Wiener Filter; PSNR.*

I. INTRODUCTION

In several applications, it might be essential to analyze a given signal. Image processing is any form of signal processing for which the input is an image, such as photographs or frames of video and the output of image processing can be either an image or a set of characteristics or parameters related to the image. Most image- processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it. There are applications in image processing that require the analysis to be localized in the spatial domain. The classical way of doing this is through what is called Windowed Fourier Transform. Central idea of windowing is reflected in Short Time Fourier Transform (STFT). The STFT conveys the localized frequency component present in the signal during the short window of time. The following equation can be used to compute a STFT.

$$STFT\ (t, f) = \int [x\ (t).\ \omega^*(t - \ )].\ e\text{-}j\ 2\Pi ft\ \ dt$$

Where x (t) is the signal itself, ω (t) is the window function and * is the complex conjugate.

It is different to the FT as it is computed for particular windows in time individually, rather than computing overall time (which can be alternatively thought of as an infinitely large window). The same concept can be extended to a two-dimensional spatial image where the localized frequency components may be determined from the windowed transform. This is one of the bases of the conceptual understanding of wavelet transforms. Hence, wavelet transforms have been kept as the main consideration in this thesis. It is well known that while receiving the input image some aberrations get introduced along with it and hence a noisy image is what we are left with for future processing. The image de-noising naturally corrupted by noise is a classical problem in the field of signal or image processing. Additive random noise can easily be removed using simple threshold methods. De-noising of natural images corrupted by noise using wavelet techniques is very effective because of its ability to capture the energy of a signal in few energy transform values. The wavelet de-noising scheme thresholds the wavelet coefficients arising from the wavelet transform. The wavelet transform yields a large number of small coefficients and a small number of large coefficients. Simple de-noising algorithms that use the wavelet transform consist of three steps. Calculate the wavelet transform of the noisy signal. Modify the noisy wavelet coefficients according to some rule. Compute the inverse transform using the modified coefficients. The problem of Image de-noising can be summarized as follows:

II. CLASSIFICATION OF DENOISING TECHNIQUES

There are two basic approaches to image denoising, spatial filtering methods and transform domain filtering methods.

Spatial Filtering
A simple way to remove noise from image data is to employ spatial filters. Spatial filters can be further classified into non-linear and linear filters.

Non-Linear Filters
With non-linear filters, the noise is removed without any attempts to explicitly identify it. In this case, the value of an output pixel is determined by the median of the neighbourhood pixels, rather than the mean.

Advantage of median filter
Median is much less sensitive than the mean to extreme values (called outliers); therefore, median filtering is able to remove these outliers without reducing the sharpness of the image. In recent years, a variety of nonlinear median type filters such as weighted median [8], rank conditioned rank selection [9], and relaxed median [10] have been developed.

Linear Filters
A mean filter is the optimal linear filter for Gaussian noise in the sense of mean square error. Linear filters too tend to blur sharp edges, destroy lines and other fine image details, and perform poorly in the presence of signal-dependent noise. The wiener filtering [11] method requires the information about the spectra of the noise and the original signal and it works well only if the underlying signal is smooth. Wiener method implements spatial smoothing and its model complexity control correspond to choosing the window size. To overcome the weakness of the Wiener filtering, Donoho and Johnstone proposed the wavelet based denoising scheme in [12, 13].

III. THRESHOLDING FUNCTION

The selection of thresholding function is the main issue of wavelet threshold denoising.

A) Global threshold function:
One is the hard threshold function:

$$\hat{W}_{j,k} = \begin{cases} W_{j,k}, & |w_{j,k}| \geq \lambda \\ 0, & |w_{j,k}| < \lambda \end{cases} \quad \dots (1)$$

One is the soft-thresholding function:

$$\hat{W}_{j,k} = \begin{cases} \operatorname{sgn}(w_{j,k}).(|w_{j,k}|-\lambda), & |w_{j,k}| \geq \lambda \\ 0, & |w_{j,k}| < \lambda \end{cases} \quad \dots (2)$$

Where sgn(*) is a sign function, $w_{j,k}$ stands for wavelet coefficients, $\hat{w}_{j,k}$ stands for wavelet coefficients after treatment, λ stands for threshold value and it can be expressed as follows:

$$\lambda = \sigma\sqrt{2\ln (N)} \quad \dots (3)$$

$$\sigma = \text{median} (|c|)/0.6745 \quad \dots (4)$$

Where N is the image size, σ is the standard deviation of the additive noise and c is the detail coefficient of wavelet transform.

The soft-thresholding rule is chosen over hard-thresholding, for the soft-thresholding method yields more visually pleasant images over hard thresholding [11].

B) Penalized Threshold Function:
In this, the value of threshold is obtained by a wavelet coefficients selection rule using a penalization method provided by Birge-Massart.

MATLAB code for Penalized Threshold
THR= wbmpen (C, L, Sigma, Alpha)

Where
[C, L] is the wavelet decomposition structure of the signal or image to be de-noised.
Sigma is the standard deviation of the zero mean Gaussian white noise in de-noising model (see wnoisest for more information).
Alpha is a tuning parameter for the penalty term. It must be a real number greater than the sparsity of the wavelet representation of the de-noised signal or image grows with ALPHA. Typically ALPHA = 2.

C) Proposed Threshold Method
Finding an optimized value (λ) for threshold is a major problem. A small change in optimum threshold value destroys some important image details that may cause blur and artifacts [11]. So, optimum threshold value should be found out, which is adaptive to different sub band characteristics. Here we proposed a new threshold estimation technique which gives an efficient threshold value for salt & pepper noise to get high value of PSNR as compared to previously explained methods.

For salt & pepper noise it is given by
λ proposed = $\lambda + 2\beta$
Where, λ = global threshold value and it is given by
$\lambda = \sigma\sqrt{2\ln(N)}$
And β = penalized threshold value.

IV. SIMULATION RESULTS

The Original Image is natural image, adding Salt & Pepper noise and De-noised image using Median filter, Wiener filter, Penalized Threshold, Global Threshold and Proposed Threshold and comparisons among them is given below:

Figure 1: Original gray scale image

Figure 2: Image with salt & pepper noise

Figure 3: Image denoising using proposed threshold (For salt &pepper noise)

Figure 4: Image denoising using wiener filter (For salt &pepper noise)

Figure 5: Image Denoising using global threshold (For salt & pepper noise)

Figure 6: Image denoising using penalized threshold (For salt &pepper noise)

Figure 7: Image denoising using median filter (For salt &pepper noise)

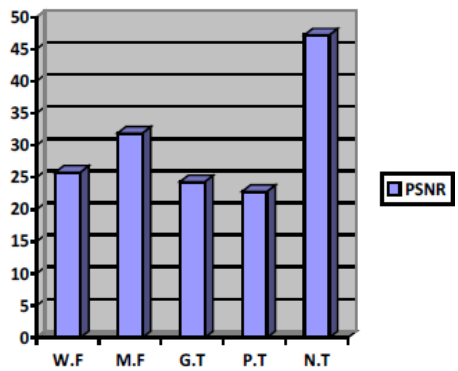

Figure 8: PSNR for Salt & pepper noise

Here x-axis shows denoising techniques & y-axis shows value of PSNR.

Table which shows the Performance analysis of Median filter, Wiener filter, penalized threshold, global threshold and proposed threshold salt & pepper noise for noise is given below:

Table: PSNR of test image corrupted by salt & pepper noise using various denoising methods

Types of Noise	Penalized threshold	Wiener Filter (W.F.)	Median Filter (M.F.)	Global Thresholding (GT)	Proposed Threshold
Salt&Pepper noise	22.9	25.7	32	24.4	46.9

V. CONCLUSION

In this paper, we have proposed a new threshold estimation technique in which a gray scale image in 'jpg' format is injected salt & pepper noise. Further, the noised image is denoised by using different filtering and denoising techniques. From the results (figure (1) to figure (7)) we conclude that; the proposed threshold mentioned in this paper shows better performance over other techniques. Thus we can say that the proposed threshold may find applications in image recognition system, image compression, medical ultrasounds and a host of other applications.

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