Analysis And Implementation Of Mean, Maximum And Adaptive Median For Removing Gaussian Noise And Salt & Pepper Noise In Images

Gokilavani.C[1], Naveen Balaji.G[1]
[1]Assistant Professor, SNS College of Technology, Coimbatore-641 035, Tamilnadu, India.

Abstract: Recently, in all image processing systems, image restoration plays a major role and it forms the major part of image processing systems. Medical images such as brain MRI images, All image restoration techniques attempts to remove various types of noises. This paper deals with various filters namely mean, averaging filter, median filter, adaptive median filter and Fuzzy filter for removing salt and pepper noise and Gaussian noise in retinal images. Among all the filters, Fuzzy filter removes the Gaussian noise and salt and pepper noise better than the other filters and the performance of all the filters are compared using metrics such as PSNR (Peak Signal to Noise ratio), MSE (Mean Square Error), NAE (Normalized Absolute Error), Normalized Cross Correlation (NK), Image Enhancement factor (IEF), Structural Similarity Index (SSID), Average Difference (AD), Maximum Difference (MD), SC (Structural content) and time elapsed to produce the denoised image. Fuzzy filter gives best values for all the filters.

Key-words: Fuzzy filter, Averaging filter, Median filter, MSE (Mean Square Error), NAE (Normalized Absolute Error), PSNR (Peak Signal to Noise ratio) and SC (Structural content).

I. INTRODUCTION

Generally image processing deals with processing of raw images into a suitable form which can be used for variety of applications [1]. There are many domains in image processing such as image segmentation, image enhancement, image restoration, image compression, image recognition and so on. Among all the domains, major part of image processing deals with image restoration. Images may be corrupted with noise during its acquisition and transmission and also due to blurring artifacts, an image may be corrupted with noise. Blurring is a form of reduction in bandwidth. Also the noises may arise due to motion of the camera or the motion of the object itself. Image restoration attempts to remove these noises in the images while trying to preserve as much as features as possible.

One important issue to be considered while restoring the original image from the noisy image is that, balance between removing noise and preserving signal features must be considered. This paper deals with removing one such type of noise namely salt and pepper noise. This noise is removed using various filters such as Mean Filter, median filter and Fuzzy filter. Here Fuzzy filter attempts to remove the salt and pepper noise better than all the filters mentioned above. The performances of all these filters are measured using various evaluation metrics such as PSNR (Peak Signal to Noise Ratio) and MSE (Mean Square Error), NAE (Normalized Absolute Error) and SC (Structural content).

This paper is organized as follows. Chapter 2 deals with various types of noises present in the images and the mathematical formulations for the representation of noise. Chapter 3 deals with various types of filters used to remove the noises present in the images. Chapter 4 deals with filters such as averaging filter, median filter and Fuzzy filter for removing salt and pepper noise. Chapter 5 gives the performance comparison among all the three filters and chapter 6 deals with the conclusion and future works of this paper.

II. TYPES OF NOISES

A. Mathematical Formulations:

Generally two types of noise models are present. They are the additive noise model and multiplicative noise model. The mathematical representations of the additive noise model is generally given by,

$$F(x,y) = S(x,y) + N(x,y) \quad (1)$$

And the equation for multiplicative noise model is given by,

$$F(x,y) = S(x,y) \times N(x,y) \quad (2)$$

Where F(x,y) is the original noisy image, S(x,y) is the original noise free image and N(x,y) is the noise present in the image S(x,y). All the image restoration techniques aim at removing the noise N(x,y) and restores the original image S(x,y) as such, preserving all features.

B. Various types of noises:

In [2, 3] various types of noises are discussed namely, gaussian noise, speckle noise, salt and pepper noise, Brownian noise and Poisson noise.

Gaussian noise is an additive noise and the principal source of this noise is due to data acquisition. A gaussian noise is evenly distributed in the signal. That means every pixel in the noisy image is the sum of the random Gaussian distributed noise value and true pixel value. This type of noise has a Gaussian distribution. This noise is independent of each pixel and is independent of signal intensity.

Speckle noise is a type of multiplicative noise and it is mainly present in ultrasound medical images and SAR (Synthetic Aperture Radar) images. Speckle noise is mainly caused by the constructive and destructive interference of the ultrasonic waves that are passed in to the human body.

Salt and pepper noise also called as flat-tail distributed or impulse noise. An image affected by salt and pepper noise has dark pixels in bright region and bright pixels in dark region. Salt and pepper noise is impulse type of noise, which is also referred to as intensity spikes. It is caused generally due to the errors in the data transmission. It has only two possible values that is a and b. The probability of each is typically less than 0.1. Corrupted pixels can be set alternatively to the minimum or to the maximum value, giving image a “salt and pepper” like appearance. Pixels remain unchanged for unaffected. For an 8-bit image, the value of pepper noise is 0 and for salt noise are 255. Salt and pepper noise is mainly caused by malfunctioning of pixel elements in the sensors of cameras, faulty memory locations, or timing errors of the digitization process. The main source of salt and pepper noise is due to the errors in ADC (Analog to Digital Converter) and due to bit errors in transmission.

Brownian noise is a kind of 1/f noise or fractal noise. Brownian noise is a non-stationary stochastic process and it follows normal distribution. It is obtained by integrating white noise. The model for brownian noise is given by fractional Brownian motion

Poisson noise is mainly found in images of radiography Magnitude of Poisson noise varies across an image and it depends on the image intensity that makes removing such noise very hard. Poisson images occur in situations where the image acquisition is performed.

This paper deals with removal of salt and pepper noise using various filters such as averaging filter, median filter and Fuzzy filter.

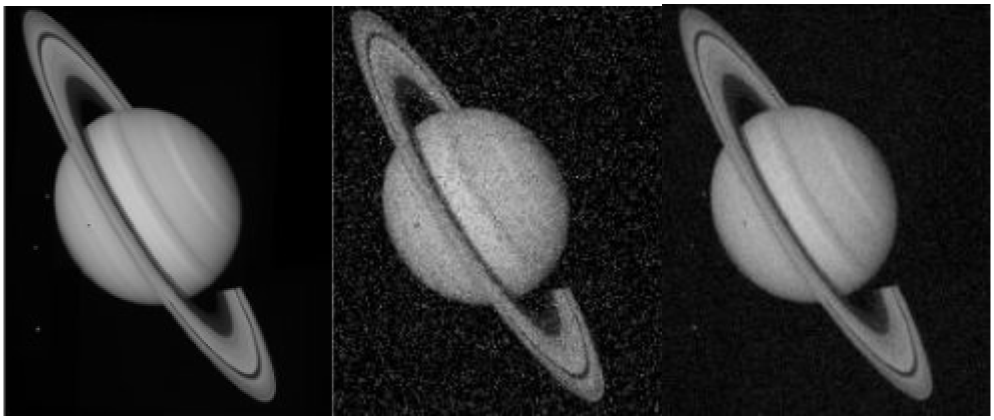
III. TYPES OF FILTERS

There are various filters available in the literature for removing noises in the images. In [4, 5], various filters and various denoising methods including wavelet based denoising techniques are discussed. Filtering may be used for noise reduction, interpolation and re-sampling of the images. The choice of filter depends on the nature of the image to be denoised and it also depends upon applications. Filtering can be generally done without detection and it can be done after the process of detection. In filtering without detection, there is a window mask which is moved across the observed image. In detection followed by filtering, two steps are there. At first, noisy pixels are identified and after that, in second step, these noisy pixels are removed using a filter. Here also mask is used. There is another filtering technique called hybrid filter in which two or more filters are combined and used at the same time.

Filtering techniques can be divided into two type’s namely linear techniques and non-linear techniques. Linear filtering techniques are suitable only for certain types of noises and they tend to blur the images. Mean Filter and Gaussian filter are examples of this filter. Non-linear filtering techniques include mean filter, median filter and wiener filter. Mean filter is a simple filter and it has a sliding window that replaces center pixel. It is easy to implement and it removes salt and pepper noise. The drawback is that, it does not preserve the details of the image. It is a simple and powerful filter that uses order statistics. Here we will replace the median value instead of replacing the pixel value as in the mean filter. It is used to remove different type of noises but it will not produce satisfactory results if the noise is dependent on the signal. Wiener filter reduces mean square error as much as possible. This deals with filtering of image in a different view and produces better results than other non-linear filters.

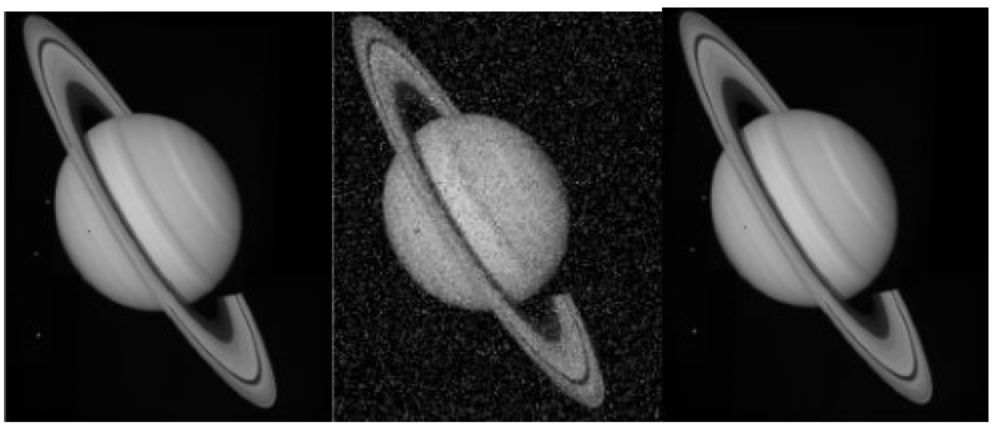
IV. FILTERS FOR REMOVING SALT AND PEPPER NOISE:

Mean Filter is applied to the image affected by the salt and pepper noise. The result is simulated using MATLAB R2013a and the results are shown below. In figure 2, (a) shows the original image, (b) shows the image added with salt and pepper noise with a variance of about 0.09and (c) shows the restored image with a 3x3 averaging filter. In figure 3, (a) shows the original image, (b) shows the image added with salt and pepper noise with a variance of about 0.09 and (c) shows the restored image with a 3x3 median filter. In figure4, (a) shows the original image, (b) shows the image added with salt and pepper noise with a variance of about 0.09and (c) shows the restored image with a 3x3 Fuzzy filter.



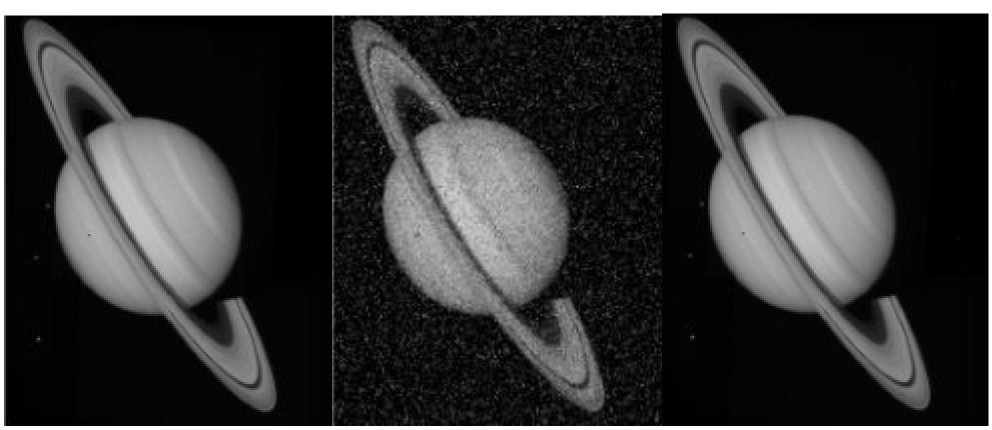
(a) (b) (c)

Fig.2 Results for Mean Filter



(a) (b) (c)

Fig.3 Results for median filter



(a) (b) (c)

Fig.4 Results for Fuzzy filter

V. PERFORMANCE COMPARISON:

The performance of all the filtering techniques is compared using performance evaluation metrics such as PSNR (Peak Signal to Noise Ratio) and MSE (Mean Square Error). The formula for MSE and PSNR are given by the following equations (1) and (2).

$$MSE = \frac{1}{MN}\sum_{j=1}^{M}\sum_{k=1}^{N}(x_{j,k} - x'_{j,k})^2 \quad (1)$$

$$PSNR = 10log\frac{(255)\string^2}{MSE} \quad (2)$$

Where $x_{j,k}$ represents the original image and $x'_{j,k}$ represents the restored image.

The other metrics are NAE (Normalized absolute Error) and SC (Structural Content) which are given in the equation (3) and (4).

$$NAE = \sum_{j=1}^{M}\sum_{k=1}^{N}\left|x_{j,k} - x'_{j,k}\right| / \sum_{j=1}^{M}\sum_{k=1}^{N}\left|x_{j,k}\right| \quad (3)$$

$$SC = \sum_{j=1}^{M}\sum_{k=1}^{N} x_{j,k}^2 / \sum_{j=1}^{M}\sum_{k=1}^{N} x'^2_{j,k} \quad (4)$$

Where $x_{j,k}$ represents the original image and $x'_{j,k}$ represents the restored image.

Table 1: Performance Comparison

S.No	Metrics	Original Image	Mean Filter Result	Median Filter Result	Fuzzy Filter Result
1	MSE	1.4966e+03	227.5567	0.9203	0.5229
2	PSNR	16.3798	24.5599	48.4914	50.9463
3	NAE	0.0806	0.0640	0.0019	9.2233e-04
4	SC	0.9519	0.9931	1.000	1.000

Thus it is evident from the above table than Fuzzy filter denoises the image better than the averaging filter and median filter. It has lowest mean square error, highest peak signal to noise ratio, lowest normalized absolute error and a maximum structural content of 1.000. This clearly shows that, Fuzzy filter produces best quality in the restored image from the noisy image.

VI. CONCLUSION AND FUTURE ENHANCEMENT:

Generally denoising is a critical task and this paper attempts to denoise the salt and pepper noise affected image with the help of three filters namely average, median and Fuzzy filter. Among all the three filters, Fuzzy filter proves to be the best in terms of all performance metrics. The future enhancement of this paper includes implementing various filters for removing not only this salt and pepper noise but also all other types of noises. Also the future work aims at implementing most of the filters in the literature for the maximum number of images as possible.

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