An Improved Image Denoising using Spatial Adaptive Mask Filter for Medical Images

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***Abstract*— Medical images are affected by the noise and image quality is degraded especially in magnetic Resonance Imaging (MRI) and ultrasound imaging. These images are mostly containing salt and pepper noise. It is critical to remove the noise from the medical images because the important information may affect.**

In this paper, a robust image denoising technique called spatial adaptive mask filtering technique has been proposed. The proposed algorithm is able to remove the noise from the MRI and ultrasound images while retaining the important information of the image. Experimentation results show that the quality of the images are improved and it is measured in terms of Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE). The comparative analysis of mean, median and adaptive median filter has been presented.

Keywords*— *Adaptive median, medical image denoising, mean, median, spatial adaptive mask, filter component

I. Introduction

In recent years, the medical imagining techniques like Magnetic Resonance Imaging (MRI), X-ray, Computed Tomography (CT) scan, PET and SPECT etc. are used to diagnose the disease in the human body. These techniques are used to detect tumors, cancers, blockage in the veins. The medical imaging technique is quite complicated because of it different from the normal camera capturing. In medical image acquiring, the images are captured by physical and physiological procedures. This capturing process produces noise in the image. This noise will make it complicated to the doctors for detection of disease.

To improve the diagnosis rate, the noise removal algorithms need to implement to remove the noise from the medical image. Hence medical image enhancement area attracted researchers toward the implementation of denoising algorithms. The principal aim of the proposed work is to remove the salt and pepper noise from the medical image using improves image processing filters while preserving the original data [1].

The noise may be self-generated by capturing devices or additive. It depends on the modality used for capturing the medical image acquisition. The noise introduced due to the electronic component is mostly data dependent Gaussian noise while in X-Ray, quantum Noise and it is modeled with Poisson distribution, in ultrasound imaging, speckle noise is present and it is modeled by Rayleigh distribution.

The image can be denoising in spatial as well as in frequency domain. The various denoising techniques have been discussed in [2]. The median is the filter which is popular to remove salt and pepper noise from the images but while processing it produces artifacts in the images. It is popular to remove impulse noise because it gives good noise reduction with minimum artifacts [3]. The different types of spatial filters are explained section II.

II. Different Filtering Technique

The different filtering techniques used for denoising the image is as explain below

A. Median Filter

The median filter is the non linear filter which performs the nonlinear operation of neighboring filter. it is very effective for salt and pepper noise and it preserves the edges. It also works on the neighborhood pixels. In this method, each pixel is replaced by a median value of its neighborhood pixel. It is very effective when the neighborhood considers is small while it causes blurring in an output image for the large neighborhood. [4].

B. Adaptive Median Filter

The limitations of the median filter are overcome by designing the adaptive median filter [5]. The advantage of this filter is it removes the noise while preserving the outer edges. It is based on the local statistical characteristics. This also preserves the useful information when deals with the impulse noise.

C. Mean Filter

Mean filter is the used to reduce the intensities in an image. It uses convolution mask to process. The mask has some specific size which calculates the mean by considering the neighborhood pixels. In this method, the middle pixel of the mask is replaced by the mean value of its neighboring pixels. When filter neighborhood extends to the edges which may smoothen the corners of an image [6].

D. *Gaussian smoothing filter*

The Gaussian filter is especially popular to remove the blurring effect of the images. It requires weighted 2D convolution operator. The 2D Gaussian smoothing filter is given by the equation [7].

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$$G_\sigma(x,y) = \frac{1}{2\pi\sigma^2} exp^{-\frac{x^2+y^2}{2\sigma^2}} \quad (1)$$

Where, G (x, y) = Gaussian mask,
σ = standard deviation,
x, y = Grid value

For a 3x3 mask, the values of x and y are taken from the below grid.

-1,-1	0,-1	1,-1
-1,0	0,0	1,0
-1,1	0,1	1,1

Gaussians are used because:

- Smooth (infinitely differentiable)
- Decay to zero rapidly
- Simple analytic formula

The value of σ is responsible for the amount of blurring of an image.

E. *Adaptive Wiener filter(AWF)*

It is a frequency domain filter. The behavior of this filter depends on the statistical relationship of the image region inside the mask of size m x n to the neighborhood image inside the kernel. This filter is used to measure mean, standard deviation and variance of the image [8].

F. *Min Filter*

Min filter replaces the each pixel by the minimum intensity of the neighborhood pixel in the mask of size m x n. It is popularly known as 0^{th} percentile filter. It is used to suppress salt noise from the image [9]. It can be mathematically represented as:

$$f(x,y) = min\{g(s,t)\} \quad (2)$$

Where, $(s, t) \in S_{xy}$

G. *Max Filter:*

Max filter replaces the each pixel by maximum intensity of the neighborhood pixel in the mask of size m x n. It is popularly known as 100^{th} percentile filter. It is used to suppress pepper noise from the image [9]. It can be mathematically represented as:

$$f(x,y) = max\{g(s,t)\} \quad (3)$$

Where, $(s, t) \in S_{xy}$

III. PROPOSED SYSTEM

The proposed algorithm is the modified version of the adaptive median filter. It is called as spatial adaptive mask filter. It is work based on the sub-mask. It is more accurate and adaptive than the median filter. The block diagram for proposed system is explained below.

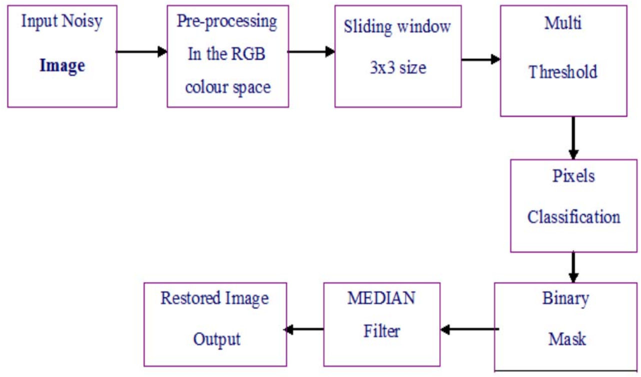

Fig. 1. Block diagram of Proposed system

In the proposed system, the input medical image with salt and pepper noise is taken as an input. First convert the color image into grayscale to reduce the complexity of the processing. The filtering process is initiate by creating mask of size 3x3. If the entire elements in the blocks are zero or 255 then count is increases. If such a count is less than or equal to 4 then window size selected as 3x3, if count is in between 5 to 12 then window 0f size 5x5 is selected and if count is greater than 13 then window of size 7x7 is selected for processing. This makes the results better. After selecting the block window size, the block is sliding over the image. The pixels are classified into original and noisy pixel by taking the median value of the mask. The middle pixel of each mask is replaced by its median value. Hence the pixel values which are extreme black i.e. nearer to zero and extreme white i.e. nearer to 255 are normalized and help to remove the salt and pepper noise. The flow chart of the proposed system is shown below.

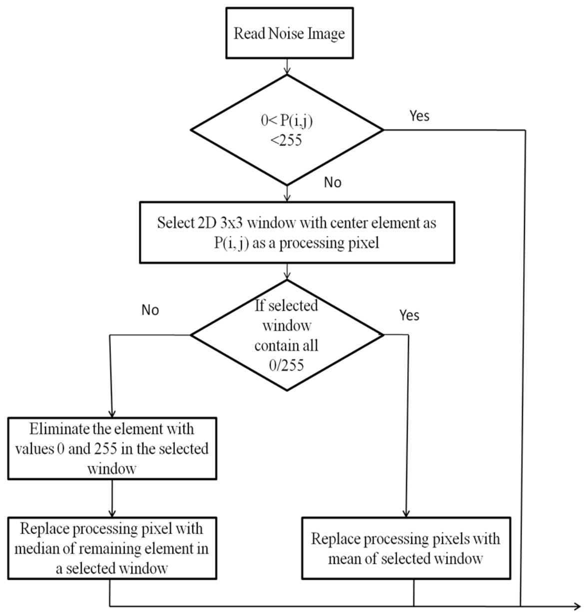

Fig. 2. Flowchart of the proposed algorithm

IV. RESULT

The proposed algorithm is implemented in the MATLAB software. In the proposed approach the results are explained in qualitative and quantitative manner.

A. Qualitative analysis

The qualitative results of the proposed system are shown in Fig. 1. The first image is noisy input image to the system, it is filtered by existing mean, median, adaptive median, spatial adaptive mask filter and proposed algorithm and results are shown respectively.

In Fig 3, the qualitative analysis of the proposed system on MRI images is shown.

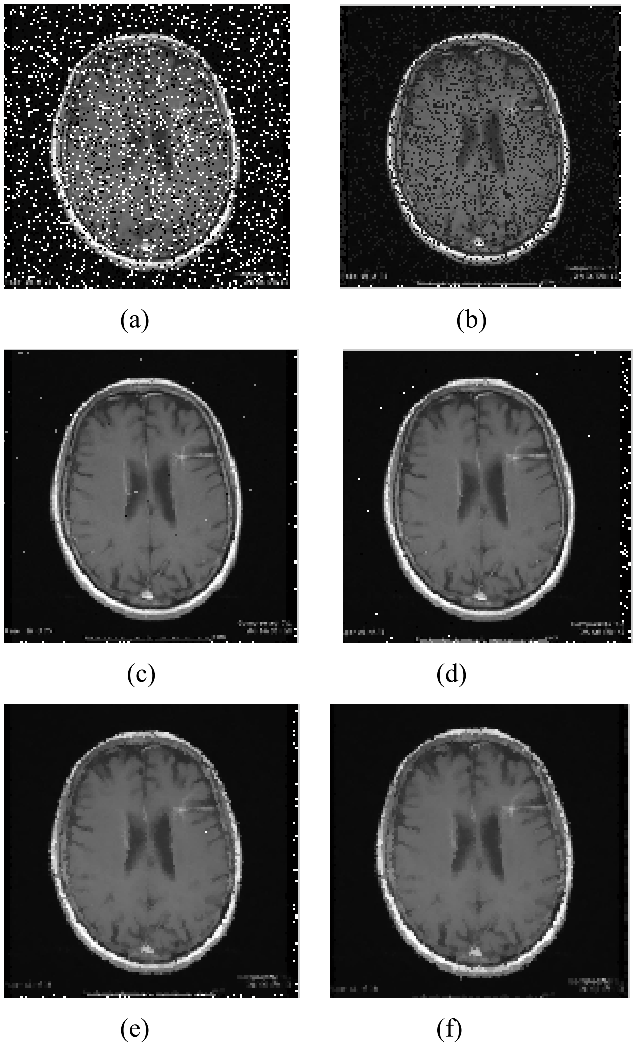

Fig. 3. Qualitative analysis of the proposed system on MRI images(a) Input Noisy MRI image (b) Mean filter output (c) Median filter output (d) Adaptive filter output (e)Spatial adaptive mask filter output (f) Proposed system output

In Fig 4, the qualitative analysis of the proposed system on ultrasound images are shown.

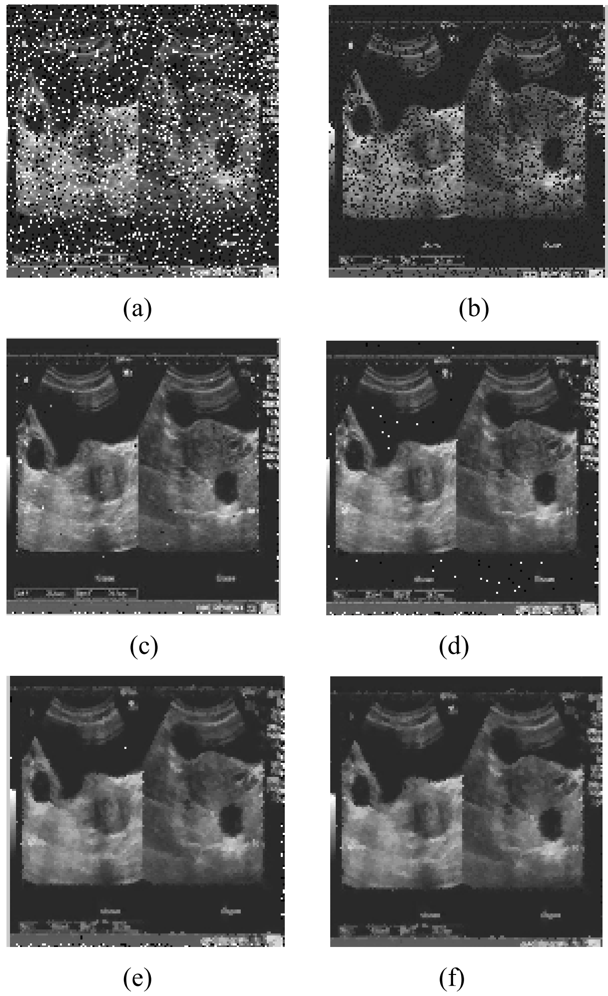

Fig. 4. Qualitative analysis of the proposed system on ultrasound images(a) Input Noisy MRI image (b) Mean filter output (c) Median filter output (d) Adaptive filter output (e)Spatial adaptive mask filter output (f) Proposed system output

B. Quantitative analysis

The quantitative analysis of the proposed algorithm is performed on two parameters PSNR and MSE. These are the image quality metrics. The higher the PSNR of the output image higher will be the quality of an image while lower the mean square error higher will be the quality. Mathematically PSNR and MSE is given by

$$MSE = \frac{1}{MN}\sum\sum(X - Y)^2 \tag{4}$$

$$PSNR = log_{10}(255^2/MSE) \tag{5}$$

Where, X is the noisy image

Y is denoise image

The results of the quantitative analysis of the proposed system in terms of PSNR and MSE of MRI and ultrasound images are tabulated in Table 1 and Table 2 respectively. The noise is introduced in the images from the noise level 0.1 to 1 with a difference of 0.1. The PSNR values of different noise removal filter are noted and finally analyze the results. From

PSNR value it is found that the noise level increases the PSNR values of the each algorithm is decreases.

TABLE I. COMPARISON OF PSNR VALUES FOR MRI IMAGE

Image No.	COMPARISON OF PSNR VALUES FOR MRI IMAGE					
	Noise Level	*Mean filter*	*Median filter*	*Adaptive median*	*Spatial Adaptive Mask Filter*	*Proposed method*
1	0.1	34.131902	35.572737	33.42375	33.649462	39.598575
2	0.2	32.689048	35.288271	33.278233	33.460024	38.409741
3	0.3	31.802389	34.72754	33.161348	33.261409	37.447873
4	0.4	31.152762	33.631283	32.868435	34.443681	36.427703
5	0.5	30.665991	32.315404	32.541726	32.093437	35.384583
6	0.6	30.288716	30.957922	31.914578	30.899579	34.233942
7	0.7	29.95498	29.824842	30.7648	29.706589	33.0888
8	0.8	29.652105	28.776127	29.335498	28.430689	31.769413
9	0.9	29.399168	27.910556	27.944319	27.446672	30.423171
10	1	29.166842	27.181118	26.658187	26.646614	28.894879

TABLE II. COMPARISON OF PSNR VALUES FOR ULTRASOUND IMAGE

S.no	COMPARISON OF PSNR VALUES FOR ULTRASOUND IMAGE					
	Noise Level	*Mean filter*	*Median filter*	*Adaptive median*	*Spatial Adaptive Mask Filter*	*Proposed method*
1	0.1	35.201614	34.90133	33.532518	34.344837	37.749941
2	0.2	33.85698	34.758439	33.496669	34.092453	37.338152
3	0.3	33.015769	34.359641	33.447904	33.802597	36.848564
4	0.4	32.395071	33.403378	33.275232	33.253138	36.279956
5	0.5	31.929247	32.242435	32.964128	32.373047	35.534732
6	0.6	31.516844	30.900181	32.135143	31.061636	34.564481
7	0.7	31.184428	29.64075	30.789465	29.510324	33.053247
8	0.8	30.897004	28.596415	29.28167	28.251614	31.468715
9	0.9	30.631129	27.789411	27.893592	27.340715	30.144471
10	1	30.405494	26.994579	26.522511	26.486591	28.405751

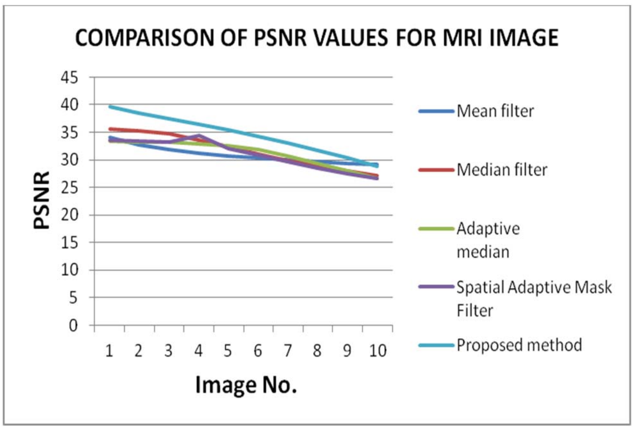

Fig. 5. PSNR performance of (1) mean (2) median (3) adaptive median (4) spatial adaptive mask filter (5) proposed algorithm

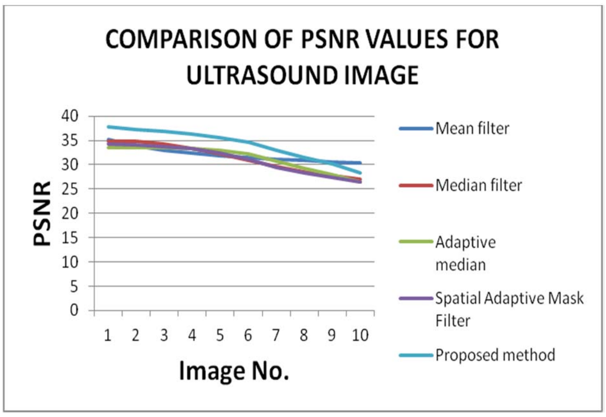

Fig. 6. MSE performance of (1) mean (2) median (3) adaptive median (4) spatial adaptive mask filter (5) proposed algorithm

The comparative analyses of different filter approaches are as shown in Fig. 3 and Fig. 4. From the graphical analysis, it is observed that the proposed algorithm gives the best PSNR performance than other approaches.

V. CONCLUSION

The various approaches were developed for the removal of noise from the medical images but each technique has some disadvantages like edge blurring. The proposed approach succeeds to remove the noise from the medical image and it preserves the edges. From the quantitative analysis, it is observed that the proposed system has highest PSNR value than other image denoising algorithms.

In future scope, there is a need of the enhancement of the bright or dark feature in an image.

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