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Article

# Removal of Salt and Pepper Noise with a Modified Median Filter

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## I N F O

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## A B S T R A C T

In this paper, we proposed a new method for removing the salt and pepper noise effectively from the images. This method is based on Modified Median Filter (MMF). This Modified Median Filter (MMF) is able to remove the noise at all densities. Its performance is compared with other existing methods with the help of Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE). The proposed method results shows that it outperforms well when compared DBA and MDBUTMF.

**Keywords:** Image, Noise, Denoising, Median Filter, PSNR, MSE, SSIM

## Introduction

A rigorous research has been done on salt and pepper noise removal from the images. Noise removal is one of the major areas of image processing. The common type of noise that degrades the image quality is salt and pepper noise.[1] Images are degraded because of impulse noise due to malfunction of hardware in the camera or problem with the camera sensor. There are two types of impulse noises and are salt and pepper noise and random valued noise. Here in this paper, the discussion is confined to salt and pepper noise. To remove this salt and pepper noise, most commonly used filters are nonlinear such as median.[1,2]

Filters with edge preserving capability and image aspect retain ability are preferred. In median we have a number filters that are available to eliminate salt and pepper noise. Some of them are standard median filter, adaptive median filter,[4] decision based algorithm and modified decision based un-symmetric trimmed median filers.[2]

Rest of the paper organized as, section 2 discuses about existing methods, section 3 about proposed method, section 4 about result and discussions and finally section 5 with conclusions.

## Existing Methods

In the existing methods, variants in the median filters such as DBA[3] and MDBUTMF[4] are discussed. These existing methods are compared over the proposed method such as Modified Median Filter (MMF).

The first method is Decision Based Algorithm (DBA).[1-3] which is used to remove the salt and pepper noise. In this method, a window of size 3x3 is selected and it is moved over the image to remove the salt and pepper noise. The salt and pepper noise is identified with the pixel values a 0 and 255. '0' represents black and '255' represents white. In this algorithm every pixel is processed for de noising using a 3 X 3 window. In the window, if a pixel is other than '0' or '255' then it is left unchanged, otherwise the pixel is identified as corrupted, then the pixel is replaced by the median of the window. At higher noise densities the median itself will be noisy, and, the processing pixel will be replaced by the neighbourhood processed pixel.

The second method is Modified Decision Based Unsymmetric Trimmed Median Filter (MDBUTMF),[1-3] used to remove high density salt and pepper noise from the gray and colour images. In this algorithm, noisy pixel is replaced by trimmed median value when the pixel values, 0's, 255's and other values are present in the selected window. If all the pixel values in the window are 0's and 255's then the noise pixel is replaced by mean value of all the elements present in the selected window.

## Proposed Method

In the proposed method, in the image if the pixels are identified as either 0 or 255, then they are noisy pixels else normal pixel values. There the normal image is taken and 3x3 window[6] is taken and then a binary matrix is formed based on the following condition, if the pixel value is 0 or 255, then it is replaced with '0', otherwise it is replaced with '1'. This form of the matrix is called, binary matrix. This binary matrix is a simplified form of the 3x3 window.

Next step involved in this process is creating a symmetric matrix of this 3x3, which becomes 9x9. Now process every pixel value, whether it consists of 0 or 1. If it is '1', replace the pixel value as it is, otherwise, based on the location of the pixel, the window size of 3x3 is shifted. Then take all the 9 elements from the window, arrange them in increasing order. Then the median value is calculated and this median is replaced with the corresponding processing pixel.

## Algorithm

**Step 1:** Read an image $I := [a_{ij}]$ $m \times n$ such that the minimum size is more than 3.

**Step 2:** Write the binary matrix Bin : = $[b_{ij}]$ $m \times n$ of $I$.

**Step 3:** Write $P^3_A$ and $P^3_B$

**Step 4:** For all $i$ and $j$,

If $b_{ij} = 1$, then keep the value of $a\,ij$ /*noiseless pixel value*/

Else if $B^1_{ij}$ is equal to '0', then find $R^1_{ij}$ for $a_{ij}$

Evaluate the median value $mR^1_{ij}$

Overwrite this value to the $a_{ij}$

else if $B^2_{ij}$ is equal to '0', then find $R^2_{ij}$ for $a_{ij}$

Evaluate the median value $mR^2_{ij}$

Overwrite this value to the $a_{ij}$

else if $B^3_{ij}$ is equal to '0', then find $R^3_{ij}$ for $a_{ij}$

Evaluate the median value $mR^3_{ij}$

Overwrite this value to the $a_{ij}$

**Step 5:** Repeat step 4 for the entire image.

The parameters that are used to estimate the quality of the filter image is Peak signal to noise ratio and structural similarity index. The formulas for calculating PSNR and SSIM is quoted as:

$$PSNR := 10 \log \left( \frac{255^2}{MSE} \right)$$

$$SSIM(X, Y) := \frac{(2\mu_X \mu_Y + C_1) + (2\sigma_{XY} + C_2)}{(\mu_X^2 + \mu_Y^2 + C_1) + (\sigma_X^2 + \sigma_Y^2 + C_2)}$$

where $\mu_X$, $\mu_Y$, $\sigma_X$, $\sigma_Y$ $\mu_X$ and $\sigma_{XY}$ are the average intensities, standard deviations and cross-covariance for images $X$ and Y, respectively.

Here, $C_1$: = $(K_1 L)^2$ and $C_2$: = $(K_2 L)^2$

such that $K_1$ and $K_2$ are small constants and $L$ = 255 for 8-bit grayscale images.

In generally, $K_1$ = 0.01 and $K_2$ = 0.03.

## Result and Discussions

Proposed method has been simulated with the help of MATLAB software and is compared with other existing methods. In order to compare with other existing methods, the parameters that are used here are Peak Signal to Voise Ratio (PSNR) and Structural Similarity Index (SSIM). For the analysis of noise removal with the help of our proposed method, cameraman and lena images has been corrupted with a noise densities from 0.1 to 0.6 and the parameters such as PSNR and SSIM[7-9] has been used for the comparison.

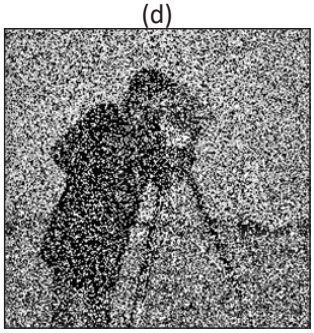
**Figure 1.Original Images of Cameraman and Lena**

(a)

(b)

(c)

(d)



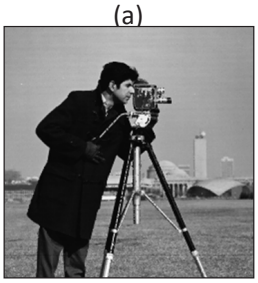
(e)

(f)

**Figure 2.(a) to (f) Image corrupted with noise density from 0.1 to 0.6**

Figure 1, shows the original images of Cameraman and Lena that are used for simulation. Then these images are being corrupted with the help of salt and pepper noise. After adding the salt and pepper noise, the images are shown in figure 2. This figure 2, shows the images that are corrupted by using salt and pepper noise with densities from 0.1 to 0.6. This noisy image has been processed by using the proposed filter to remove the salt and pepper noise. After removing the noise, the image is shown in figure 3, under various noise densities.

(a)



(b)

(c)

(d)

(e)

(f)

**Figure 2.(a) to (f) Noise removal using proposed method for densities from 0.1 to 0.6**

**Table 1.Comparison of PSNR for different Images using Median Filters**

| Image | Median Filters | Noise Density | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 |
| Lena | DBA | 33.13 | 31.76 | 30.93 | 28.82 | 26.44 | 23.59 |
| | MDBUTMF | 38.65 | 36.24 | 33.95 | 30.28 | 29.11 | 27.39 |
| | MMF | 44.99 | 41.79 | 39.62 | 38.22 | 37.09 | 36.26 |
| Cameraman | DBA | 35.17 | 32.87 | 31.22 | 30.11 | 28.49 | 26.35 |
| | MDBUTMF | 39.93 | 38.51 | 37.28 | 35.64 | 33.83 | 31.72 |
| | MMF | 45.76 | 43.21 | 41.95 | 39.22 | 38.18 | 37.05 |

**Table 2.Comparison of SSIM for different Images using Median Filters**

| Image | Median Filters | Noise Density | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 |
| Lena | DBA | 0.928 | 0.912 | 0.907 | 0.899 | 0.886 | 0.875 |
| | MDBUTMF | 0.941 | 0.938 | 0.922 | 0.912 | 0.904 | 0.89 |
| | MMF | 0.991 | 0.980 | 0.965 | 0.947 | 0.930 | 0.907 |
| Cameraman | DBA | 0.935 | 0.927 | 0.918 | 0.906 | 0.892 | 0.887 |
| | MDBUTMF | 0.962 | 0.955 | 0.948 | 0.933 | 0.925 | 0.914 |
| | MMF | 0.993 | 0.985 | 0.972 | 0.952 | 0.946 | 0.914 |

Here the filter performance is analyzed with the help of two parameters such as PSNR and SSIM. From table 1 it is evident that the proposed method has highest peak signal to noise ratio where compared over other existing methods. Table 2 shows the SSIM, which is used to indicate the similarity between original image and noise removed image. If SSIM=1 indicates that both the images are exactly the same. SSIM is also better for the proposed method. This indicates that the proposed method is capable of removing the noise effectively when compared over other methods.

## Conclusion

The performance of the proposed method is better interms of PSNR which is 45.76, where as for other methods it is 39.93 for MDBUTMF and 35.17 for DBA by using cameraman image. Similarly, SSIM is also better for the proposed method which is 0.993, where as for other methods it is 0.962 for MDBUTMF and 0.935 for DBA. From the simulation result images also it is very much evident that the proposed method is capable of removing the salt and pepper noise effectively when compared over existing methods.

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