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Impact of Wavelet Transform and Median Filtering on Removal of Noise in Digital Images.

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ABSTRACT

Image acquisition is a common task in every image processing operation. Noise is entered during image acquisition from its source and once entered it degrades the image and is difficult to remove. In order to achieve the noise cancellation in an image, non-linear filter works better than linear. The first part of the paper derives the wavelet coefficients with slight increase in noise density and in second part these coefficients are further modified by median filter. The algorithm shows the remarkable improvement over Gaussian noise model and removes most of the noisy part from the image and maintains the visual quality. The level of wavelet decomposition is restricted to three. The renowned indexes Peak Signal to Noise Ratio (PSNR) and Root Mean Square Error (RMSE) demonstrate marked improvement of image de-noising over Gaussian method.

Keywords: salt and pepper noise, median filter, wavelet transform, inverse wavelet transform.

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INTRODUCTION

Image restoration is preliminary track in image processing in current time. Image noising (distortion) is one of the well-known and a common issue in Image processing system. Image de-noising operation is often used to de-noise the degraded image. Image noising is generally seen due to various types of noise, for example Gaussian noise, Impulsive noise, Poisson noise and Speckle noise etc. These are fundamental noise types in case of digital images. Impulsive noise is completely removed by conventional median filter rather than other noise types. Impulsive noise is classified into Salt and Pepper noise and random valued noise [1].

In this paper, we use salt and pepper noise because it is most common and seen in general image processing operations. Noise is introduced in images during image acquisition or transmission or recording. This phenomenon may happen due to Electronic or photometric sources. If the image formation, transmission and reception processes in Electronic or photometric sources are imperfect, they produce blurred image. Image formation processes such as spreading of focal length, non-stationary camera placement cause bandwidth reduction in an image. Salt and pepper noise are generally caused by camera sensors, misaligned lenses and weak length of focal etc., [2].

That is why careful study of salt and pepper noise is essential which leads to proper selection of noise model for image de-noising operations. Day by day the demand of the quality images is increasing. That is why the proposed scheme is to try to maintain the quality of visual perception of an image and also try to remove most of the noisy part in the degraded images. Non-linear techniques have been proposed and used successfully for image de-noising. However, traditional linear filtering does not perform well in case of non-linear operation of impulsive noise during image formation and transmission. An image signal has structural constraints, for examples lines, junctions, edges, corners and other fine details. However most of linear filters have only low pass characteristics and hence edges, lines and other fine details are completely lost due to filtering [3-4]. Pixel based image de-noising schemes are traditional and have been used for quite long time. In recent development, wavelet based image de-noising algorithms have achieved remarkable results [5]. In this paper we propose wavelet transform of iterative noise density of salt and pepper noise and median filtering.

WAVELET TRANSFORM

Fourier Transform has been used for time frequency analysis. Fourier Transform has certain limitations and those are overcome by Wavelet transform, so wavelet transform is good replacement for Fourier transform. The wavelet transform is able to analyze the time frequency content of an image. It provides multi resolution operations. Wavelet transform works on dilation and translation properties that give a group of template functions. Unlike Fourier transform, wavelet transform can be chosen with more freedom without the need of using sine-cosine pairs [6].

Discrete Wavelet Transform (DWT)

DWT is used to find the approximation and detailed coefficients of a discrete signal. DWT represents the time frequency analysis of discrete signal. Spectrum analysis and spectral behaviour of the signal in time is essential and that is analyzed by DWT. In wavelet decomposition, signal breaks it into two classes; low pass and high pass [7-8]. These classes are separately used to carry information of original signal as shown in Fig. 1.

Highpass

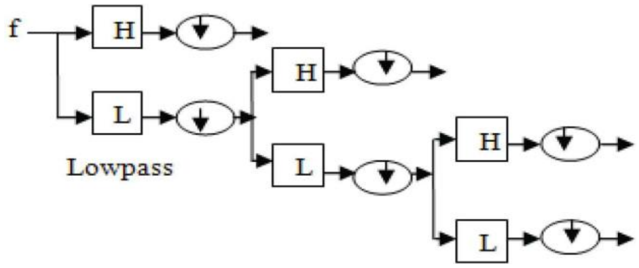


Figure I. 2·D far Discrete Wavelet Transform

MEDIAN FILTER

Median filter (Non-linear filter) works on medial pixel value of its surrounding neighbours instead of mean filter (linear filter). To preserve the smoothness in a resultant image median filter is most prominent choice. A median filter operates on pixel based noise reduction approach under structural constraints. In order to retain the smoothness and edges median filters are best choice among the other nonlinear filters [9].

In the context of Order statistics theory, the intensity value of an image is critical choice in deciding the ranking of the neighbouring pixels. To overcome the above criteria value of noisy pixel is replaced by the median value of surrounding pixel values [10-13].

PROPOSED METHOD

This paper is an extension of [14]. We present an integration of wavelet transform and median filter. This integrated approach is used for removal of salt and pepper noise from an image. Basically we are comparing the two most popular and elegant noise models, Gaussian model and proposed salt and pepper noise model. These two noise models are compared on the basis of iterative noise density in the proposed method.

We exploit the powerful integration of wavelet transform and median filtering approach. These two schemes are jointly used to remove salt and pepper noise in an image. This combined approach overcomes the limitations of each of them. Multilevel wavelet decomposition is used in this paper. The multilevel wavelet decomposition is used to arrange coefficients in a manner that enables time-frequency analysis. These coefficients are improved via wavelet in order to achieve the smoothness. Smoothness is generally seen in the low pass region where as edges are seen in the high pass region [15-17]. Further, low pass region has been improved in our method. We deploy Haar wavelet (Daubechies zero) decomposition at level three [18]. Haar wavelet decomposition is shown in the Fig. 2 using Lena image [19]. In our method wavelet decomposed an image into different offset up to three levels. These offsets are referred to as original and noisy images into HH3, HL3, LH3 and LL3 sub-bands, which are shown in Fig. 3. We exploit an iterative noise density scheme in salt and pepper noise model. The filtering window is set of 3x3 pixels. Of course 3x3 filtering window itself cannot be justified under restriction of the expansion of the filter size. Result needs the adaptation in a given filter according to optimum choice.

Enhancement

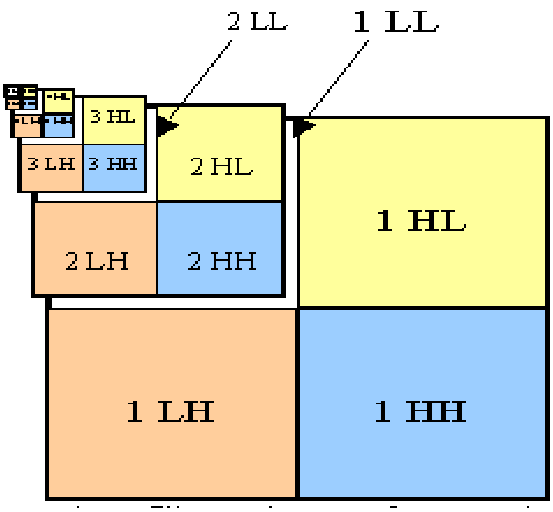
Fourier Transform has certain limitations and those are overcome by Wavelet transform, so wavelet transform is good replacement for Fourier transform To preserve the smoothness in a resultant image median filter is most prominent choice. A median filter operates on pixel based noise reduction approach under structural constraints

Figure 1: Input image with salt and pepper noise.

Figure 2: Output of median filter.

As we check the two images above. we see the first image containing the black and white dots. those black and white dots are called salt and pepper noise.

In figure two we can see the clean image with out any salt and pepper noise this is done by using median filter.



Wavelet Decomposition of image at three levels

To preserve smoothness and edges of an image we need wavelets operation in much more depth for which wavelet is reasonable choice. That is why an integration of wavelet based iterative noise density and Median filter is the best approach for salt and pepper noise instead of Gaussian noise. In this paper an image is corrupted by salt and pepper noise. That is why to estimate the noise densities of salt and pepper noise is essential [20] and successfully measured in our algorithm, which is shown in Fig. 4. First wavelet transform decomposed the noisy image Z (j, k) in the form of approximate and detail components.

In proposed method, the detail components are set to zero. Further the approximate part using the median filter [21-23]. The following equations represent the proposed method.

Z(j,k) = D[j(j,k)] + I(j,k) Where j(j,k) is original image, I(j,k) is Noise signal, Z (j, k) is degraded image and D is degrading function.

1(j,k)E A == {l, ... E}X{l, ... F} is 256X256 resize gray level image at pixel location (j, k) Where {l, ... E } and {l, ... F } are the rows and columns of I (j, k) respectively.

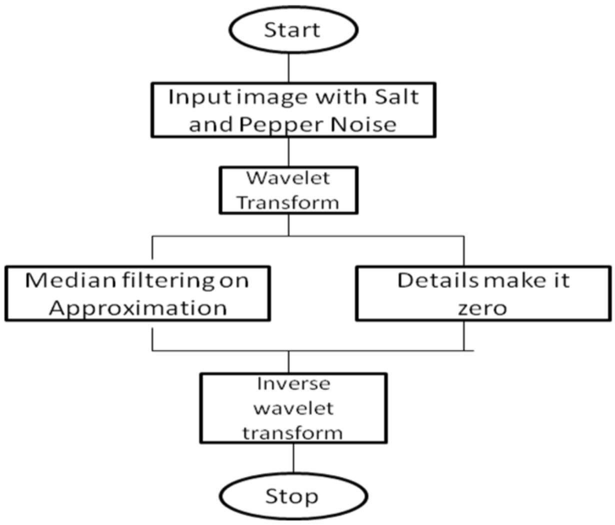


Fig. 4 The De-noising algorithm

SIMULATION AND RESULTS

The proposed method was implemented using MATLAB R2012a on a Dell Laptop with 2GB RAM, Core i-3 processor and windows 7 operating system. The simulation part in our studies is evaluating the de-noised performance of salt and pepper noise model in a proposed method over Gaussian noise model.

In this paper we have presented the wavelet based iterative noise density and median filter for determining the PSNR and RMSE. In the context of smoothness locally adaptive zero mean and known variance nearly approximated 0.01 to 0.1 for which 0.005 is the fixed interval for all iteration.

Proposed method assumes salt and pepper noise model has nearly optimal reasonable variance for each wavelet coefficient has been one of the important properties in the image de-noising. On seemingly the paper not only gives the mathematical modelling of combined approach but also gives certain level of accurate results which are shown in Fig. 5 through 10. It is examined that the comparative study of, Haar wavelet with Median filter and without Median filter have been performed over the different noise model. The proposed method describes different kind of parameters for simulation is shown in Table 1.

The algorithm displays the structural constraints such as corners and low frequency features, because the algorithm only deals with approximation signals. Therefore the proposed method modifies the structural constraints. Though the proposed method highlights the different noise model for a standard Lena image is one of the major concerned of the work. It is observed that, as we slightly increase the noise density the smoothness of de-noised image seems to be well preserved.

Table 1 Simulation parameters

S.no.	Parameter	Parameter Specification
1	Noise type	Salt and Pepper
2	Wavelet	Haar
3	Decompose Level	3
4	Filter	Median
5	Filter size	3X3
6	Iteration	18
7	Noise mean	Zero value
8	Noise density	.01 to 0.1 for which 0.005 is thefixed interval for all iteration

Image using Gaussian noise model when Noise density is 100% improved

Image using Salt and Pepper noise model when Noise density is 100% improved. But in Fig. 7 through Fig. 10 we clearly seen that the density up to 40% seems to be well results and preserved the smoothness. From 40% to 100% resultant de-noised image would start to become almost double. Proposed method achieved closer image as compared to original one and gives almost 3 dB improvement in PSNR and 5 dB falls in RMSE as compare to Gaussian model. When noise density is reached to 100% the denoised image is totally damaged because of noise density is almost double.

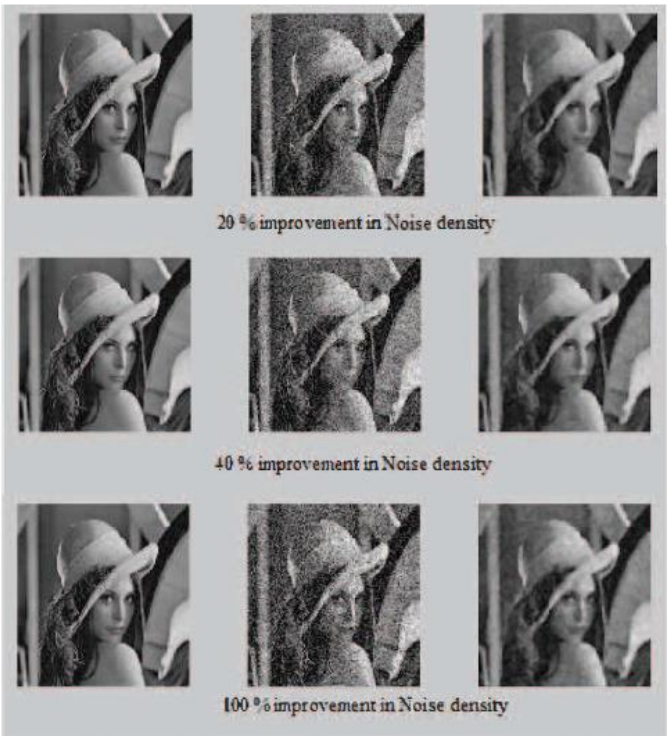


Image when Noise density is improved from 20% to 100% in Gaussian noise model.

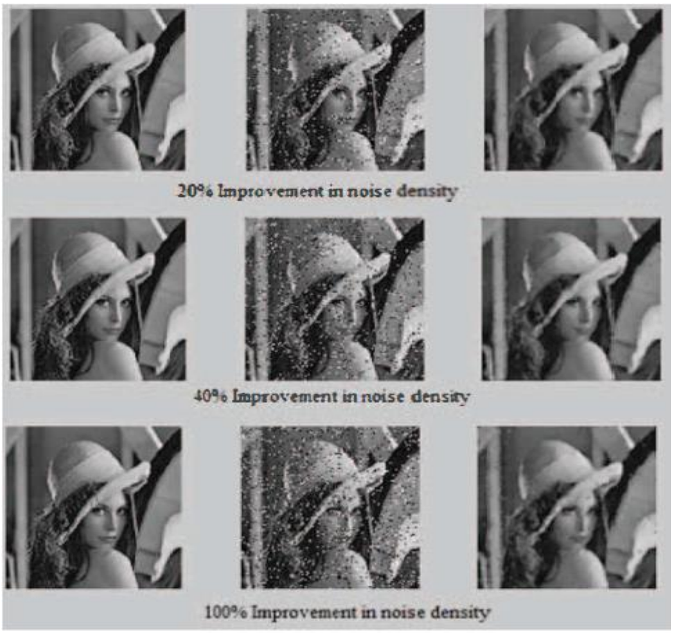
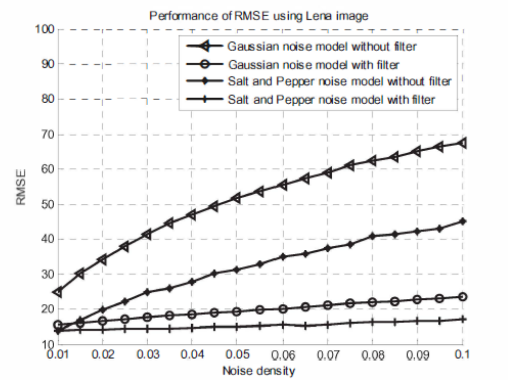
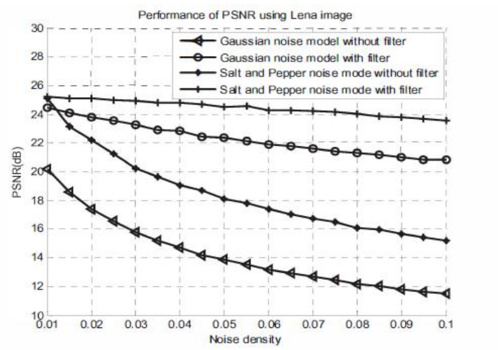


Image when Noise density is improved from 20% to 100% in Salt and Pepper noise model.



Performance of RMSE using image with and without median filter.



Performance of PSNR using Lena image with and without median filter

CONCLUSION

As commented in the proposed method Salt and Pepper noise model perform well rather than Gaussian noise model using wavelet transform and median filter approach. Hence it is observed that the proposed method is simply produces better results over the nearly constant result of traditional Gaussian noise model. The detail coefficients of wavelet have been suppressed and only considered the approximation coefficients without using any other kind of threshold. Almost 3 dB PSNR has been improved and 5 dB down fall in the RMSE against the Gaussian noise model, which make result better. We depicted the performance of both model. In a proposed method, median filtering minimized Salt and Pepper noise more accurately as compare to Gaussian noise.

The idea behind the low noise density achieved significant and remarkable result. But in practice, the noise density increases from 40% to 100% proposed algorithm gives promising results .This is because of almost double the noise density taken in both Salt and Pepper noise model and Gaussian noise model. This implies that the algorithm worked up to the 100% improvement in variations from the default variance and gives the optimum result in salt and pepper noise model over Gaussian noise model. Wavelet transform itself does the threshold. in one sense that is why in the proposed method we have not used any other kind of threshold. Since we observed in a proposed method the visual quality of image is not accurately improved without threshold. Most of the noisy part is still presence .In spite of this, another level ofthreshold that is soft threshold can be thought of.

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