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A Novel Approach for Reduction of Poisson Noise in Digital Images

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ABSTACT
An image is often corrupted by noise in its acquisition and transmission by various kinds of noises. Image denoising using thresholding methods means find appropriate value (threshold)which separates noise values to actual image values without affecting the significant features of the image.Wavelet transform represents image energy in compact form and representation helps in determining threshold between noisy features and important image feature. This paper is organized as follows: First poison noise is removed by median filter; and then removed by wiener filter, second noisy image is denoised with the help of wavelet based techniques using thresholding, third thresholding is applied on the result of first and second simultaneously for image denoising and fourth PSNR (Peak Signal To Noise Ratio), MSE (Mean Square Error) calculated and results are compared in all cases. The aim of this paper is to identify the best poison noise removal filter from the comparative study analysis of filtering methods and wavelet based thresholding technique. The best filter is estimated by calculating Peak Signal Noise Ratio (PSNR) and Means Square Error (MSE).
Key words: Image denoising, PSNR, MSE, Median filter, Wiener filter, Thresholding, Wavelet Transform.

I. INTRODUCTION

Noise is undesired information that contaminates the image. In the image filtering process, Information about the type of noise present in the original image plays a significantrole[1].

An image is unfortunately corrupted by various factors. The distortions of images by noise are common during its acquisition, processing, compression, transmission, and reproduction. These noisy effects decrease the performance of visual and computerized analysis [2]. It is clear that the removing of the noise from the image facilitate the processing.

Poison noise, which has the characteristic of multiplicative noise. This type of noise occurs in almost all coherent imaging systems such as laser, acoustics and SAR (Synthetic Aperture Radar) imagery. The source of this noise is attributed to random interference between the coherent returns [1]

Poisson noise, is a basic form of uncertainty associated with the measurement of light, inherent to the quantized nature of lightand the independence of photon detections. Its expected magnitude is signaldependent and constitutes the dominant source of image noise except in low-lightconditions.

Poisson distribution, it has theproperty that its variance is equal to its expectation, E [N] = Var [N] = λtthisshows that photon noise is signal dependent, and that its standard deviationgrows with the square root of the signal.

In practice, Poisson noise is often modeled using a Gaussian distributionwhose variance depends on the expected Poisson count.

$$N= N (\lambda t; \lambda t) \quad (2)$$

This approximation is typically very accurate. For small Poisson counts, Poissonnoise is generally dominated by other signal-independent sources of noise, andfor larger counts, the central limit theorem ensures that the Poisson distributionapproaches a Gaussian.

Since Poissonnoise is derived from the nature of the signal itself, it provides a lower bound on the uncertainty of measuring light. Even under ideal imaging conditions, free from all other sensor-based sources of noise (e.g., read noise), any measurement would still be subject to Poissonnoise. WhenPoisson noise is the only significant source of uncertainty, as commonly occurs in bright photon-richenvironments, imaging is said to be Poisson-limited [3].

II. WAVELET

A wavelet is a waveform of effectively limited duration that has an average value of zero. In Comparing with sine waves, wavelets are the basis of Fourier analysis. Sinusoids do not have limited duration, they extend from minus to plus infinity. And where sinusoids are smooth and predictable, wavelets tend to be irregular and asymmetric. Fourier analysis consists of breaking up a signal into sine waves of various frequencies. Similarly, wavelet analysis is the breaking up of a signal into shifted and scaled versions of the original (or mother) wavelet[4].

III. DWT DECOMPOSITION STEP

Wavelet transform generally has used for the decomposition of the image. Wavelet coefficients are divided into two group's first, large coefficients which represent important image features second, small coefficients which mainly represents noise features. The wavelet coefficient represents a measure of similarity in the frequency content.

Image denoising using thresholding methods means find appropriate value (threshold) which separates noise values to actual image values without affecting the significant features of the image. There are two main types of wavelet transform; continuous and discrete. Discrete wavelet transforms are widely used for image denoising because of discrete nature of images presents now a day[5].

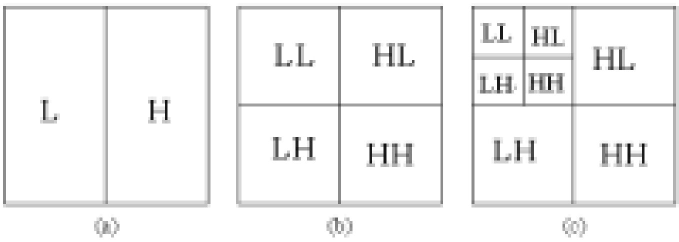

Fig.1 The two level wavelet decomposition as shown in fig (a), b) & (c)

IV. THRESHOLDING AND THRESHOLD ESTIMATION TECHNIQUE

The simpler way to remove noise or to reconstruct the original image using the wavelet coefficients used the result of decomposition in wavelet transform, is to eliminate the small coefficient associated to the noise. The thresholding is classified into two categories:

A. Hard Thresholding

Hard thresholding can be defined as follow:

$$D(U, \lambda) = U \text{ for all } |D| > \lambda \qquad \text{.... (1)}$$
$$= 0 \text{ otherwise}$$

Hard threshold is a "keep or kill" procedure and is more intuitively appealing. The Hard thresholding may seem to be natural. Sometimes pure noise coefficients may pass the hard threshold and appear as annoying "blips" in the output [4].

B. Soft Thresholding:

Soft thresholding can be defined as follows:

$$D(U, \lambda) = \operatorname{sgn}(U) \max(0, |U| - \lambda) \qquad \text{.... (2)}$$

Soft threshold shrinks coefficients above the threshold in absolute value. The false structures in hard thresholding can overcome by soft thresholding. Now a days, wavelet based denoising methods have received a greater attention [4].

V. IMAGE DENOISING

The aim of an image-denoising algorithm is then to reduce the noise level, while preserving the image features. All digital images contain some degree of noise due to the corruption in its acquisition and transmission by various effects. Because the wavelet transform has an ability to capture the energy of a signal in few energy transform values, the wavelet denoising technique is very effective. When an image is decomposed using wavelet transform, the four sub images are produced and by using the obtained thresholding value denoise the image either by hard thresholding and soft thresholding[6]. To measure the performance of noisy image and denoised image PSNR and MSE is used .The PSNR computes the peak signal-to-noise ratio, in decibels, between two images. This ratio is often used as a quality measurement between the original and a compressed image. The higher the PSNR, the better the quality of the compressed or reconstructed image [7]

The Mean Square Error (MSE) and the Peak Signal to Noise Ratio (PSNR) are the two error metrics used to compare image compression quality. The MSE represents the cumulative squared error between the compressed and the original image, whereas PSNR represents a measure of the peak error. The lower the value of MSE the lower will beerror[8]
MSE is defined as:

$$MSE = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [X(i,j) - Xc(i,j)]^2 \qquad \text{.... (3)}$$

Where,
X (i , j) =original image
X_c(i, j) =compressed image

PSNR represents a measure of the peak error & is expressed in decibels. It is defined by:

$$PSNR = 10 \log_{10} \left(\frac{255^2}{MSE} \right)$$

VI. EXPERIMENTAL RESULTS

Experiments are performed on the 256x256 noisy images. Figure 4(a) is noisy image added with poison noise Fig 4(b), 4 (c), 4(d), 4(e) ,4(f) & 4(g) are the output of median filter,wiener filter, soft thresholding, hard thresholding , hardthresholding plus median filtering & hard thresholding plus wiener filter is implemented using MATLAB [7.8.0.347(R2009a)].

6.1 EXPERIMENTAL IMAGES DURING DENOISING PROSSES:

(a) (b) (c) (d)

(e) (f) (g)

Fig 2.Comparing the performance of (a) Noisy image (b) Median filter (c) Wiener filter (d)Softthresholding (e) Hard thresholding(f)Hard thresholding + Median filter (g) Hard thresholding +Wiener filter.

TABLE 1: EXPERIMENTAL RESULT OF DENOISING ON POISON NOISE

METHOD	WAVELET TYPE	DECOMPOSITION LEVEL	PSNR	MSE
Noisy image	**Haar**	**8**	**25.30**	**192.1**
Median filter	**Haar**	**8**	**28.63**	**89.11**
Wiener filter	**Haar**	**8**	**28.82**	**85.25**
Soft thresholding	**Haar**	**8**	**31.02**	**51.43**
Hard thresholding	**Haar**	**8**	**31.05**	**51.10**
Hard thresholding + median filter	**Haar**	**8**	**31.14**	**49.99**
Hard thresholding + wiener filter	**Haar**	**8**	**31.91**	**48.46**

Results shown as in table 1 that PSNR & MSE in case of hardthresholding plus wiener filtering method is better than other one.

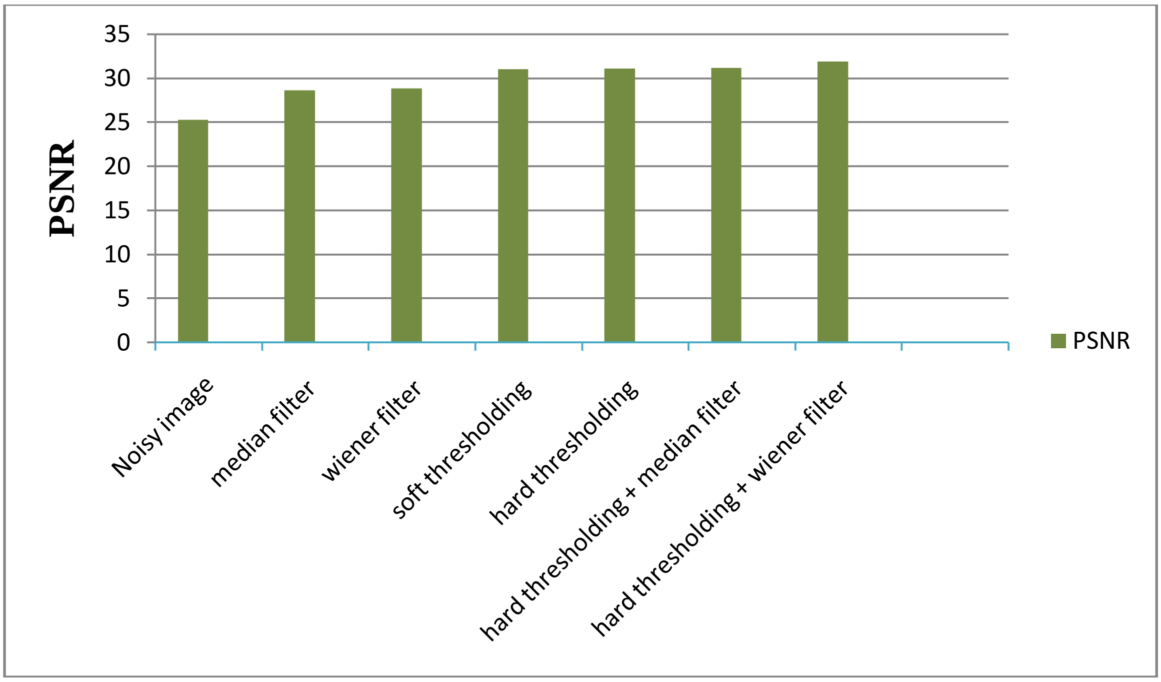

Fig 3. PSNR v/s METHODS

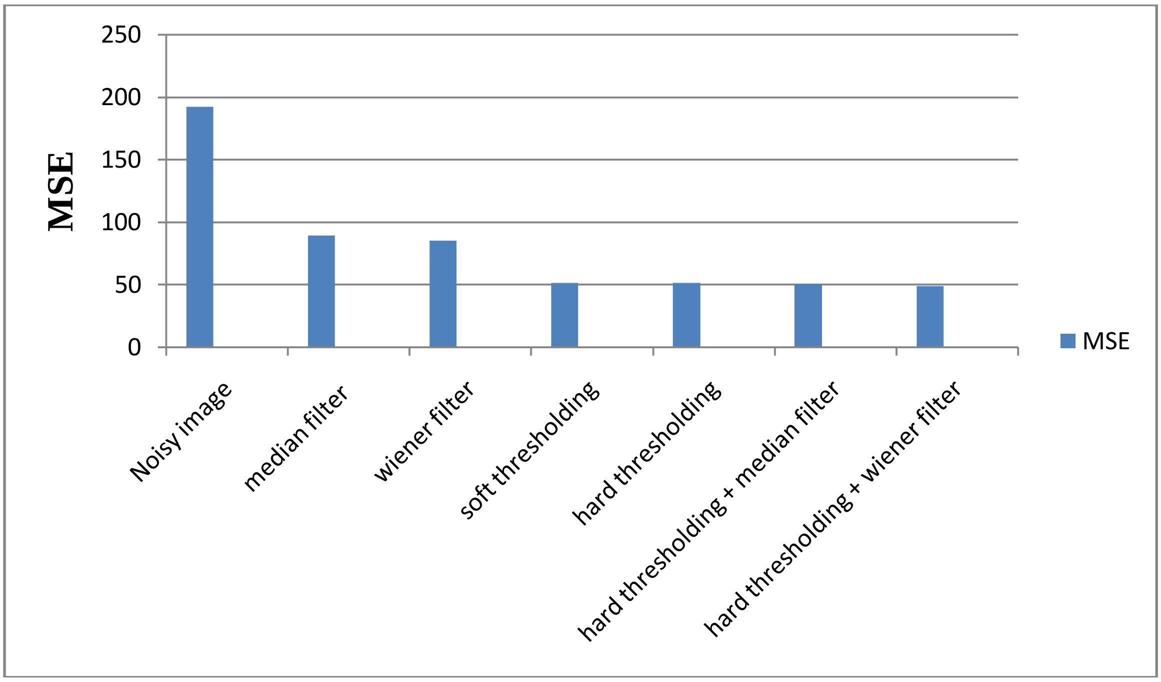

Fig 4. MSE v/s METHODS

VII. CONCLUSION

In this work, we performed filtering (median & wiener filtering) on noisy image than soft & hard thresholding is performed and found the best threshold then finally we combine the result of filtering method and hard thresholding. Denoising is performed on the basis of performance measure like PSNR, MSE as well as on basis of visual quality of image. During examining several techniques we have find that wiener filteringmethod and wavelet thresholding(hard thresholding) technique jointly gives good agreement of PSNR & MSE than other.

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