ABSTRACT

The aim of this paper is to embark on the study of four types of noises such as Gaussian, Salt and Pepper, Poisson, and Speckle noise. Image denoising is not only significant on the contrary problem of image processing which is helpful in the fields of remotely sensed scene interpretation, Biomedical imaging techniques, Gathering image's lost information, image retrieval, mining of image etc, and an essential preprocessing technique to preserve the clarity of the naturally corrupted image which may be affected by the various types of noises.

This paper reviews on the existing various filters having various variance of noises. Further, it analyses, examines and compares various filters with the proposed filter. The experimental results shown to be precised in terms of SNR and variance in noise. The results consider the quantitative measures of comparing the denoised images as output of various filters and the hybrid filter with the help of Root Mean Square Errors (RMSE) and Peak-Signal to Noise Ratio (PSNR).

Keywords Gaussian, Salt & Pepper, Poisson, Speckle Noise, Denoising, Hybrid filter.

1. INTRODUCTION

Images have much importance in the fields of research and technology like Image processing. Noise introduces to image through inadequate devices, problem with data achievement process, interference natural phenomena, compression, denoising and transmission [1]. Noise can be defined as an unwanted entity that corrupts the significant information and disgraces the visual quality of digital image. Image de-noising process is used for removing the effect of noises, the goal of de-noising methods are to recover original image from the noisy measurements.

Different approaches have been used by the authors to preserve the accuracy of the novel image. In [2], the author has removed the noise using iterative median filtering in spatial domain instead of using frequency domain as it takes less processing time. In [3] the author used weight median filter with thresholding and decomposing image to remove impulse noise. Here the author has compared the linear and nonlinear filters.

Median filter is low pass, non-linear filter which is helpful in denoising the image which is affected by speckle noise. It also filters isolated pixels whether they might be bright or dark. This type of problem is overcome by adaptive filter [4]. Adaptive Filter (AF) has superior performance compared to non adaptive filters. As the performance increases the
complexity also been increases. The AF can be designed using the two statistical measures Mean and variance [5]. There are various techniques to remove the noise. Traditional median filter is used to remove the salt and pepper noise whereas mean filter is used to reduce Gaussian noise. But when these two noises together present in the original image use of only one filter method cannot preserve the originality [6].

2. TYPES OF NOISE

Various types of noise have their own characteristics and are inherent in images in different ways.

2.1 Salt and Pepper Noise: This type of noise is represented as random existence of white and black pixels. Such type of noise is to be reduced by using median. Whenever faulty switching takes place, Salt and pepper noise creeps into images.

2.2 Gaussian Noise: This noise is also called as statistical noise which has a probability density function of the normal distribution. In other words, the values that the noise can take on are Gaussian-distributed. It is most commonly used as white noise as addition to yield additive white Gaussian noise.

2.3 Poisson Noise: This type of noise has a probability density function of a Poisson distribution.

2.4 Speckle Noise: Speckle noise is a rough noise that naturally exists in and corrupts the quality of images. Speckle noise is an increasing noise. The signal and the noise are statistically independent of each other.

3. FILTERS

$$S_{xy} = \text{set of coordinates in a rectangular subimage window (neighborhood) of size (m x n) centered at point (x,y)}$$

3.1 Mean Filter:

This filter can be used to remove certain types of noise whereas Gaussian and Average filters are additionally suitable for removing noise. Average filter is useful to remove the grain noise from the image as it works to get the neighborhood pixels average. The mean filters are simplest filters also called as linear or average filter. Thus uses a mask over each pixel in the signal. Each components of the pixels which fall under the mask are averaged together to form a single pixel. The Mean filter is defined by:

$$\text{Mean}(P_1, ..., P_n) = \frac{1}{m} \sum_{i=1}^{n} P_i$$

where $P_1, ..., P_n$ is the pixel range of image.

In general, the linear filters are more helpful in suppression of noise.

3.2 Median Filter:
The Median filter is a preprocessing technique to the performance of the later technique also called as nonlinear digital filter. Median filter have wide use in image processing to remove the noise from corrupted images, at the same time it preserves smooth edges and also useful details in the image. The basic theme of the median filter is to go through the signal, entry by entry, further swapping it with the median of neighboring entries. The median filter is a dynamic filter which works like smoothers for image processing, as well as time series processing and in signal processing. A major advantage of the median filter is that it can eliminate the effect of input noise values with extremely large magnitudes. The median is calculated by first sorting all the pixel values from the surrounding neighborhood into numerical order and then replacing the pixel being considered with the middle pixel value. Let the output generated by median filter be ‘M’ at the moment x is calculated as the median of the input values corresponding to the moments adjacent to x:

\[ M(x) = \text{median} ((M(x-T/2), M(x-T1+1), ..., M(x),...), M(x +T/2)). \]

where \( x \) is the size of the window of the median filter.

The one-dimensional median filter described above.

Normally images are represented in discrete form as two-dimensional arrays of image elements, or "pixels" – i.e. sets of non-negative values \( B_{ij} \) ordered by two indexes –

\[ i = 1, ..., N \text{ (rows)} \]
\[ j = 1, ..., N \text{ (columns)} \]

where the elements \( B_{ij} \) is the scalar values, there are methods to process color images, where each pixel can be represented by values, such as by its "red", "green", "blue" values determining the color of the pixel.

3.3 Weiner Filter:

The goal of the Wiener filter is to filter out noise that has corrupted a signal. It is based on systematical approach. Some filters are designed to get responses from frequency. The Wiener filters advances filtering from different way. One should have knowledge of spectral characteristics of the original signal and the noise, and one seeks the filter whose output would come as near to the original signal as possible.

The Wiener filter is:

\[ W(a, b) = \frac{D^*(a, b)Su(a, b)}{|D(a, b)|^2 Su(a, b) + Sn(a, b)} \]

Dividing through by \( Su \) makes its behavior easier to explain:

\[ W(a, b) = \frac{D^*(a, b)}{|D(a, b)|^2 \frac{Sn(a, b)}{Su(a, b)}} \]

Where

\( D(a,b) = \text{Degradation function} \)
\( D^*(a,b) = \text{Complex conjugate of degradation function} \)
\( Sn(a,b) = \text{Power Spectral Density of Noise} \)
\( Su(a,b) = \text{Power Spectral Density of un-degraded image} \)

The term \( Sn/Su \) can be interpreted as the reciprocal of the signal-to-noise ratio.
4. PROPOSED ALGORITHM

![Proposed Algorithm Diagram]

**Figure 1 Proposed Algorithm**

Select an image and add a particular type of noise to the selected image. Take this noisy image as an input for the application. Analyze the noise in the image and choose the appropriate filter or combination of filters. Apply the selected filter on the noisy image for denoising. Hence after applying the selected filtering technique, a new noiseless image will be produced as an output. We have analyzed that the proposed hybrid filter produces the better output compared to other filters. Firstly we denoised the noisy image with average filter then this output was given to the Gaussian filter. The performance in terms of PSNR and quality of image was better.

5. Experimental Evaluation

5.1 Testing procedure

The filters were implemented using (MATLAB R2008a, 7.6.0) and tested four types of noise: Salt and Pepper, Gaussian, Poisson, and Speckle noise corrupted on the Flower image illustrated in the Fig. 2, fig 3, fig 4 & fig 5 respectively.

5.2 Quality evaluation metrics

The proposed methods have been implemented using MATLAB. The measurement of image enhancement is difficult to measure. There is no common method for the enhancement of the image. The behavior of each filter is evaluated quantitively for rose image using quality metrics like MSE, RMSE, PSNR, SNR AND ENL (Equivalent number of looks).

5.2.1 Mean Square Error (MSE) :

Mean Square Error (MSE) for two P×Q monochrome images (G and R) where one of the images is considered a noisy approximation of the other is defined as:

\[
MSE = \frac{1}{PQ} \sum_{m=0}^{P-1} \sum_{n=0}^{Q-1} [G(m, n) - R(m, n)]
\]

5.2.2 Root Mean Square Error (RMSE) :

The Root Mean Square Error (RMSE) is the square root of the squared error averaged over P×Q window
5.2.3 Signal to Noise Ratio (SNR):

Signal to Noise Ratio (SNR) compares the level of the desired signal to the level of background noise. Larger SNR values correspond to good quality image.

\[
SNR = 10\log_{10}\left(\frac{\sum_{m=1}^{P} \sum_{n=1}^{Q} (G_{m,n}^2 + R_{m,n}^2)}{\sum_{m=1}^{P} \sum_{n=1}^{Q} (G_{m,n} + R_{m,n})}\right)
\]

5.2.4 Peak Signal to Noise Ratio (PSNR):

The PSNR is most commonly used as a measure of the quality of de-speckled image. The PSNR is defined as:

\[
PSNR = 10\log_{10}\left(\frac{MAX^2}{MSE}\right)
\]

5.2.5 Equivalent number of looks (ENL)

This index is calculated as follows:

\[
ENL = (\text{mean/SD})^2
\]

where SD is standard deviation.
The efficiency of smoothing speckle noise will be higher when the ENL value will be higher over homogeneous region.

6. EXPERIMENTAL SETUPS AND RESULTS

Table 1: Performance Metrics of various filters

<table>
<thead>
<tr>
<th>PM/FILTERS</th>
<th>MSE</th>
<th>PSNR</th>
<th>RMSE</th>
<th>SNR</th>
<th>ENL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>16</td>
<td>36.0896</td>
<td>4</td>
<td>34.4940</td>
<td>∞</td>
</tr>
<tr>
<td>Proposed Hybrid</td>
<td>1</td>
<td>48.1308</td>
<td>1</td>
<td>40.2173</td>
<td>13.8380</td>
</tr>
<tr>
<td>Mean</td>
<td>4</td>
<td>42.1102</td>
<td>2</td>
<td>37.3854</td>
<td>∞</td>
</tr>
<tr>
<td>Laplacian</td>
<td>25</td>
<td>34.1514</td>
<td>5</td>
<td>32.9898</td>
<td>∞</td>
</tr>
<tr>
<td>Unsharp</td>
<td>16</td>
<td>36.0896</td>
<td>4</td>
<td>34.0183</td>
<td>∞</td>
</tr>
<tr>
<td>Weiner</td>
<td>64</td>
<td>30.0690</td>
<td>8</td>
<td>30.7710</td>
<td>∞</td>
</tr>
<tr>
<td>Gaussian</td>
<td>0</td>
<td>∞</td>
<td>0</td>
<td>∞</td>
<td>17.20</td>
</tr>
</tbody>
</table>

Denoising is carried out for the color image using the different standard filters like average, mean, laplacian, unsharp, weiner, Gaussian and proposed hybrid filter. Simulations are carried out in MATLAB. The performance of different filters has been calculated in terms of MSE, RMSE, SNR, PSNR and ENL are compared in table 1.
The performance of average and unsharp filter is same. But our proposed method provides better SNR, PSNR, MSE, RMSE and ENL also. This means our method removes substantial noise from the image.

References


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