A New Method of Gaussian Noise Reduction in Gray and Colour Images by Fuzzy Filter

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Abstract— Image denoising is one of the important image processing techniques to reduce noises from a corrupted image. This paper proposes a new efficient fuzzy based filter for the restoration of images that are corrupted with Gaussian noise in gray and color images. This filter is applied iteratively to reduce heavy noise in images. The proposed scheme is simulated using standard image of lena under different noisy conditions and different pixel levels. This filter is suitable for both gray and color images. The efficiency of this filter is evaluated based on image metrics PSNR and MSE. The performance study shows better results compared to other standard filters.

Keywords— Gaussian Noise, Denoising, Fuzzy filter, Trapezoid membership function, Fuzzy derivative

I. INTRODUCTION

The aim of the image denoising technique is to provide better output image. Its objective is to get remove noises in the images.

Noise: It is an unwanted signal in images. An image gets corrupted with noise during the process of acquisition, transmission, storage and retrieval. Noise may be classified as substitutive noise, impulsive noise (salt and pepper noise, random valued impulse noise etc..) and additive noise e.g. additive white Gaussian noise.

Gaussian Noise: Gaussian noise is a type of a statistical noise in which the amplitude of the noise follows that of a Gaussian (normal) distribution. In Gaussian noise, power spectral density is normally distributed.

The probability density function of a Gaussian random variable Z is given by

\[ P(z) = \frac{1}{2\pi\sigma} e^{-\frac{(Z - \mu)^2}{2\sigma^2}} \]

where Z represents gray level, \( \mu \) is the average value of Z, \( \sigma \) is its standard deviation, \( \sigma^2 \) is variance.

Image Reduction is one of the most important image processing tasks. The important analysis of image is to effectively reduce noises from the image. The nature of denoising algorithm depends on the type of noise corrupting the image. A number of non linear filters have been developed to remove Gaussian noise. D Van De Ville et al [1] proposed a new fuzzy filter to reduce Gaussian noise in images Androutsos et al [2] presented a a new class of filters called fuzzy vector rank filters based on a combination of different distance measures, Khrij and Gabbouj [3] designed a multi channel filter by combining fuzzy rational and median functions. Choi and Krishnapuram [4] proposed a three fuzzy filter system to reduce Gaussian and impulse noise in images. Morillas et al [5] presented a filter removing noises in color images using fuzzy bilateral filtering method. M.Natchtegael et al [6] designed a new fuzzy filter for removing the Gaussian noise. In literature review [7]-[11], many methods are available to reduce Gaussian noise in gray and color images. Entropy filter denoises image by replacing every value by the information entropy of the values in its range \( r \) neighborhood. The range filter allows selecting a range of values. The left and right drag box can be used to change the lower and upper limit of the range, meaning that only rows with values within the chosen range remain in the visualization. An important feature of the range filter is that the values are distributed on a linear scale according to the values of the data. Standard filter filters image by replacing every value by the standard deviations of the values in its range \( r \) neighborhood. This proposed filter can be applied for both the images.

II. Proposed New Fuzzy Filter For Gaussian Noise Reduction In Gray And Color Images

This paper focuses on developing a new filter to remove Gaussian noise in gray and color images. This paper proposes Gaussian Noise Removal using Enhanced Fuzzy Classifier (GNREFC). During the initial process, to denote a color and gray image, a gray tone image \( f \) with a dimension \((x,y)\) is characterized by intensity value \( i_{x,y} \) for gray levels denoted as

\[ f = \{(i_{x,y}, \beta_{i,x,y}(i_{x,y})\} \]  

where \( i_{x,y} \) denotes the intensity of gray and color image with membership function defined as \( \beta_{x,y} \). Trapezoid membership function is used to denote the pixels present in gray and color images based on the equation given below

\[ \beta(x,y) = e^{[(\mu(x,y) - \mu(i{x,y})]/\sigma]} \]
where $i,j$ denotes the edge detector value and $\mu(x,y)$ denotes the membership function at point $(x,y)$. A $(2\times2)$ neighbourhood of pixel $(x,y)$ using a simple derivative defined as the difference between the pixel and its neighbour present in the direction is considered. The derivative value is denoted by $\Delta(x,y)$. The Gaussian noise removal using fuzzy derivative is denoted as shown below

$$\Delta(x,y) = f(x,y+1) - f(x,y) \quad (2.3)$$

The idea behind the Gaussian function is that if no edge is assumed to be present in a certain direction, the derivative value of that direction is used. For the sake of filtering, positive and negative values are distinguished using

- If $\Delta(x,y)$ is positive
  - Then classify “presence of noise”
- else if $\Delta(x,y)$ is negative
  - Then classify “absence of noise”

To find out the performance of the proposed Gaussian Noise Removal using Enhanced Fuzzy Classifier (GNREFC), simulations are carried out in an extensive manner under different noisy conditions in MATLAB using the standard color image of lena. The performance is evaluated on the basis of PSNR and MSE.

(i) **PEAK SIGNAL NOISE RATIO**

$$\text{PSNR} = 10 \log_{10} \left( \frac{255^2}{\text{MSE}} \right) \text{dB}$$

(ii) **MEAN SQUARE ERROR**

$$\text{MSE} = \frac{1}{MN} \sum_{x=1}^{M} \sum_{y=1}^{N} \left( f(x,y) - f'(x,y) \right)^2$$

where $f(x,y) – M \times N$ initial image, $f'(x,y) –$ noised image

The trapezoid membership function and a simple derivative model are introduced to minimize the noise level and finally to maximize the accuracy.

### III. Experimental Results of Gaussian noise detection and filtering using Enhanced Fuzzy Classifier

The performance of Gaussian noise detection and filtering using Enhanced Fuzzy Classifier (GNREFC) are carried out in extensive manner using standard color image of lena. The lena image illustrated in fig 3.1 (a) is given as input to measure the Gaussian noise detection and filtering using enhanced fuzzy classifier and fig 3.1(b) illustrates the noise removal process.

![Input Lena Image](image-url) ![Gaussian Noise Detection Using Enhanced Fuzzy Classifier](image-url)

**Fig 3.1 Gaussian Noise Reduction Process**

The performance of the proposed Gaussian Noise Removal using Enhanced Fuzzy Classifier GNREFC is evaluated on basis of parameters listed below.

(i) PSNR
(ii) MSE

### 3.1 Measure of PSNR

<table>
<thead>
<tr>
<th>Image Size (pixels)</th>
<th>PSNR (db)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Proposed EFC</td>
</tr>
<tr>
<td>150</td>
<td>14.11</td>
</tr>
<tr>
<td>200</td>
<td>20.25</td>
</tr>
<tr>
<td>250</td>
<td>25.3</td>
</tr>
<tr>
<td>300</td>
<td>30</td>
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</tbody>
</table>
The table 1 and fig 3.2 given above shows, the peak signal-to-noise ratio for Gaussian noise removal using enhanced fuzzy classifier. From the figure, it is evident that the proposed Gaussian noise removal using enhanced fuzzy classifier outperforms the three methods shown above which is due to the fact that the intensity of gray and color image with trapezoid membership function is introduced resulting in higher peak signal-to-noise ratio. The variance achieved is 2-4% high when compared to entropy filter, 5-10% high when compared to range filter.

2.1.2 Measure of MSE

<table>
<thead>
<tr>
<th>Image Size (pixels)</th>
<th>Proposed EFC</th>
<th>Entropy Filter</th>
<th>Range Filter</th>
<th>Standard Filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>0.01</td>
<td>0.02</td>
<td>0.05</td>
<td>0.08</td>
</tr>
<tr>
<td>200</td>
<td>0.008</td>
<td>0.01</td>
<td>0.012</td>
<td>0.015</td>
</tr>
<tr>
<td>250</td>
<td>0.003</td>
<td>0.005</td>
<td>0.009</td>
<td>0.012</td>
</tr>
<tr>
<td>300</td>
<td>0.001</td>
<td>0.008</td>
<td>0.012</td>
<td>0.015</td>
</tr>
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</table>

The table 2 and fig 3.3 illustrated above shows the mean square error obtained using lena image. The figure shows the comparative chart analysis using three other methods with the error ratio being less in the proposed Gaussian noise removal using enhancing fuzzy classifier. This is due to the fact that novel concept, edge detector and a simple derivative model is introduced. The variance achieved 6-10% reduced when compared to entropy filter and 6-12% reduced when compared to the range filter model.
IV. RESULTS AND CONCLUSION

An enhanced approach has been proposed for the removal of Gaussian noise using enhanced fuzzy classifier. The trapezoid membership function and a simple derivative model are introduced to minimize the peak signal-to-noise ratio, noise level and finally to maximize the accuracy. Simulations are conducted using MATLAB with the help of color image of lena. Finally, the Gaussian noise removal from color and gray images prove to be effective using enhanced fuzzy classifier such that the enhanced fuzzy classifier outperforms the entropy filter, range filter and standard filter in terms of PSNR, and MSE. This filter can also be applied to gray images. This is a simple filter which can be applied for both the images. Our future work will be on focusing reduction of speckle noise, stripping noise etc., in gray and color images.

REFERENCES


