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Image De-noising using Median Filter and DWT Adaptive Wavelet Threshold

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Abstract: *Image de-noisingplays an important role in satellite communication and signal processing applications. In thispaper, we propose an medianfilter and adaptive wavelet thresholding shrinkage technique for image de-noising. The noisy image ispassedthroughpre-processingmedianfilter to remove the noise and twoleveldiscretewavelettransformisappliedwhichispassedthrough post-processingmedianfilter to remove noise. Finally, Bayes thresholding shrinkageisapplied to all sub-bands to obtain de-noised image. The Inverse discretewavelettransformisapplied to reconstruct the image. The Image qualityismeasured in terms of the PSNR and isobservedthat the proposedmethodobtainsbetter PSNR compared to existingmethod.*
Keywords: *Bayes shrinkage, DWT, median filter, PSNR, Denoise.*

I. Introduction

Digital image plays an important role in our daily life but, they usually suffer from the poor quality of the image, generally with lack of contrast, presence of artifact, blurring, noise and shading due to improper focusing of camera lens, lighting and other factors. Hence we have to improve the quality of the image for proper analysis which can be done by image enhancement.Noise is defined as, pixel in the image show different intensity value instead of true value of pixels or noise is an unwanted signal that interferes with original image and degrades the quality of the image. Noise causes the random variations of image intensity and poor visibility of pixel. De-noising is a process of removing noise from the image. Image de-noising is not an easy task because it introduces blurring and artifacts in image. There are different types of de-noising technique and their application depends upon type of noise present in the image.Image de-noising technique classified into two categories. i.e., Spatial domain filtering where pixels are operated directly and Transform domain where transfornations are used to denoise the image.

II. Literature Survey

S.Deivalakshmi et al [1],proposed a method consist of noise detection followed by removal of detected noise by median filter using selective pixels that are not noise themselves this method was implemented using gray level and binary image. The proposed method provides good performance when compared to conventional median filter and center weighted threshold value for median (CWM) filter. Threshold value for gray scale image was taken zero but threshold value for binary image varies from 0 to 255.Threshold value for binary image varies from one image to another but it remains constant for gray scale image. LiwenDong [2] proposed a technique of adaptive de-noising method which exploits the inter scale dependencies of wavelet co-efficient .This technique was compared with classical threshold method. The result were improved by taking the dependency between co-efficient and their performance. Here de-noising threshold can be adaptively adjusted itself on the basis of its position and decomposition scale. The performance of this method can preserve image detail well in both PSNR and visual effect.

Yungang Zhang et al,[3] proposed adaptive threshold selection technique followed by morphological operation to improve de-noised and enhanced result. The result were compared with some of the existing method such as visu shrinkage, bayes shrinkage .The proposed method solves the problem of finding the optimum threshold .Test image taken in this method was corrupted by white Gaussian noise.MantoshBiswas and Hari Om,[4] proposed an adaptive de-noising method that provides an adaptive way of setting up minimum threshold by shrinking the wavelet co-efficient by means of exponential function. The proposed method provide better PSNR and structural similarity index measure (SSIM) compared to neigh shrink, IAWDMBNC and IIDMWT method. However this method cannot recover the better quality of original image since threshold value does not minimize the noisy wavelet co-efficient across the scale.

YaserNorouzzadeh and MasoudRashidi[5] proposed an efficient thresholding function. This function is continuous and has higher order derivation therefore it is suitable for thresholding neural network method ,which is a gradient decent learning method .Here least mean square (LMS) algorithm is utilized to estimate the threshold value for wavelet sub-bands. In this method problem of tuning parameter is resolved since the proposed thresholding function doesnot require additional parameter. The proposed function provides better PSNR and visual quality compared to well-known thresholding function.BogdanSmolka and Krystyna Malik,[6] proposed a method which is utilizing the concept of trimmed cumulative distance assigned to pixels from the local filtering window which serves as measure of pixel distortion. Here filtering technique is used to reduce the impulsive and Gaussian noise present in color image. The output of the filter is weighted average of pixel in processing window. Weights are obtained by measuring pixel corruption in that particular window.

Harnani Hassan and AzilahSaparon[7] proposed wavelet thresholding and translation invariant methods of image de-noising to remove noise using orthogonal wavelet basis. The result shows that translation invariant method give the better PSNR and visual performance when compared to wavelet transform method this is due to translation invariant method has capability of attenuating Gibbs oscillation and adaptation to discontinuities.Hari Kumar Singh et al, [8] proposed an adaptive and efficient multi resolution algorithm for compression of digital image.DWT based compression technique have more advantage when compared to different transform domain compression because DWT has region of interest, quality scalability ,low bit rate transmission and most of the wavelet coefficient are close to zero.one of the main difference between FT and DWT is that DWT provide both time and frequency information but FT gives only frequency information

G. Andria et al,[9] proposed a method that consists, basically in liner filtering of only the vertical and diagonal details of the image. Using 1st level 2D wavelet decomposition the details are obtained .The linear filtering is performed with a Gaussian filter with kernel size that mainly depends on speckle noise. This method provides better result when compared to liner and non-liner de-nosing method.A. leoSahayaDharshini et al,[10] proposed tree based switching mechanism for the replacement of corrupted pixel. If the pixel is noisy then it checks for the neighbors of the processed pixel. If all the 4 neighbors are noisy then mean of the 4 neighbors are replaced. If any of the 4 neighbors are not noisy then the corrupted pixel is replaced by unsymmetrical terminal midpoint. The proposed method provides better performance in high noise density. M.Vijay et al, [11] proposed a new hybrid image de-noising method fusing the bilateral filter (BF) ,wavelet thresholding, multistate products wavelet thresholding which reduces blurring effects and preserve the edge details of the digital image .The proposed method also multiplies the adjacent wavelet sub-band to improve the features in image. First image is passed through the BF, output of the filter is an image with reduced noise but introduces blurring effect and also edge details are not preserved.in order to reduce this effects wavelet thresholding and adaptive wavelet thresholding is used in further stages. Blurring effect is reduced by passing through the wavelet thresholding method in 2nd stage .In 3rd stage dyadic wavelet transform is applied and multiproduct adaptive threshold rule is used to calculate an adaptive threshold to reduce the multistate product.

Ms. Jignasa M. Parmar and Ms. S. A. Patil, [12] proposed an wavelet thresholding method.Removing of noise from an image is not an easy task. Image gets corrupted by noise during acquisition, transmission, retrieval and storage process. This paper as made an comparison in terms of PSNR and RMSE between modified image de-noising which is based on spatial and wavelet domain and local adaptive wavelet image de-noising method which is based on wavelet domain and it proves that local adaptive de-nosing method proved provide low RMSE and high PSNR.AdibAkl and Charles Yaacoub[13] proposed A hybrid wavelet-special de-noising filter for image despeckling .this filter contains the combination of adaptive kuan filter and wavelet shrinkage technique to approximate image smoothing. Filter has capability to switch purely to special or wavelet function .when it switches in between special and wavelet function it reduce the speckle noise without over blurring.

D.Srinivasulu Reddy et al,[14] proposed a novel approach to image de-noising using diversity enhanced wavelet transform like diversity enhanced discrete wavelet transform(DEDWT), hyper analytic wavelet transform (HWT) and diversity enhanced hyper analytic wavelet transform (DEHWT).This proposed method provides an better visual performance compared to classical DWT with various mother wavelet that belongs to daubechies family. One of the drawback of the DEDWT is that it fails to remove the noise at the edges of the image.C.ShobanaNageswari and K. HelenPrabha, [15] proposed an hybrid filter techniques such as modified median(max) and modified mean(max) , modified median (N4 max) and modified mean (Nd max). it informs that this hybrid filter has better corner protective characteristics. Removal of speckle noise is very difficult to remove when compared to that of AWGN noise and also removal of noise in ultrasound images is very difficult task. Here modified median (N4 max) and modified mean(Nd max) provide the best result when compared to all other filters. One of the important applications of median filter is that it removes the noise from image by preserving edges but it is location invariant filter that is it alters the pixel which was not affected by noise.

Arpita Joshi et al., [16] ,proposed a joint scheme of wavelet transform using iterative noisy density and median filtering to remove salt and pepper noise in digital image. In this method thresholding is performed by wavelet transform itself no other kind of thresholds are used. Here median filtering minimizes salt and pepper noise effectively when compared to AWGN noise. The 3bd PSNR improvement and 5db down fall of RMSE is observed in salt and pepper noise when compared to AWGN noise.BhabeshDeka and P. K. Bora [17] proposed switching based median filter for removal of salt and paper noise on gray scale images. Noise removal is performed in two stages. In 1st stage signal dependent rank-order mean(S-D ROM) filter is used to detect impulse. In second stage the noisy pixel are determined using the 2D non causal liner prediction technique and replaced by the median of the neighborhood pixel. This method provides improvements in both visual and quantitative compared to other switching based median filter.T.M.Benazir and B.M.lmran[18], proposed an algorithm for restoration of gray scale image that are highly corrupted by impulse noise. There are 2 phases, 1st phase detects whether the processing pixel is corrupted or not, in 2nd phase by using proposed algorithm recreates the corrupted pixel. This method uses less computational time since filter need to apply only once. One of the advantages of this method is that it does .not need threshold parameter. Images captured through CCTV camera may get blurred in such case we can use this method.

III. Proposed Method

The proposed model for de-noising of image using median filter, DWT and thresholding is shown in fig 1

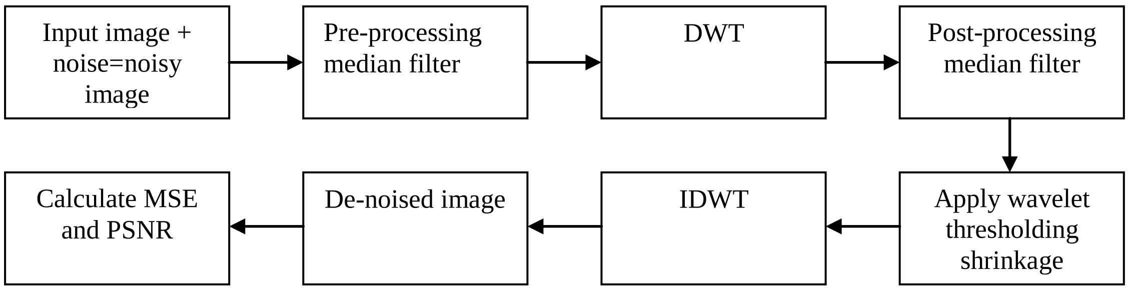

Fig1- model for image de-noising

3.1 Noisy Image

Noisy image is obtained by adding noise to the original gray scale images of size 512×512. Here 512×512 indicates that an image is having 512 rows and column respectively. Here we are considering three types of noise they are salt & pepper noise with noise density 0.05, additive white Gaussian noise and speckle noise wiyh noise variance 0.05.

3.2 Preprocessing Median Filter

In second step noisy image is passed through the pre-processing median filter. Image filters are mainly used for noise removal, edge detection, sharpen contrast etc. median filter generally belongs to the family of non-liner filters and are implemented using LPF, it is mainly used to remove the noise whole preserving the edges. Median filtering is a powerful technique used in image processing to remove noise. The main principal function used in median filter is to force points with distinct gray levels to be more like their neighbors. The traditional median filtering algorithm provides good result in image de-noising. Classical median filter algorithm perform some alteration to traditional median filtering algorithm to active some additional properties.The drawbacks of the standard median filter can be overcome median filter with boundary extension. To overcome the existence of noisy pixels around the boundary of the image, the entire matrix of image pixel is padded with zeros or ones or symmetric values. A row of zeros or ones or symmetric values is added at the top and bottom of the matrix. Similarly a column with zeros or ones or symmetric values is added at the left and right end of the matrix. Here symmetric values are padded across the boundary rather than that of zeros or ones because symmetric values preserve the edges and boundary information.

3.3 Discrete Wavelet Transform

Discrete wavelet transform is the transformation of array values into wavelet co-efficient. DWT of image is calculated by passing it through series of filter with different cut-off frequency this is called as decomposition or analysis. Mathematically analysis is also called as DWT. First image is decomposed through LPF with impulse response **g** which eliminates the frequency above the cut-off frequency. Simultaneously image is decomposed through HPF with impulse response **h** which eliminates the frequency below the cut-off frequency. DWT gives good time resolution and poor frequency resolution at high frequency which means less information is present in high pass filtered image. Good frequency resolution and poor time resolution at low frequency which means more information is present in low pass filtered image. We will obtain a 2 sub band of size M and N/2.

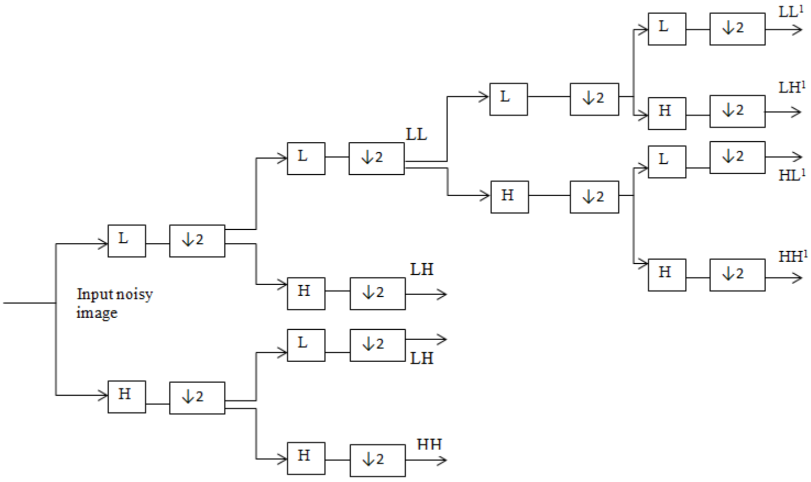

Fig 2 – Two level discrete wavelet decomposition

3.4 Post Processing Median Filter

Median filter is applied to all sub-bands after 1st level decomposition of DWT in order to remove the residual noise present in the image. Post processing median filter work similar to that of pre-processing median filter. This filter is not applied after 2nd level decomposition because it causes blur in the decomposed image.

3.5 Wavelet Thresholding Shrinkage

After post-processing median filter thresholding shrinkage [12] is applied to all the sub-bands. Wavelet thresholding is decomposition of image into wavelet co-efficient, comparing this co-efficient with the threshold value and shrinking these co-efficient close to zero to take away the noise present in image. The de-noised image is reconstructed from the modified co-efficient. The choice of thresholding is an important factor because it plays an important role in image de-noising. De-noising produces the smoothen image hence reducing the sharpness in the image. There exists a various thresholding method for noise removal it includes visu shrink, sure shrink and bayes shrink which is based on selection of threshold value.

3.5.1BAYES shrinkage

It uses the soft threshold and it is sub-band dependent i,e thresholding is done at each band of BAYES shrink threshold is given by,

$$t_B = \begin{cases} \frac{\sigma_v{}^2}{\sigma_x{}^2} & if\, \sigma_y{}^2 > \sigma_v{}^2 \\ \max(|y_{i,j}|) & \sigma_y{}^2 \le \sigma_v{}^2 \end{cases}$$

Where $y_{i,j}$ is the sub-bands ,σ_v is the noise variance, σ_x is the original image variance and σ_y is the corrupted image variance

$$\sigma_y^2 = \frac{1}{M \times N} \sum_{i=1}^{M} \sum_{j=1}^{N} (y_{i,j})^2$$

Where yi,j is the sub-bands

$$\sigma_x = \sqrt{\max(\sigma_y{}^2 - \sigma_v{}^2, 0)}$$

$$\sigma_y = \frac{median(|x_{i,j}|)}{0.6745} \qquad x_{i,j} \in \text{sub band } HH^i : i=1, 2\ldots$$

visu shrink does not minimize the MSE and it does not remove speckle noise. Bayes shrink is suitable for all type of noise. Hence we goes with Bayes shrink

3.6 Inverse Discrete Wavelet Transform

In this step IDWT of threshold image is performed. The information from the sub bands are up sampled and filtered with the corresponding filter. The results that belong together are added and again up sampled and filtered with corresponding filter this process is repeated until original image is obtained.

3.7 De-noised Image

Here de-noised image obtained after inverse wavelet transform.

3.8 Calculating PSNR and MSE

PSNR is used to measure the quality of image. It is the ratio between maximum possible power and the distortion signal in image. It is expressed in decibels. Higher the value of PSNR indicates high quality of image.

$$\text{PSNR}=\frac{(\text{Max})^2}{MSE}$$

Since we are using bit gray scale image maximum value is equal to 255.
PSNR in dB is given by

$$\text{PSNR in db} = 10\log_{10}(\text{PSNR}).$$

MSE is the average squared difference between a original image and reconstructed image. It is computed as pixel by pixel by adding square difference of the entire pixel and dividing it by total number of pixel.

$$\text{MSE} = \frac{1}{M \times N} \sum_{i=1}^{M} \sum_{j=1}^{M} (I(i,j) - R(i,j))^2$$

Where, I(i, j) is the original image and R(i, j) is the reconstructed image.
PSNR and MSE are inversely proportional i,e as PSNR increases as MSE decreases and vice versa.

IV. Results

4.1Below figures indicate images reconstructed from different types of noises and table indicates the PSNR value reconstructed images

4.1.1 Lena image

Fig (a)

Fig (b)

Fig (c)

Fig (d)

Fig (e)

Fig (a) original image, fig(b) de-noised image from salt and pepper noise, fig(c) de-noised image from Gaussian noise, fig(d) de-noised image from speckle noise, fig(e) de-noised image from salt and pepper, Gaussian and speckle noise.

Table 1-PSNR result of existing and proposed method of Lena image with noise variance 0.05 (Gaussian and speckle noise) and noise density 0.05(salt and pepper noise)

Name of the image	Added noise	Existing method PSNR	Proposed method PSNR
Lena image	Salt and pepper	25.7208	36.9320
	Gaussian	32.1684	35.4091
	speckle	24.9479	36.2851
	Salt & pepper, Gaussian and speckle noise	28.2803	35.4852

4.1.2 Barbara image


Fig (a)


Fig (b)


Fig(c)


Fig (d)


Fig(e)

Fig (a) original image, fig (b) de-noised image from salt and pepper noise, fig (c) de-noised image from Gaussian noise, fig (d) de-noised image from speckle noise, fig (e) de-noised image from salt and pepper, Gaussian and speckle noise.

Table 2-PSNR result of existing and proposed method of Lena image with noise variance 0.05 (Gaussian and speckle noise) and noise density 0.05(salt and pepper noise)

Name of the image	Added noise	Existing method PSNR	Proposed method PSNR
Barbara image	Salt and pepper	24.3847	35.1599
	Gaussian	28.3690	34.3353
	speckle	24.0721	34.8806
	Salt & pepper, Gaussian and speckle noise	26.3278	34.4594

4.3 PSNR value is compared with many more images

Table 3-PSNR result of existing and proposed method of images at noise density 0.05(salt and pepper noise)

Name of the image	**PSNR of existing method**	**PSNR of proposed method**
Graylonesome	25.0166	36.1483
Coins	27.0428	37.1723
Chessboard	25.5257	36.4972
Fingerprint	23.6715	36.6393
House	26.3441	37.9545
Paolina	26.2647	38.6600
Obama	26.1534	36.9362
Rice	25.9974	37.0326
Trui	26.4568	38.8188
Rbc	25.3474	36.4984

Table 4-PSNR result of existing and proposed method of images at noise variance 0.05(Gaussian noise)

Name of the image	PSNR of existing method	PSNR of proposed method
Graylonesome	30.4585	34.9893
Coins	33.5571	35.5145
chessboard	27.2124	35.8455
fingerprint	29.7519	35.1942
House	34.4380	35.8473
paolina	34.5700	36.0326
Obama	33.9614	35.3821
Rice	32.2136	35.4749
Trui	35.0059	36.1169
Rbc	31.5269	35.1676

Table 5-PSNR result of existing and proposed method of images at noise variance 0.05(speckle noise)

Name of the image	PSNR of existing method	PSNR of proposed method
graylonesome	24.4657	35.7165
Coins	26.3260	36.6766
chessboard	21.9519	35.6660
fingerprint	23.7017	35.8099
House	25.1998	36.8582
paolina	25.3662	37.2046
Obama	24.7061	36.1545
Rice	25.5713	36.5151
Trui	25.1033	37.3496
Rbc	24.6930	35.9516

Table 6-PSNR result of existing and proposed method of images at noise variance 0.05(Gaussian noise, speckle noise) and noise density 0.05(salt and pepper noise)

Name of the image	PSNR of existing method	PSNR of proposed method
graylonesome	27.0663	35.0939
Coins	28.7326	35.7643
chessboard	21.2737	34.6636
fingerprint	25.4021	35.1808
House	28.3303	35.8852
paolina	26.8094	36.1311
Obama	27.1941	35.3855
Rice	28.9044	35.6263
Trui	27.9573	36.2055
Rbc	27.6596	35.2004

V. Conclusion

Image de-noising is using median filter and adaptive wavelet threshold using bayes shrinkage is proposed. The proposed method achieves good PSNR value when compared to that of existing method. The image is with Gaussian noise, salt and pepper and speckle noise are tested using propose de-noising method and quality of image is compared in terms of PSNR with existing method. It is observed that better PSNR values are obtained for different types of noises.

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