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A Novel Approach for Removal of Spike Noise from Satellite Milky Way Images

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Abstract

Images are shaped to show validation or display valuable information and it plays a vital role in research and technology. The main drawback in digital images is occurrence of noise and degradation during their attainment or transmission. This paper presents a novel approach for removal of spike noise from satellite milky way images. In this paper, the comparison of existing image noise filtering techniques is discussed and a new technique is introduced by allocating difference of pixels values to damaged cells for removal spike noise. Image rebuilding approaches can preserve image details while suppressing spike noise. The working standard of this technique is introduced and analyzed with different simulation results using MATLAB. A new technique is implemented which is better than the existing algorithms. Experiment results of the techniques are compared with the image quality measures like Mean Square Error (MSE), Peak Signal to Noise ratio (PSNR) and Structural Similarity Index Metric (SSIM).

Keywords: Spike Noise; Image filtering, Image quality measures.

I. INTRODUCTION

Digital Image Processing is mainly concerned with improvement of pictorial information for human understanding and processing of image data for storage, communication and representation. Image restoration from corrupted image is a classical problem in the field of image processing.

Noise can arise in an image, (i) If the picture is scanned from a photograph made on film, the film granule is a source of noise. Noise can also be the result of damage to the pictures or may be introduced by the scanner itself. (ii) If the image is obtained directly in a digital format, the mechanism for gathering the data (such as a CCD detector) can introduce noise. (iii) Electronic transmission of image data, Light levels and sensor temperature can also introduce noise.

The field of image restoration (sometimes referred to as image de-noising or image de-convolution) is concerned with the reconstruction or estimation of the uncorrupted image from a blurred and noisy image [1].

The detection and removal of the noise play a crucial role in restoration. Estimating the noise level from a single image is an impossible task, and hence we need to recognize whether local image variations are due to the color, texture, or lighting variations from the image itself or due to the noise. Image restoration increases the quality of the image by removing of noisy pixels. The restoration of a degraded image can be done by algorithm, which identifies noisy pixel in the entire image [2].

This paper is organized as follows. Section 2 is a brief review of the degradation and impulse (salt & pepper) noise model. In Section 3, Mean (MF), Median (SMF) and Adaptive median filter (AMF) are explained and in section 4, the proposed method of Pixel Difference Sharing Algorithm (PDSA) is presented in detail. Experimental evaluation is performed in section 5 and finally conclusion is given in section 6.

II. DEGRADATION

Image degradation is a process that acts on an input image $f(x,y)$ through a degradation function H and an additive noise $\eta(x,y)$. It results in degraded image $g(x,y)$ such that:

$$g(x,y) = h(x,y) * f(x,y) + \eta(x,y) \qquad (2.1)$$

Where $h(x,y)$ is the spatial representation of the degradation function and the character * indicates convolution.

III. REVIEW OF DENOISING FILTERS

Noise filtering methods can either be linear or non-linear. Linear filters have a tendency to blur sharp edges, demolish lines and other fine details of image. The non-linear filtering method is a two stage filtering process. In the first stage, the pixels are identified as affected or unaffected pixel and in the second stage the affected pixel is filtered using the specified algorithm and the unaffected pixel value is retained.

a. Mean Filter (MF):

The Mean filter is a linear filtering method, often used to remove noise. It simply smoothens local deviation in an image.

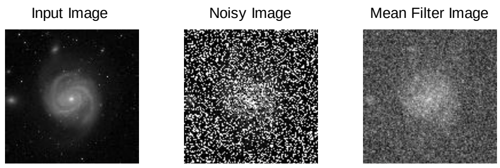

Fig. 1 Restoration by Mean filter

The Mean filtering techniques are applied linearly to all the pixels in the image without defining the image as affected or unaffected pixel. Since these algorithms are applied to the entire pixels in the image, the uncorrupted pixels are also filtered and hence these filtering techniques are not effective in removing impulsive noises.

b. Standard Median Filter (SMF):

The most commonly used non-linear filter is the median filter which uses the median value to substitute the corrupted pixel, and these filters have the capability to remove impulsive noise while preserving the edges. It is also called order-statistics filter. The main idea of the median filter is to run through the signal entry by entry, replacing each entry with the median of neighboring entries.

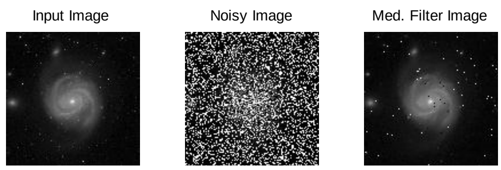

Fig. 2 Restoration by Median filter

A major advantage of the median filter over linear filters is that the median filter can eliminate the effect of input noise values with extremely large magnitudes. In this method, a square window of size 2k+1, where k goes from 1 to N, is used to filter the center pixel. The pixels in the window are first sorted and the center pixel is changed to the median value of the sorted sequence. This method is the simplest of the median filtering techniques and because of its simplicity it has been used for a long time.

c. Adaptive Median Filter (AMF):

The adaptive median filter also applies the noise detection and filtering algorithms to remove impulsive noise. The size of the window applied to filter the image pixels is adaptive in nature, i.e. the window size is increased if the specified condition is not met. If the condition is met, the pixel is filtered using the median of the window.

Let I_{ij} be the pixel of the corrupted image, I_{min} be the minimum pixel value and I_{max} be the maximum pixel value in the window, W be the current window size applied, W_{max} be the maximum window size that can be reached and I_{med} be the median of the window assigned.

The algorithm of this filtering technique completes in two levels as given below.

Level A:

a) If $I_{min} < I_{med} < I_{max}$ then the median value is not an impulse; go to Level B

b) Else increase the window size and repeat Level A until the median value is not an impulse; or the maximum window size is reached, in which case the median value is assigned as the filtered image pixel value.

Level B:

a) If $I_{min} < I_{ij} < I_{max}$ then the current pixel value is not an impulse so the filtered image pixel is unchanged.

b) Else the image pixel is either equal to I_{max} or I_{min} (corrupted), then the filtered imaged pixel is assigned the median value from Level A.

Adaptive median filters are widely used in filtering image that has been denoised with noise thickness greater than 20%.

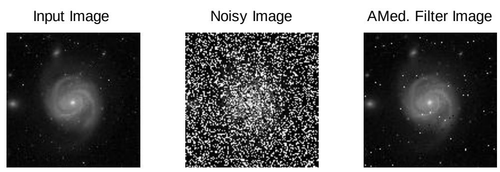

Fig. 3 Restoration by Adaptive Median filter

IV. PROPOSED METHOD - PDSA

Restoration methods are basically mathematical modeling of degradation and applying inverse process to restore the original image. In the proposed method, Pixel difference sharing algorithm (PDSA) is implemented to restore the image. The algorithm has two phases.

a. Phase-I: Phase I processes the first column of noisy image pixels by looking at the pixel value to decide whether the pixel is corrupted or not. If the pixel value lies between the minimum (0) and the maximum (255) the pixel is left unchanged (as it is detected as a noise free pixel), otherwise the pixel is replaced with the nearest uncorrupted pixel value.

Algorithm:

1: Take input image.

2**:** Add Salt & Pepper noise in the input image.

3: Repeat for each I_{ij} in the first column

If $0 < I_{i,j} < 255$ no filtering

Else replace with the nearest noise free pixel

b. Phase-II:In this phase, Pixel difference sharing algorithm (PDSA) is really implemented. Here the algorithm is implemented by row wise. It starts with second pixel ($I_{i,j+1}$) of first row and initialize the counter to zero. If it is noise free pixel, then it moves to next pixel ($I_{i,j+2}$) otherwise increases the counter and makes the next move. The above action is repeated until uncorrupted pixel is found out.

Now counter has the number of corrupted pixels between two noise free pixels. These two pixels are called left and right pixels. The difference between the left and right noise free pixels is calculated and this difference is divided by the counter value. This result is exact pixel difference value that lays between left and right noise free pixels.

Then the iteration starts from the exact next position of the left pixel and it ends with exact previous position of right pixel. If the left pixel value is smaller than right pixel value then the exact difference is added with left pixel value otherwise the value is subtracted from left pixel value and stored in the first position of the iteration and counter value is decreased.

The action repeats until the value is stored in all the positions of iteration and the counter becomes zero. The above operation continues until all the pixels of the degraded image are tested.

Algorithm:

In PDSA, two loops are constructed.

1: For each I_{ij}, i = 1, 2, 3 …. m, j = 2, 3, 4 …. n

2: If $0 < I_{i,j} < 255$ no filtering

Else use PDSA filtering

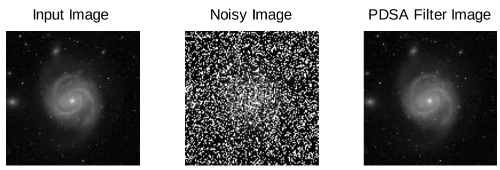

Fig. 4 Restoration by PDSA filter

Restored images are compared on the basis of performance parameters like MSE, PSNR and SSIM.

V. PERFORMANCE EVALUATION

The above restoration methods are evaluated using the quality measures like Mean Square Error (MSE), Peak Signal to Noise ratio (PSNR) and Structural Similarity Index Metric (SSIM).

The above mentioned algorithms are all implemented in a image Lena of size 512 x 512 pixels. Impulse noises are added to the image and their performances are evaluated.

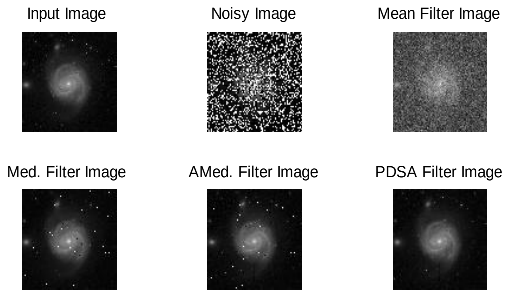

Fig. 5 Simulation results for Lena image at 50% noise density

The MSE, PSNR are calculated from equations (5.1) and (5.2) respectively. It is to be noted that greater the value of PSNR and lower the value of MSE, the filtering technique is better. These results are presented in a graph form.

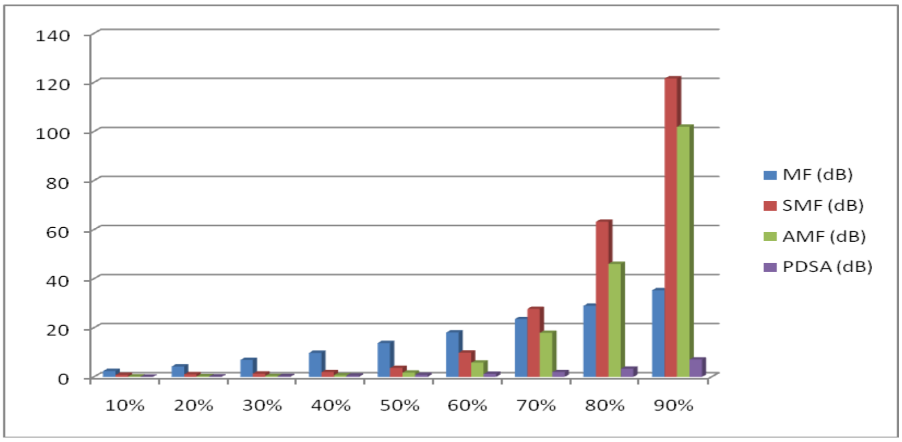

Fig. 6 Histogram of MSE values

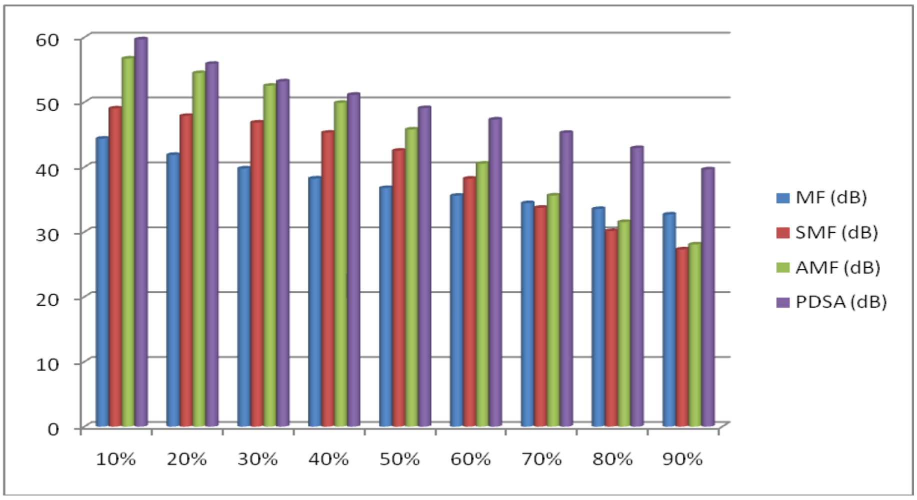

Fig. 7 Histogram of PSNR values

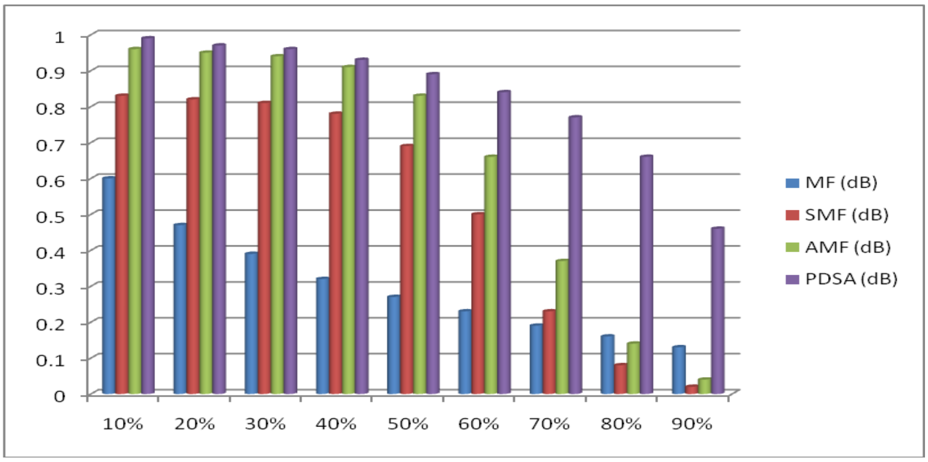

Fig. 8 Histogram of SSIM values

The results presented in the tables and figures are suggested that pixel difference sharing algorithm (PDSA) performs better than other techniques.

VI. CONCLUSION AND FUTURE SCOPE

In this paper, different filtering techniques have been discussed and the new algorithm proposed produces better results compared to the better techniques available. Noisy image is restored by using mean filter (MF), standard median filter (SMF) and adaptive median filter (AMF) techniques. Restored images are compared on the basis of performance parameters like MSE, PSNR and SSIM.

The results based on adaptive median filter (AMF) provided better results than other two filtering techniques. But the proposed method pixel difference sharing algorithm (PDSA) gives good visual clarity and better results than adaptive median filter (AMF) while de-noising impulsive noise for all noise densities. In future, if the noise densities are considerably higher, then the new algorithms can be developed to get much better results than the techniques described.

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