DENOISING COLOR IMAGES USING WAVELET BASED FUZZY FILTERING

Dr.R.Dineshkumar, Dr.M.Kalimuthu, Dr.C.Sridhathan

Abstract— Image processing involves various steps to be carried on selected images. The first process includes, noise removal, the process to remove irrelevant information present in the images. Mostly the images are affected with noise (blur, cracks etc.).Preprocessing steps applied on the image gains the original quality of the image in terms of color, shape, size etc. Denoising gives the good quality image by applying either linear or non linear filtering. The various traditional linear and non linear filtering techniques applied to remove noise present in the images. In this paper, the wavelet based fuzzy filtering is applied on different images and the performance analysis is made with other different filtering techniques. The implementation is processed in MATLAB with four different images with good accuracy and quality of images.

Index Terms— Linear Filtering, Non linear filtering, Noise removal, Mean Square Error, PSNR, Fuzzy filtering, Median filtering

1 INTRODUCTION

Denoising is the procedure to remove the noise from the image without affecting the quality of the image. The images are normally carried out with additive, Gaussian and random noise. The noise image reduces the quality of the image and also the low contrast images are not visible to the human eyes. Noise removal is the important process to enhance the quality and also to identify the hidden data in the images. Two types of filtering are used to remove the noise such as linear and non linear filters [1]. Linear filters are used to remove the Gaussian noise. The linear filters are implemented by convolution mark and weighted sum of pixels in successive windows [2]. The linear filter is shown below in Equation (1)

\[
y(t) = \int_{-\infty}^{\infty} h(r) \cdot x(t-r) \, dr
\]

Image Filtering

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Linear filtering

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Fig 1. Image and linear filtering

Non linear filter doesn’t match the property of output with its input. This filtering technique uses the neighboring pixel values instead of convolution or Fourier multiplication.

2 RELATED WORKS

2.1 Hann Window (Mean filtering)

Hann window is defined as smooth function given in Equation 2.

\[
H(t) = 1 + \cos(t), \quad -\pi \leq t \leq \pi
\]

(2)

The Hann window works with the complex exponent which increases the accuracy without affecting the quality of the image. [3]

2.2 Gaussian Filtering

In horizontal direction the mask is used to smooth an image. Horizontal and vertical directions are the two dimensional Gaussians. The mask weight is obtained from the discrete Gaussian distributions to ensure the intensity is not affected [4].

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</table>

Fig 2. 7 X 7 Gaussian mask

2.3 Median filtering

The steps included in median filtering are:

- Step 1: In a given image consider all the pixels in to account
- Step 2: With their intensities sort the neighboring pixels in order
- Step 3: The median value is replaced on the original value of the pixel

In median filtering the output pixel is obtained by median of the neighboring pixel. The median filtering is suitable than the mean filtering in terms of sharpness of the image [5].

3 PROPOSED WORK

3.1 Wavelet based Fuzzy Filter

Wavelet based fuzzy filter provides the better performance and accuracy on the quality of the image when compared to other filtering techniques. It recovers more noise affected images also.
This filtering technique is used to remove additive noise. It consists of two phases namely, wavelets, which differentiate between local variations and fuzzy filter remove the noise without affecting the quality of the image by considering the Red, Green, Blue local differences.

3.2 Gaussian Noise Removal
RGB model is constructed in 3D vector. Color image is denoted as 2D vector. The Gaussian coefficients is expressed in terms of the Equation (1)

\[ N_{s,d}(I,j,1)N_{s,d}(I,j,2)N_{s,d}(I,j,3) = [(C_{s,d}(I,j,1)+\eta_1)(C_{s,d}(I,j,2))+\eta_2)(C_{s,d}(I,j,3)) +\eta_3)] 

(3)

3.3 Wavelet filter
The steps for the wavelet filters are as follows:
Step 1: Consider Image pixel at position \((i,j)\) create window size of \((2K+1)\times(2K+1)\)
Step 2: In each single channel obtain the feature from non-linear averaging filter
Step 3: Calculate large weights and assign to neighboring coefficients. The weights for the red, green and blue at position \((i+k,j+l)\) are \(w(i+k,j+l,1)\), \(w(i+k,j+l,2)\) and \(w(i+k,j+l,3)\) respectively.
Step 4: Next, for the red, green and blue component calculate the magnitude and spatial similarity fuzzy function. and is shown in Equation (4)(5)(6)

\[ w(i+k,j+l,1) = m(i+k,j+l,1) * s(i+k,j+l,1) \]  
(4)

\[ w(i+k,j+l,2) = m(i+k,j+l,2) * s(i+k,j+l,2) \]  
(5)

\[ w(i+k,j+l,3) = m(i+k,j+l,3) * s(i+k,j+l,3) \]  
(6)

Step 5: The red, green and blue component, output image wavelet filter is calculated

3.4 Fuzzy filter
The working of fuzzy filter is provided below
Step 1: For the red (LDR), green (LDG) and blue (LDB) the gradient and derivatives are calculated
Step 2: Correction terms is calculated for 3X3 window
Step 3: Obtain the fuzzy filter output for RGB.

The results of different and proposed filtering techniques is shown in the fig

4 PERFORMANCE ANALYSIS
The proposed method is used to remove the additive noise from the colored image. This wavelet based fuzzy filtering technique applied to different images and the performance is obtained by comparing the output of each filtering technique with the proposed work. The two metrics have been considered, Mean Square Error and Peak Signal to Noise Ratio, to obtain the good quality of the image.

4.1 Mean Square Error
The minimum MSE reflects the high quality image from the noisy image. The Equation (7) is used to calculate MSE

\[ MSE = \frac{1}{n \times m} \sum_{m=1}^{N} \sum_{n=1}^{M} (I_1(m,n)-I_2(m,n))^2 \]  
(7)
Where $I_1$ → Denoised image  
$I_2$ → Image with noise  
$M$→ Input image row  
$M$→ Input image column  

### 4.2 Peak Signal to Noise Ratio

The measurement of the quality of the image depends on the peak signal to noise ratio. The higher PSNR denotes the good quality image. The Equation (8) is used to calculate PSNR values.

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

### Table 1

MSE values for different filtering technique

<table>
<thead>
<tr>
<th>Sample Input Images</th>
<th>Hann window</th>
<th>Gaussian Filtering</th>
<th>Median Filtering</th>
<th>Wavelet based Fuzzy Filtering</th>
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</thead>
<tbody>
<tr>
<td>Bird</td>
<td>16.82</td>
<td>16.25</td>
<td>14.56</td>
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<tr>
<td>Tiger</td>
<td>192.98</td>
<td>129.65</td>
<td>25.66</td>
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<tr>
<td>Bear</td>
<td>186.66</td>
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<tr>
<td>Elephant</td>
<td>64.92</td>
<td>25.32</td>
<td>22.45</td>
<td>9.67</td>
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</table>

### Table 2

PSNR values for different filtering technique

<table>
<thead>
<tr>
<th>Sample Input Images</th>
<th>Hann window</th>
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<tbody>
<tr>
<td>Bird</td>
<td>35.87</td>
<td>36.25</td>
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<td>Tiger</td>
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### Table 3

Performance analysis of different filtering technique

<table>
<thead>
<tr>
<th>Filtering Techniques</th>
<th>Average MSE values</th>
<th>Average PSNR values</th>
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</thead>
<tbody>
<tr>
<td>Hann window</td>
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<td>Wavelet based fuzzy filtering</td>
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<td>39.38</td>
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</table>

### 5 CONCLUSION

The additive noise removal is carried out using wavelet based fuzzy filtering techniques. The output of the wavelet based fuzzy filtering techniques is compared with different other techniques based on MSE and PSNR values. The wavelet based fuzzy filtering techniques gives the better accuracy in smoothing additive noise.

### REFERENCES


