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Research Paper

DESIGN AND IMPLEMENTATION OF MEDIAN FILTER FOR IMAGE DENOISING

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In this paper, a median filtering algorithm for the removal of salt and pepper noise by filtering in both the black and white and colored images has been proposed. Linear and nonlinear filters have been proposed earlier for the removal of impulse noise, i.e., salt and pepper noise; however the removal of impulse noise often bring blurring which results in edges being distorted and poor quality. Here, we introduced salt and pepper noise for the image corruption and reconstruct original image using different filters, i.e., mean and median filter. The mean filter suppresses little noise and gets the worst results. Whereas performance of median filter is good at lower noise density levels. It removes most of the noises effectively while preserving image details very well.

Keywords: 2 dimensional, Median filter, Image denoising

INTRODUCTION

Image denoising finds applications in fields such as astronomy where the resolution limitations are severe, in medical imaging where physical requirements of high quality imaging are needed for analysing images of unique events where potentially useful photographic evidence is sometimes of extremely bad quality (Reginald and Jan, 1991).

In image transmission, images are mostly affected by additive noise like Impulse noise (e.g., salt and pepper noise). The image enhancement requires a series of filtering operations on the received image. These filters are serially connected since image processing design is divided into number of processing stages. Implementing such filters on general purpose computer image is utilized for visual interpretation or for automatic analysis.

Noise may be considered to be any unwanted entity that corrupts information. Among the various types noise known in digital images, salt and pepper noise typically cause

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error in pixel elements in camera sensors, faulty memory locations, or timing errors in the sampling process.

The search for efficient image de-noising methods still is valid challenge, at the crossing of functional analysis and statistics. In spite of sophistication of the recently proposed methods, most algorithm have not attended desirable level of applicability all show an outstanding performance when image models corresponds to algorithm assumption, but fails in general and create artifacts or remove image fine structures. The filters that are used for the purpose of denoising are broadly divided in to two types, linear and nonlinear filters. Linear filters tend to blur edges and other image details. Also these filters perform poorly on images corrupted by non Gaussian type of noises. Hence for removal of impulsive noise like salt and pepper noise non linear filters are used. Non linear filters can preserve edges and other fine details (Reginald and Jan, 1991; Baxes, 1994; James *et al.*, 2008; Vijaykumar *et al.*, 2008; Maheswari and Radha, 2010; and Robert, 1985).

Of the various nonlinear filters known median filters have provided the best results for salt and pepper noise removal. The main focus of this paper is to implement filtering scheme using median filter.

THE MEDIAN FILTER

Median filter is a robust method to remove the impulsive noise from an image. It is a computationally intensive operation, so it is hard to implement it in real time. The median filter is considered to do a better job than the mean filter of preserving useful detail in the image. The filter considers each pixel in the image in turn and looks at its nearby neighbors to decide whether or not it is representative of its surroundings. It then replaces the pixel value with the median of the neighboring pixel values. The median is calculated by first sorting the entire pixel values from the surrounding neighborhood into numerical ascending order and then replacing the pixel being considered with the middle pixel value. If the neighborhood under consideration contains an even number of pixels, the average of the two middle pixel values is used.

Median filter is a spatial filtering operation, so it uses a 2-D mask that is applied to each pixel in the input image. To apply the mask means to centre it in a pixel, evaluating the covered pixel brightness and determining which brightness value is the median value. The median value is determined by placing the brightness in ascending order and selecting the centre value. The obtained median value will be the value for that pixel in the output image.

PROPOSED METHOD

In this proposed technique, salt and pepper noise from corrupted image is removed, the algorithm are presented as below:

Step 1: Window size of 3×3 is selected from the 256×256 image.

Step 2: Sort the pixel from the selected window according to the ascending order and find out median pixel value p.

Step 3: The pixel p is replaced by the median of that pixels in the 3×3 neighborhood

Step 4: Above steps are repeated for complete test image.

PROBLEM SOLUTIONS

The parameters used to define the performance of proposed filter are defined as follows:

Mean Square Error (MSE): Two of the error metrics used to compare the various image compression techniques are the Mean Square Error (MSE) and the Peak Signal to Noise Ratio (PSNR). The MSE is the cumulative squared error between the compressed and the original image, whereas PSNR is a measure of the peak error. The mathematical formula for MSE is:

$$MSE = \frac{1}{MN}\sum_{Y=1}^{M}\sum_{X=1}^{N}[I(x,y) - P(x,y)]^2$$

where M and N are the total number of pixels in the horizontal and. Where $I(x, y)$ is the original image, $p(x, y)$ noisy image and M, N are the dimensions of the images.

Normalised Mean Square Error (NMSE): The images under consideration consist of 256 × 256 pixels with eight bits of resolution. In order to quantitatively compare the performance of the filters, the Normalized Mean Square Errors (NMSE) between the original and filtered images are evaluated. The NMSE is given by:

$$NMSE = \frac{\sum_{i=0}^{M-1}\sum_{j=0}^{M-1}\left[Y(i,j) - S(i,j)\right]^2}{\sum_{i=0}^{M-1}\sum_{j=0}^{M-1}\left[X(i,j) - S(i,j)\right]^2}$$

NMSE of median filter is always smaller than mean filter. where $S(i, j)$, $X(i, j)$ and $Y(i, j)$ are the original, noisy input, and filtered images, respectively, and $M = 256$.

Correlation:

$$COR = \frac{\sum i,j(Y_{ij} - \mu_y)(X_{ij} - \mu_X)}{\sqrt{\sum_{i,j}(Y_{ij} - \mu_y)^2 \sum_{i,j}(X_{ij} - \mu_X)^2}}$$

where, Y_{ij} and X_{ij} denote the pixel values of the filtered and original image respectively, $M \times N$ is the size of the image, μ_x and μ_y represent the mean of the original and filtered images.

Root Mean Square Error (RMSE):

$$\text{RMSE} = \sqrt{\frac{1}{\text{MN}}\sum_{i,j}(Y_{ij} - X_{ij})^2}$$

where, Y_{ij} and X_{ij} denote the pixel values of the restored and original image respectively, $M \times N$ is the size of the image.

Peak Signal to Noise Ratio (PSNR):

$$\text{PSNR} = 20\log_{10}\left(\frac{255}{RMSE}\right)$$

A lower value for NMSE means lesser error, and as seen from the inverse relation between the MSE and PSNR, this translates to a high value of PSNR. Logically, a higher value of PSNR is good because it means that the ratio of Signal to Noise is higher. Here, the 'signal' is the original image, and the 'noise' is the error in reconstruction.

EXPERIMENTAL RESULTS

MATLAB Simulation Results for Black and White Image

Salt and pepper noise was added to the original test black and white images shown in Figure 1, with Noise variance ranging from 0.05 to 0.5. The results for noisy and denoised images are shown in Figure 2 and the performance metrics obtained are shown in Table 1 for the Black and White image.

Figure 1: Original Test Image

Figure 2: Noisy and Denoised Black and White Image at Noise Variances 0.05 to 0.3

Noise Level = 0.05

Noise Level = 0.06

Noise Level= 0.07

Noise Level= 0.08

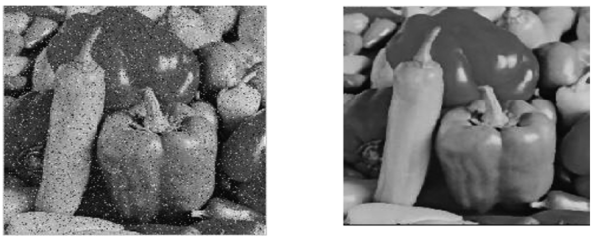
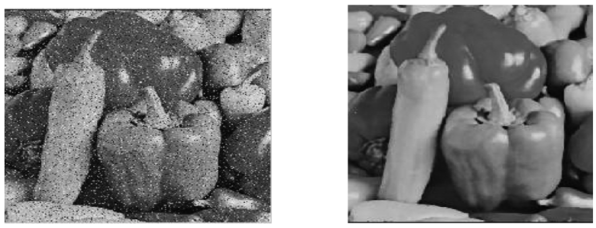


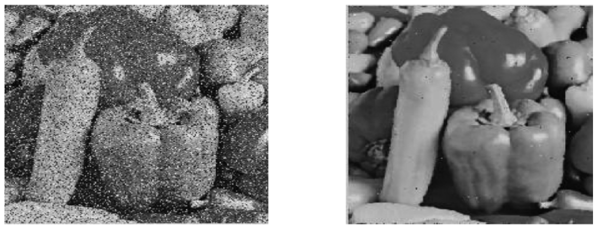
Figure 2 (Cont.)

Noise Level = 0.09

Noise Level = 0.1



Noise Level = 0.2



Noise Level 0.3

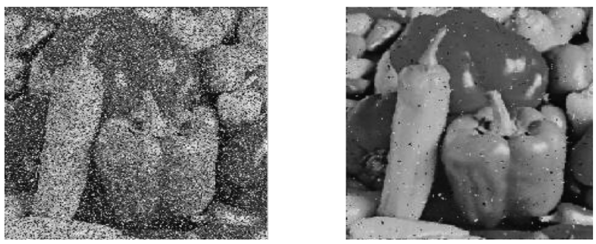


Table 1: Performance Matrices for Noisy and Denoised Image Using Proposed Method

Noise Level	NMSE	PSNR	Correlation
0.01	0.1499	33.6757	0.9797
0.02	0.0752	33.5630	0.9795
0.03	0.0520	33.4825	0.9793
0.04	0.0396	33.3314	0.9791
0.05	0.0320	33.2319	0.9789

Table 1 (Cont.)

Noise Level	NMSE	PSNR	Correlation
0.06	0.0277	33.1447	0.9787
0.07	0.0249	32.9322	0.9783
0.08	0.0223	32.8567	0.9782
0.09	0.0203	32.6927	0.9778
0.1	0.0188	32.5680	0.9775
0.2	0.0211	29.1056	0.9662
0.3	0.0498	23.5644	0.9166
0.4	0.1056	19.0680	0.8126
0.5	0.2031	15.2730	0.6513
0.6	0.3340	12.3250	0.4873
0.7	0.4947	9.9439	0.3316
0.8	0.6751	8.0034	0.1956

Figure 3 shows the MATLAB simulation of Median filter for a greyscale image. The noise is added in the input image and then filter with median filter. The observation is that the noise is removed. At the same time, the edges are also preserved and the image is not blurred as in the case in Mean filter.

Figure 3: Original Colour Black and White Test Image

MATLAB Simulation Results for Color Image

Salt and pepper noise was added to the original test color images with noise variance ranging from 0.05 to 0.3. The results for noisy and denoised images are shown in Figure 4.

Figure 4: Noisy and Denoised Colour Image at Noise Variances 0.05 to 0.3

Figure 4 (Cont.)

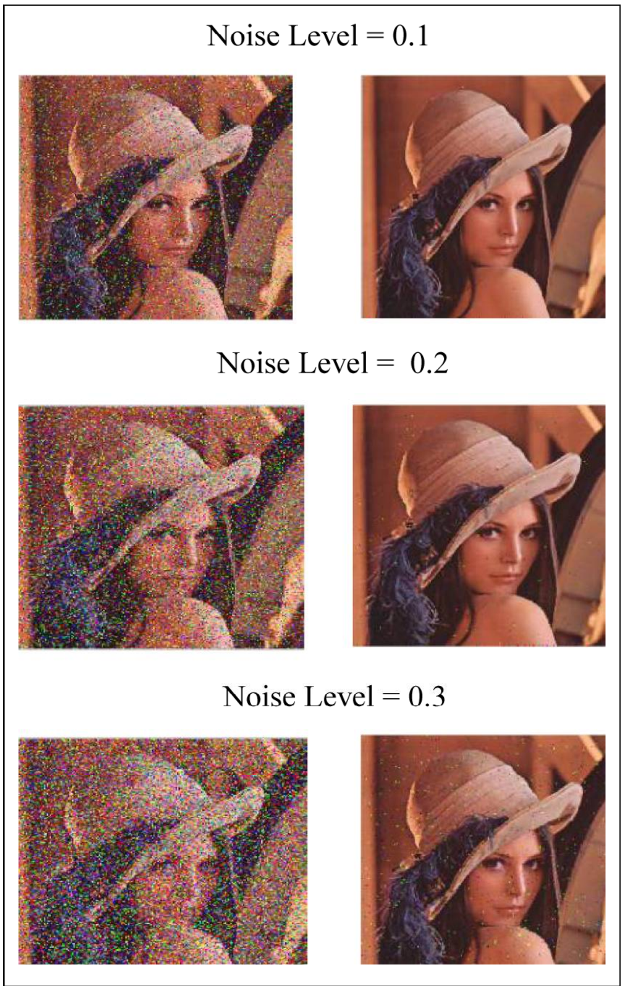


Figure 5 shows the MATLAB simulation of Median filter for a colour image. The noise is

Figure 5: NMSE, PSNR, Correlation Based Analysis of Median Filter

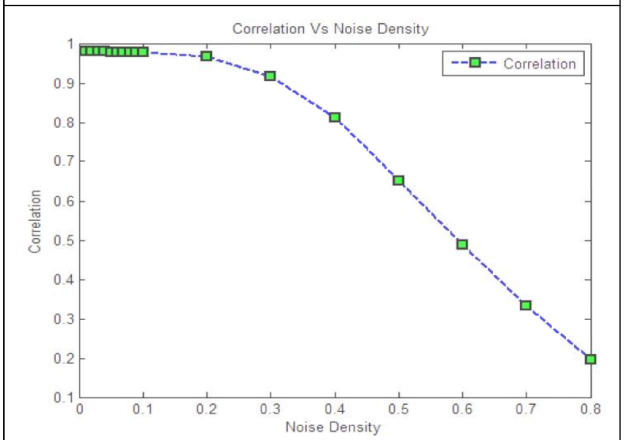
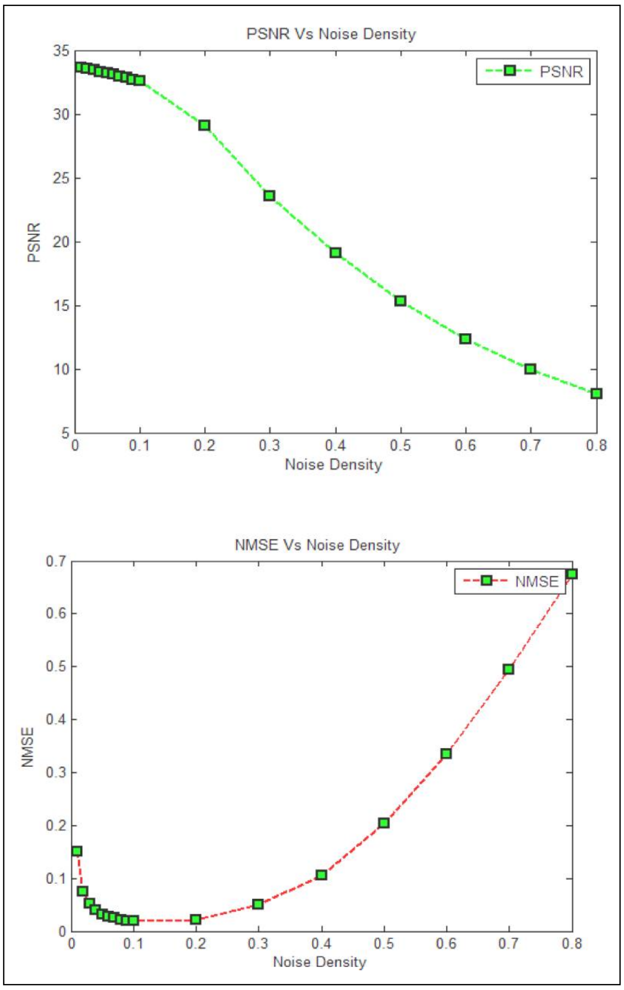


Figure 5 (Cont.)

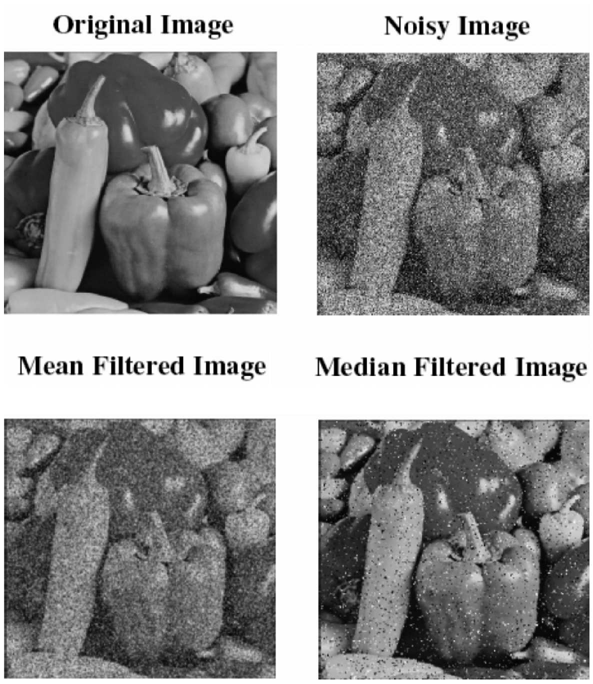


added in the input image and then filter with median filter. The observation is that the noise is removed. At the same time, the edges are also preserved and the image is not blurred as in the case in Mean filter.

The graphical analysis of the results shows that error in denoised image is reduced to great extent as compared to noisy image. With high noise variance the Normalised Mean Square Error (NMSE) is comparatively low and performs high PSNR.

The simulation results for Mean filter and Median filter are presented for comparison. The Figure 6 shows the results with noise of level 0.2.

Figure 6: Results with Noise Level 0.2



The careful examination shows that the median filter preserves the sharpness in a better way. Also, it removes the noise level more than mean filter.

CONCLUSION

From the experimental and mathematical results it can be concluded that for salt and pepper noise, the median filter is optimal compared to mean filter. It produces the maximum PSNR for the output image compared to the linear filters considered. The image obtained from the median filter has no noise present in it and is close to the high quality image. The sharpness of the image is retained unlike in the case of linear filtering.

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