Removal of Mixed Noise in Images using Hybrid Method

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Abstract— Images often corrupted by various noises during the process of generation and transmission. Mostly Images are corrupted by impulse noise & Gaussian noise. There are several methods to remove noises from different types of images. But still noise removal is a challenging task in order to obtain better recognition rate. So, keeping in view, a new hybrid approach for image denoising is presented, which is hybridization of wavelet filter and median filter. This hybrid method is proposed for denoising multiple noise (Gaussian and Impulse) images. To quantitatively evaluate and prove the performance of the new method, series of comparisons with some existing denoising methods are carried out in the paper and performance parameters are calculated such as MSE(Mean Square error), PSNR (Peak Signal to Noise Ratio).

Key words: Impulse noise, Gaussian noise, Image denoising, wavelet transform, median filter, hybrid approach, PSNR, MSE

I. INTRODUCTION

Many scientific datasets are contaminated with noise, either because of the data acquisition process, or because of naturally occurring phenomena. Pre-processing is the first step in analyzing such datasets. There are several different approaches to denoise images [1].

In many applications, image denoising is generally used to produce a good estimate of the original image from noisy states. Image denoising technique is necessary to eliminate as much random additive noise as possible while retaining required image features, such as edges and texture.

The main problem faced during diagnosis is the noise introduced due to the consequence of the coherent nature of the image capture. In image processing applications, linear filters tend to blur the edges and do not remove Gaussian and mixed Gaussian impulse noise effectively. Inherently noise removal from image introduces blurring in many cases. These noises corrupt the image and often lead to incorrect diagnosis. Gaussian noise is an additive noise, which degrades image quality that originates from many microscopic diffused reflections leads to discriminate fine detail of the images in diagnostic examinations. Many methods have been available for noise reduction. The existing filters used for mixed noise reduction techniques includes median filter, centre weighted median filter and wavelet filters. In this paper hybrid technique is proposed to find the best possible solution, so that after denoising PSNR, MSE values of the image will be optimal. The proposed method is based on wavelet transform and median filtering, which exploits the potential features of the combination of both wavelet and median filter.

II. EXISTING TECHNIQUES

Over the past decades, many techniques for image denoising have been proposed & these methods can be viewed in reference [1].But these methods do not give best solution. These methods operate individually on particular noise removal not for all types of noises. Hence to obtain best solution the combined algorithm can be formed which extracts the advantages of all these methods.

Method suggested by Namrata Dewangan & Agam Goswami based on comparative analysis of different image denoising thresholding techniques using wavelet transforms. They have experimented with four different thresholding methods (Sure shrink, Bivariate shrink, Neigh shrink, Block Shrink) using the various noisy images and report the results for the 512×512 standard test images They are contaminated with Gaussian noise, salt and paper noise and speckle noise with standard deviations 10. These results are measured by the PSNR and MSE [2].

Mantosh Biswas and Hari Om have developed an image denoising threshold estimation method which is completely data driven and utilizes the information about subband coefficients. This method succeeds in removing a large amount of additive noise and also preserves most of the edges and visual quality of the image. Proposed method gives better performance than the VisuShrink, SureShrink, and BayesShrink [3].

Method suggested by Geeta hanji and Dr. M. V. Latte based on a nonlinear decision based algorithm for the removal of blotches in the presence of impulse noise in grayscale images[4] .This algorithm removes impulse noise effectively and preserves the edges without any loss thus gives better result. The algorithm is implemented in two stages.

In the first stage, decision rule based on the switching threshold is applied to the whole image unconditionally to detect the pixels as corrupted/uncorrupted. In the second stage the new pixel value is estimated only for the corrupted pixels. The performance of the algorithm is analyzed using MSE, PSNR, IEF and computation time .But this is useful only to reduce impulse noise in grayscale images not for colour images.

Kiruthika .D & Sarathbabu .R suggested a novel and effective method for removal of blotches and impulse noises in corrupted colour images. The first phase is a noise detection phase where a nonlinear decision based algorithm is used to detect impulse noise pixels. The second is a noise filtering phase where a new algorithm based on performing vector median first in RGB [5].

J Umamaheswari & Dr.G.Radhamani suggested new technique based on the hybridization of wavelet filter and center weighted median filters for denoising multiple noise (Gaussian and Impulse) images**.** In this paper, an important research challenge is to improve the visual quality of CT brain images through image processing in order to detect abnormal brain at an early stage. This paper describes new methods for brain image pre-processing for noise suppression based on the wavelet transform. The image pre-processing was designed to suppress the noise present in local dense regions adaptively [6].

III. WAVELET BASED DENOISING

Wavelet transforms provide a framework in which a signal is decomposed, with each level corresponding to a coarser resolution or lower frequency band, and higher frequency bands. There are two main groups of transforms, continuous and discrete. Of particular interest is the DWT, which is based on sub-band coding is found to yield a fast computation of Wavelet Transform. It is easy to implement and reduces the computation time and resources required [7].This algorithm is used to denoise the Gaussian noise present in noisy image.

The following figure 1 shows the wavelet denoising steps:

Step1: Apply wavelet transform to the noisy image to produce the noisy wavelet coefficients.

Step2: Select best appropriate threshold limit at each level by using threshold method (hard or soft thresholding) to remove the noises. Here soft thresholding is used for removal of noise.

Step3: Inverse wavelet transform is applied to threshold wavelet coefficients to obtain a denoise image.

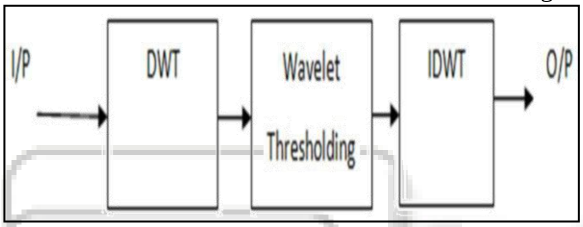


Fig. 1: Denoising using wavelets transform filtering

A. *Wavelet Thresholding*

Thresholding is a simple non-linear technique, which operates on one wavelet coefficient at a time. In its most basic form, each coefficient is threshold by comparing against threshold, if the coefficient is smaller than threshold, set to zero; otherwise it is kept or modified. Replacing the small noisy coefficients by zero and inverse wavelet transform on the result may lead to reconstruction with the essential signal characteristics and with less noise.

Hard and soft thresholding with threshold *are* defined as follows:

The hard thresholding operator is expressed in equation (1) as,

$D(U, \lambda) = U$ for all $|U|> \lambda$................1.1

The soft thresholding operator on the other hand is expressed in equation (2) as,

$D(U, \lambda) = \text{sgn}(U)\max(0, |U| - \lambda)$.........1.2

Hard threshold is a "keep or kill" procedure and is more intuitively appealing. The alternative, soft thresholding, shrinks coefficients above the threshold in absolute value while at first sight hard thresholding may seem to be natural, the continuity of soft thresholding has some advantages. It makes algorithms mathematically more tractable. Sometimes, pure noise coefficients may pass the hard threshold and appear as annoying "blips" in the output. Soft thresholding shrinks these false structures. The threshold selection is the core of the whole wavelet shrinkage. There are many threshold selection methods exist such as normal shrink, visu shrink, sure shrink etc, but in this paper, we mainly focus on ***Bayes Shrink*** for threshold selection [7].

B. *Bayes Shrink*

BayesShrink was proposed by Chang, Yu and Vetterli. The goal of this method is to minimize the Bayesian risk, and hence its name, BayesShrink. It uses soft thresholding and it is also subband-dependent, which means that thresholding is calculated at each band of resolution in the wavelet decomposition. Like the SureShrink procedure, it is smoothness adaptive. The Bayes threshold,t_b

$$t_B = \sigma^2/\sigma_s \quad 3$$

Where $\sigma 2$ is the noise variance and σs^2 is the signal variance without noise. The noise variance σ^2 is estimated from the subband HH1 by the median estimator. BayesShrink performs better than SureShrink in terms of MSE. The reconstruction using BayesShrink is smoother and more visually appealing than one obtained using SureShrink [9].

IV. MEDIAN FILTER BASED DENOISING

To overcome the drawbacks of median filter, Decision Based Unsymmetrical Trimmed Median Filter (DBUTMF) is proposed. The proposed Modified Decision Based Unsymmetrical Trimmed Median Filter (MDBUTMF) algorithm removes this drawback at high noise density and gives better Peak Signal-to-Noise Ratio (PSNR) values than the existing algorithm.

A. *MDBUTMF Algorithm*

Modified Decision Based Unsymmetrical Trimmed Median Filter (MDBUTMF) algorithm processes the corrupted images by first detecting the impulse noise. The processing pixel is checked whether it is noisy or noisy free. That is, if the processing pixel lies between maximum and minimum gray level values then it is noise free pixel, it is left unchanged. If the processing pixel takes the maximum or minimum gray level then it is noisy pixel which is processed by MDBUTMF [10].

The steps of the MDBUTMF are elucidated as follows.

Step1: Select 2-D window of size 3*3.Assume that the pixel being processed is Pij

Step2: If 0<Pij<255 then Pij is an uncorrupted pixel and its values is left unchanged

Step3: If Pij=0 or 255 then it is corrupted pixel then 2 cases are possible as given below

Case 1: If selected window contains salt/paper noise as processing pixel & neighboring pixel values contains all pixels that adds salt and paper noise to image. To solve the problem, the mean of selected window is found and the processing pixel is replaced by the mean value.

Case2: If selected window contains salt or paper noise as processing pixel & neighboring pixel values contains some pixels that adds salt and paper noise to the image. Then replace that processing pixel Pij by its median value.

Step 4: repeat steps 1 to 3 until all pixels in the entire image are processed

The pictorial representation of each case of the proposed algorithm is shown in Fig. 2.

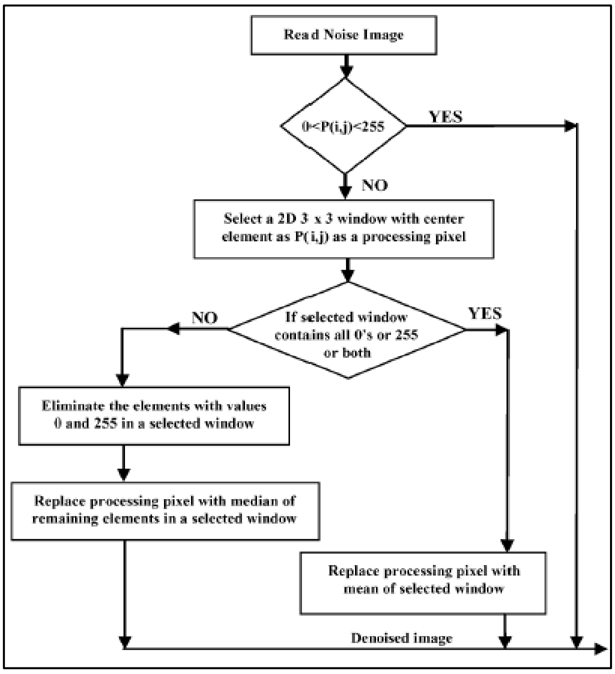


Fig. 2: Flowchart of MDBUTMF.

V. PROPOSED HYBRID ALGORITHM

In the hybrid work, two techniques namely, wavelet thresholding and center weighted median filters are combined to form a hybrid denoising model. These techniques are used to suppress the mixed noise (Gaussian and impulse noise). The following steps show the proposed method for denoising mixed noise in images.

Step1: Gaussian and impulse noises are estimated

Step2: Perform multiscale decomposition of the image corrupted by Gaussian noise using wavelet transform.

Step3: For each level, compute the scale parameter.

Step4: For each Sub-band

- Compute the standard deviation
- Compute threshold using Bayes Shrink
- Apply soft thresholding to the noisy coefficient

Step5: Invert the multiscale decomposition to reconstruct the denoised image

Step6: The denoised image obtained from wavelet method is again processed for reducing impulse noise

Step7: To reduce impulse noise MDBUTMF filter is applied and finally denoised image is obtained

VI. PERFORMANCE PARAMETERS

Performance of hybrid algorithm is evaluated by using MSE (Mean Square error) and PSNR (Peak signal to noise ratio).
MSE: This is Simplest, and the most widely used for image quality measurement. By subtracting the test signal from the reference, and then computing the average energy of the error signal.
Where x (i, j) represents the original image and y(i , j) represents the denoised (modified) image and i and j are the pixel position of the M×N image. MSE is zero when x(i, j) = y(i, j)

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(x(i,j) - y(i,j))^2$$

PSNR: This can be calculated by comparing two images one is original image and other is distorted image. The PSNR has been computed using the following formula:

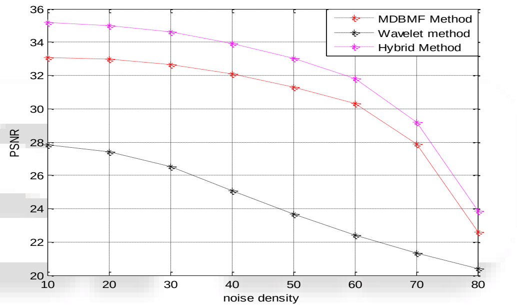
$$PSNR = 10log\frac{s^2}{MSE}$$

VII. EXPERIMENTAL RESULT:

The performance of the proposed algorithm is tested with different grayscale and color images. The noise density (intensity) is varied from 10% to 80% Denoising performance quantatively measured by PSNR and MSE as defined in performance parameters.

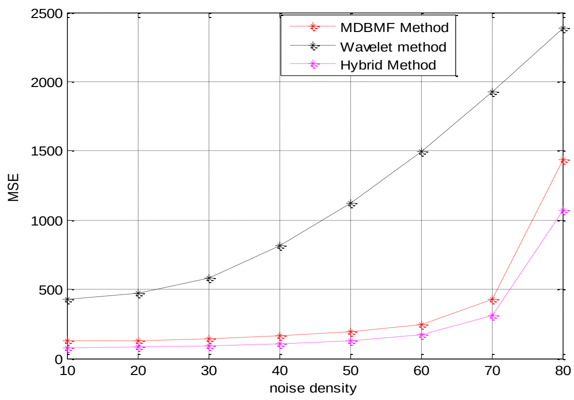
Noise Density	PSNR of Noisy Image	MDBMF Output	Wavelet Method	Hybrid Algorithm
10	20.94	33.062	27.8341	35.1797
20	18.093	32.9796	27.4226	35.0111
30	16.3659	32.6464	26.508	34.5968
40	15.1369	32.0816	25.0722	33.9296
50	14.1925	31.318	23.6549	33.0387
60	13.4211	30.3095	22.4183	31.8343
70	12.7462	27.8862	21.3151	29.1955
80	12.1824	22.6066	20.3856	23.8779

Table 1: comparison of PSNR values different algorithms for Lena image at different noise densities



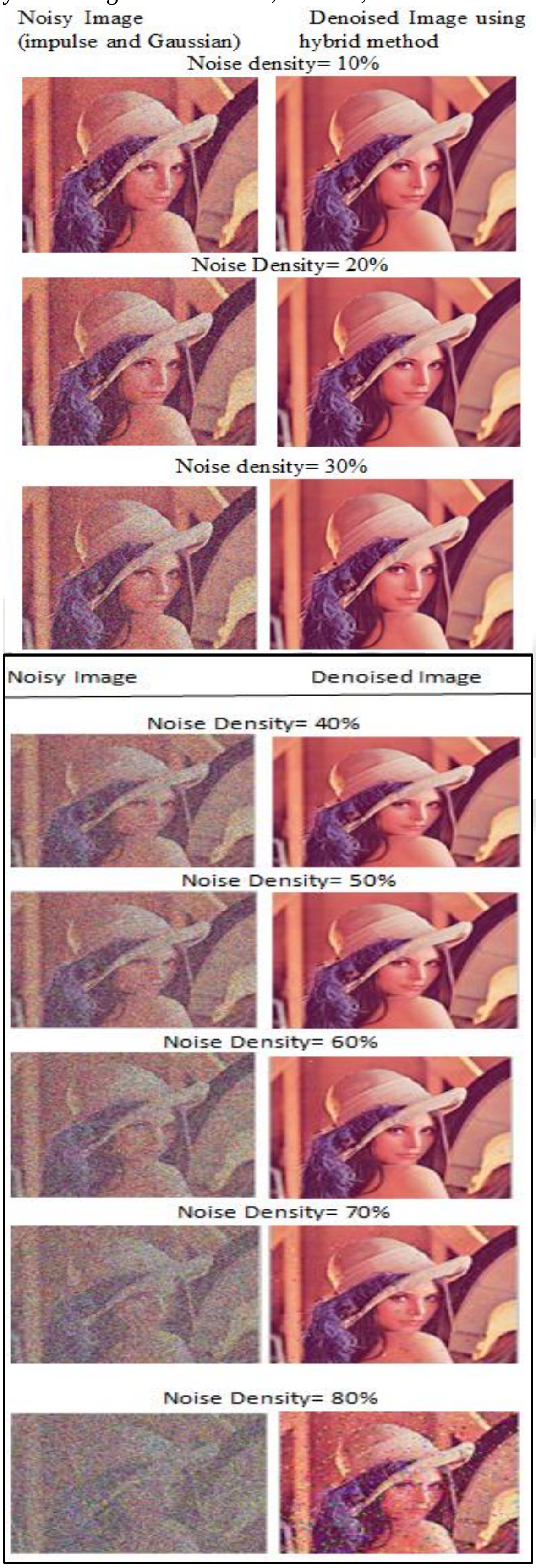
Noise Density	MSE of Noisy Image	MDBMF Output	Wavelet	Hybrid Algorithm
10	2102.62	129.017	429.967	79.2263
20	4050.77	131.487	472.693	82.3626
30	6029.05	141.973	583.505	90.6062
40	8001.09	161.689	812.132	105.652
50	9944.62	192.772	1125.51	129.71
60	11877.6	243.162	1496.27	171.165
70	13874.6	424.836	1928.99	314.261
80	15798	1432.78	2389.35	1069.17

Table 2: comparison of MSE values different algorithms for Lena image at different noise densities



From the Tables I and II, and plot of PSNR & MSE against noise density it is observed that the performance of the proposed hybrid algorithm is better than the existing algorithms at high noise densities.

The proposed algorithm is tested against colour & grayscale images such as Lena, Barbara, baboon etc.



VIII. CONCLUSION

In this paper , a new hybrid algorithm is proposed which gives better performance in comparison with median filter, wavelet transform and other existing noise removal algorithms in terms of PSNR & MSE. The performance of the algorithm has been tested at low, medium and high noise densities on both gray-scale and color images. Even at high noise density levels i.e 60% the hybrid algorithm gives better results in comparison with other existing algorithms. Both visual and quantitative results are demonstrated. This hybrid algorithm will gives better noise removal of mixed noise than individual algorithm on particular noise.

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