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# A Modified Decision Based Mean Median Algorithm for Removal of High Density Salt and Pepper Noise

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**ABSTRACT**
This paper presents a modified decision based mean median filter for removal of salt and pepper noise in gray scale images. This is a computationally efficient filtering technique. It is implemented in two steps: In the first step, noisy pixels are identified and in the second step, the proposed algorithm is applied only on noisy pixels. The noise free pixels are not modified, which helps in retaining the image features. Experimental results show that the proposed algorithm performs better than various recent denoising methods in terms of PSNR, IEF and MSE.

## I. INTRODUCTION

Denoising is a very important pre-processing task in image processing. Salt and pepper noise is an impulse type of noise, which is also referred to as intensity spikes. Salt and pepper noise is generally caused by faulty memory locations, malfunctioning of pixel elements in the camera sensors or timing errors in the digitization process [1]. Various filters [2] such as Median Filter (MF), Decision Based Algorithm (DBA), Decision based Unsymmetrical Trimmed Median Filter (DBUTMF) has been proposed for removal of salt and pepper noise. Among these the Median Filter is used widely but it has a problem that it modifies both the noisy and noise free pixels [3]. To overcome this drawback Decision Based Algorithm (DBA) first detect the noisy pixels and replace that noisy pixel with the median of neighborhood pixels in the window [4] [5]. DBA has a problem that it takes corrupted pixels while calculating the median. To overcome this problem, Decision based Unsymmetrical Trimmed Median Filter (DBUTMF) was proposed in which the corrupted pixel is replaced by the median value of the pixels in 3x3 window [6]. But before calculating median, the corrupted pixels are trimmed from the current window. It gives better performance than MF and DBA, but it has a problem that it crashes at noise densities of more than 80%.

To remove this problem, here modified decision based mean median filter (MDBMMF) is proposed, which combines the median and mean to give better results.

This paper is organized in four sections. Section 2 explains the proposed method. Section 3 explains the simulation results and performance analysis. Conclusion and future scope is explained in section 4.

## II. THE PROPOSED METHOD

Modified decision based mean median filter (MDBMMF) algorithm was developed for the restoration of gray scale images that are highly corrupted by salt and pepper noise. In this algorithm each and every pixel of the image is checked for the presence of salt and pepper noise. In this algorithm we take a window of size 3x3 around the processing pixel. The three different cases are illustrated for the processing pixel

**Case 1:** when the processing pixel is noise free i.e. if the value of processing pixel is neither “255” nor “0”, then the pixel is not processed as shown in Fig. 2.1.

| | | |
|---|---|---|
| 152 | 111 | 0 |
| 255 | **126** | 34 |
| 241 | 135 | 55 |

Figure 2.1: window of gray scale image containing noise free pixel as processing pixel.

**Case 2:** When the processing pixel is noisy i.e. the value of pixel is either “0” or “255” then check for values of pixels in 3x3window. If all the neighboring pixels are corrupted with salt and pepper noise (i.e. either “0” or “255”) as shown in Fig. 2.2, then take the mean of the values of pixels in the selected window and replace the processing pixel with mean value.

| | | |
|---|---|---|
| 0 | 255 | 255 |
| 0 | **255** | 0 |
| 255 | 0 | 255 |

Figure 2.2: window of gray scale image containing all noisy pixels.

**Case 3:** When the processing pixel is noisy i.e. the value of pixel is either “0” or “255”, then check for values of pixels in 3x3window. If some of the neighboring pixels are not corrupted with salt and pepper noise as shown in Fig. 2.3, then store the value of the pixels in a 1-D array. Remove the corrupted pixels (i.e. pixels with value “0” or “255”) from the array. Then take the median of the remaining pixels and replace the processing pixel with the median value.

| | | |
|---|---|---|
| 122 | 0 | 235 |
| 110 | **255** | 255 |
| 135 | 124 | 240 |

Figure 2.3: window of gray scale image containing noisy processing pixel and some noisy neighboring pixels.

## III. RESULTS AND ANALYSIS

All the algorithms described in section 1 such as Median Filter, Decision based Algorithm (DBA), Decision based unsymmetrical Trimmed Median Filter (DBUTMF) and the proposed MDBMMF algorithm have been applied on standard grayscale image of size 512 X 512 pixels. The results were evaluated both qualitatively and quantitatively. In order to evaluate performance of the algorithm quantitatively the noise free image is used for comparison with the denoised image produced by the above methods.

The metrics used for evaluation are Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR) and Image Enhancement Factor (IEF).

**MSE=** $\frac{\sum\sum(Y(i,j)-Y'(i,j))^2}{M*N}$

**PSNR=** $[10\log_{10}\frac{255^2}{MSE}]$

**IEF=** $\frac{\sum\sum\left(N(i,j)-Y(i,j)\right)^2}{\sum\sum\left(Y'(i,j)-Y(i,j)\right)^2}$

In the above equations M * N is the size of the image, Y denotes the original image, Y’ denotes the denoised image and N is the noisy image.

MSE, PSNR and IEF are calculated for the test image with their noisy and denoised counterparts respectively. Hence, we get a good amount of comparison between the noisy and denoised images keeping the set standard image intact. Fig. 3.1 shows test image of size 512 X 512 pixels and image format is .png which is original images applied for denoising.

Lena.png

Figure 3.1: original images of size 512 x 512.

Quantitative analysis is made by varying noise densities in steps from 10% to 90% on test images and comparisons are made in terms of MSE, PSNR and IEF. Quantitative results and graphs are shown in Table 3.1, 3.2, 3.3 and Fig. 3.2, 3.3, 3.4 respectively. From the Table 3.1 and Fig. 3.2 it is inferred that the PSNR value is high for the proposed algorithm which eliminates salt and Pepper noise effectively even at high noise densities.

Table 3.1: Performance comparison of PSNR at various noise densities for Lena image.

| Noise Densities | PSNR(dB) | | | |
|---|---|---|---|---|
| | MF | DBA | DBUTMF | MDBMMF |
| 10% | 33.08 | 42.92 | 43.14 | 43.14 |
| 20% | 29.02 | 38.72 | 39.39 | 39.39 |
| 30% | 23.54 | 35.51 | 36.87 | 36.87 |
| 40% | 18.92 | 32.48 | 34.48 | 34.48 |
| 50% | 15.27 | 28.94 | 32.36 | 32.36 |
| 60% | 12.33 | 25.53 | 30 | 30 |
| 70% | 9.96 | 22.04 | 27.69 | 27.69 |
| 80% | 8.2 | 18.39 | 24.75 | 24.75 |
| 90% | 6.69 | 13.98 | Error | 20.37 |

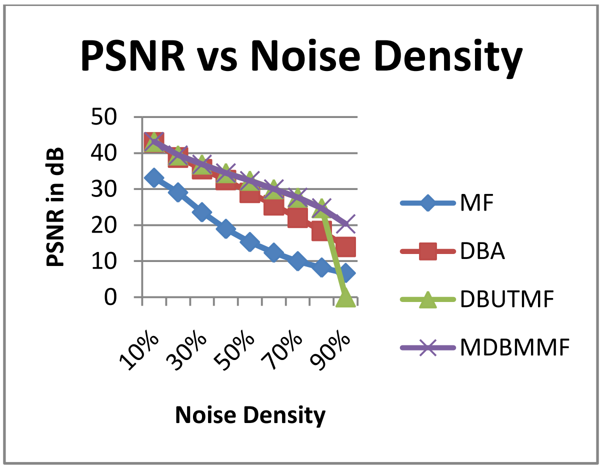
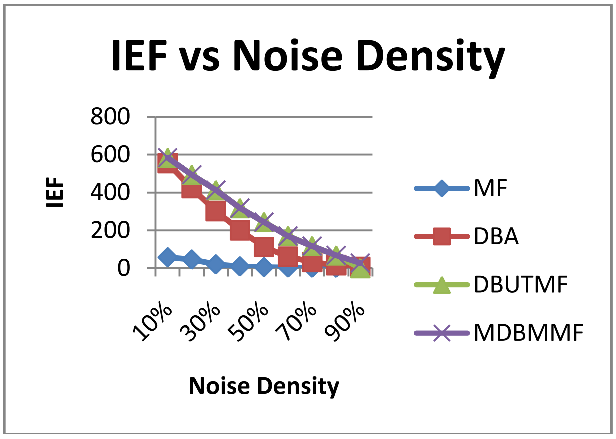



Figure 3.2: PSNR vs Noise Density.

From Table 3.2 and Fig. 3.3 an excellent image enhancement factor, even at very high noise densities as high as 90% can be observed.

Table 3.2: Performance comparison of IEF at various noise densities for Lena image.

| Noise Densities | IEF | | | |
|---|---|---|---|---|
| | **MF** | **DBA** | **DBUTMF** | **MDBMMF** |
| 10% | 57.42 | 554.51 | 582.54 | 582.54 |
| 20% | 45.2 | 422.34 | 492.93 | 492.93 |
| 30% | 19.51 | 301.45 | 412.01 | 412.01 |
| 40% | 8.81 | 200.15 | 317.16 | 317.16 |
| 50% | 4.76 | 111.02 | 243.76 | 243.76 |
| 60% | 2.91 | 60.81 | 170.19 | 170.19 |
| 70% | 1.97 | 31.87 | 117.1 | 117.1 |
| 80% | 1.49 | 15.61 | 67.5 | 67.5 |
| 90% | 1.18 | 6.37 | - | 27.72 |




From Table 3.3 and Fig. 3.4 it can be observed that mean square error is also very less for proposed algorithm at high noise densities.

Figure 3.3: IEF vs Noise Density.

Table 3.3: Performance comparison of MSE at various noise densities for Lena image.

| Noise Densities | MSE | | | |
|---|---|---|---|---|
| | **MF** | **DBA** | **DBUTMF** | **MDBMMF** |
| 10% | 32.24 | 3.33 | 3.17 | 3.17 |
| 20% | 82.08 | 8.78 | 7.52 | 7.52 |
| 30% | 289.4 | 18.38 | 13.45 | 13.45 |
| 40% | 839.85 | 36.96 | 23.32 | 23.32 |
| 50% | 1947.32 | 83.55 | 38.05 | 38.05 |
| 60% | 3830.53 | 183.38 | 65.52 | 65.52 |
| 70% | 6604.17 | 409.26 | 111.41 | 111.41 |
| 80% | 9897.96 | 947.54 | 219.23 | 219.23 |
| 90% | 14042.32 | 2616.38 | Error | 601.67 |

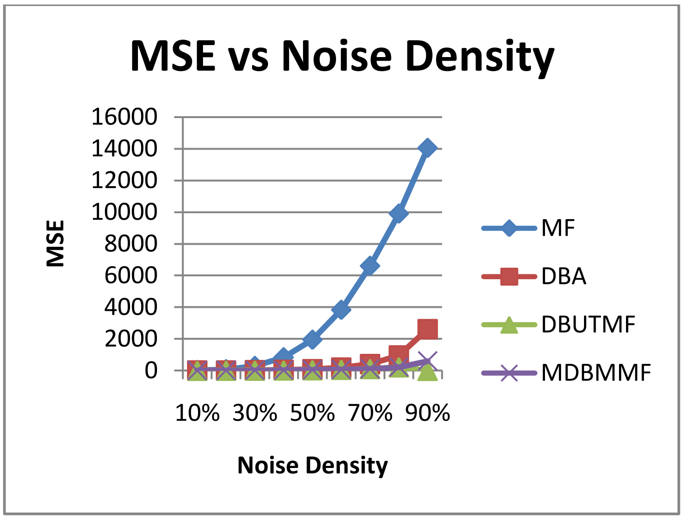



Figure 3.4: MSE vs Noise Density.

Qualitative performance of the proposed MDBMMF algorithm with other algorithms are shown below in Fig. 3.5, Fig. 3.6, Fig. 3.7, Fig. 3.8 and Fig. 3.9 at noise densities of 10%, 30%, 60%, 80% and 90% respectively :

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

Figure 3.5: result for lena image of size 512x512 at 10% noise density (a) noisy image (b) MF output (c) DBA output (d) DBUTMF output (e) MDBMMF output (proposed algorithm).

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

Figure 3.6: result for lena image of size 512x512 at 30% noise density (a) noisy image (b) MF output (c) DBA output (d) DBUTMF output (e) MDBMMF output (proposed algorithm).

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

Figure 3.7: result for lena image of size 512x512 at 60% noise density (a) noisy image (b) MF output (c) DBA output (d) DBUTMF output (e) MDBMMF output (proposed algorithm).

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

Figure 3.8: result for lena image of size 512x512 at 80% noise density (a) noisy image (b) MF output (c) DBA output (d) DBUTMF output (e) MDBMMF output (proposed algorithm).

ERROR

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

Figure 3.9: result for lena image of size 512x512 at 90% noise density (a) noisy image (b) MF output (c) DBA output (d) DBUTMF output (e) MDBMMF output (proposed algorithm).

Various above discussed algorithms such as Median Filter (MF), Decision Based Algorithm (DBA), Decision Based Unsymmetrical Trimmed Median Filter (DBUTMF) and the proposed Modified Decision Based Mean Median Filter (MDBMMF) are implemented in MATLAB. The snapshot of the implementation is shown below in Fig. 3.10.

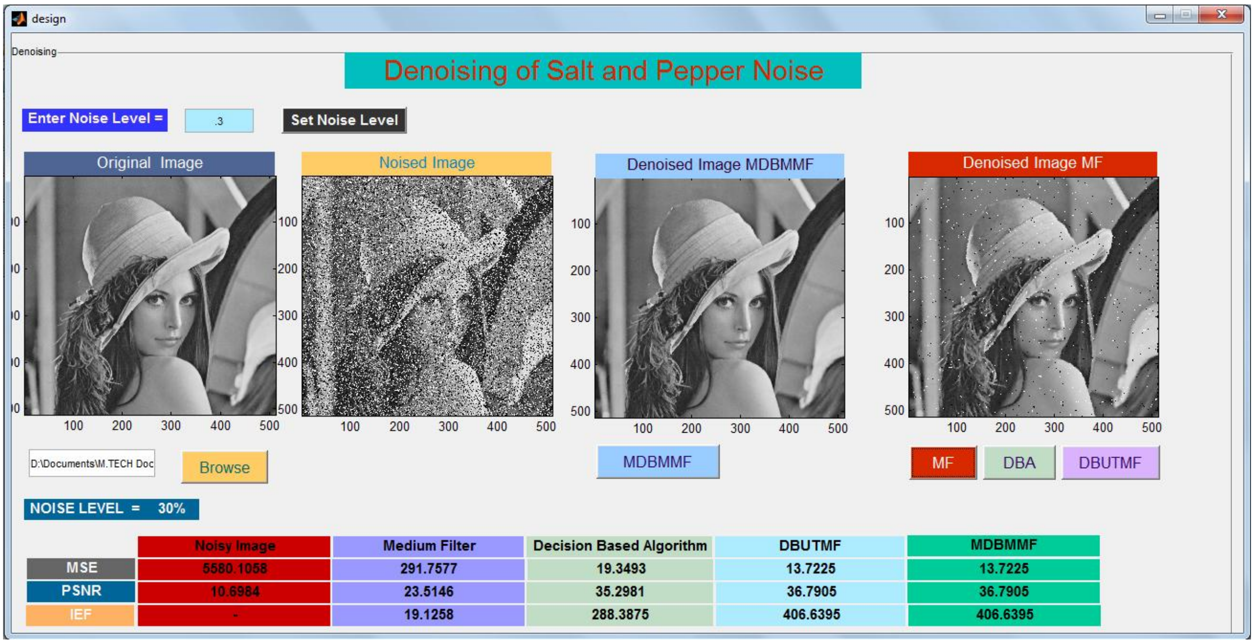



Figure 3.10: snap shot of graphical user interface for lena image at 30% noise density

## IV. CONCLUSION

In this project, Modified decision based Mean Median filter(MDBMMF) algorithm is illustrated which gives better performance in comparison with Median Filter (MF), Decision Based Algorithm(DBA) and Decision Based Unsymmetrical Trimmed Median Filter (DBUTMF) algorithms in terms of PSNR. The performance of these algorithms has been tested at low, medium and high noise densities for grayscale images. Even at high noise density levels the MDBMMF gives better results in comparison with other existing algorithms. Both visual and quantitative results are demonstrated.

The results obtained have shown significant noise reduction but the images tend to get blurred at high noise densities. Hence, there are still areas that can be done to improve this work.

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