IMAGE DENOISING USING HYBRID FILTER

Vinod Kumar  
Deenbandhu Chhotu Ram University  of Science & Technology Haryana, India

Anil Kumar  
DCTM Palwal University of Science & Technology Haryana, India

Pushpraj Pal  
SRM Global Institute of Engg @ Technology Haryana, India

ABSTRACT
Image denoising is the basic problem in digital image processing. Removing Noise from the image is the main task to denoise the image. Salt & pepper (Impulse) noise and the additive white Gaussian noise and blurredness are the types of noise that occur during transmission and capturing. To remove these types of noise we have many filters like mean filter, median filter, inverse filter, wiener filter. No single one filter can remove both types of noise. So I design a hybrid filter which can be used to denoise these both types of noises from the image.

Keywords
Denoising; Salt & Pepper (Impulse) noise; Median filter; Wiener filter.

1. INTRODUCTION
To denoise the image we have various filters. The main purpose of denoising is to make the image noise less. The noise may be generated in any form or at any time. The salt & pepper noise is generated during analog to digital image conversions or due to the dead pixels in the image. The additive white gaussian noise is added during the transmission of images. Also the images are blurred during capturing of the photos due to the cameras displacement or object movement. So we have to denoise the images from the noise. The various filters are used to denoise the images which are contaminated these types of noise which are explained below:

2. MEDIAN FILTER
Median filtering is a nonlinear operation used in image processing to reduce “salt and pepper” noise. Also Mean filter is used to remove the impulse noise. Mean filter replaces the mean of the pixels values but it does not preserve image details. Some details are removed with the mean filter. In the median filter, we do not replace the pixel value with the mean of neighboring pixel values, we replaces with the median of those values. 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. (If the neighboring pixel which is to be considered contains an even number of pixels, than the average of the two middle pixel values is used.) Fig.1.1 illustrates an example calculation.

![Example Calculation](Image)

**Fig.1:Exp. of median filtering**

The median filter gives best result when the impulse noise percentage is less than 0.1 \%. When the quantity of impulse noise is increased the median filter not gives best result.

3. WIENER FILTER

The main purpose of the Wiener filter is to filter out the noise that has corrupted a signal. Wiener filter is based on a statistical approach. Mostly filters are designed for a desired frequency response. The Wiener filter deals with the filtering of image from a different point of view. One method is to assume that, we have knowledge of the spectral properties of the original signal and the noise, and one deals with the Linear Time Invariant filter whose output comes to be as closed as to the original signal as possible [1]. Wiener filters are characterized by the following assumption:

- Requirement: the filter must be physically realizable, i.e. causal (this requirement can be dropped, resulting in a non-causal solution).
- a. signal and (additive white gaussian noise) noise are stationary linear random processes with known spectral characteristics.
- b. Requirement: the filter must be physically realizable, i.e. causal (this requirement can be dropped, resulting in a non-causal solution).
- c. Performance criteria of wiener filter: minimum mean-square error.

4. WIENER FILTER IN THE FOURIER DOMAIN
The wiener filter is given by following transfer Function:

\[
G(u, v) = \frac{H^*(u, v)P_x(u, v)}{|H(u, v)|^2 + P_n(u, v)P_x(u, v)}
\]

Dividing the equation by \(P_x\) makes its behaviour easier to explain:

\[
G(u, v) = \frac{H^*(u, v)}{|H(u, v)|^2 + \frac{P_n(u, v)}{P_x(u, v)}}
\]

Where

- \(H(u, v)\) = Degradation function
- \(H^*(u, v)\) = Complex conjugate of degradation function
- \(P_n(u, v)\) = Power Spectral Density of Noise
- \(P_x(u, v)\) = Power Spectral Density of un-degraded image.

The term \(P_n /P_x\) is the reciprocal of the signal-to-noise ratio.

5. IMAGE NOISE
Image noise is the degradation of the quality of the image. Image noise is produced due to the random variation of the brightness or the color information in images that is produced by the sensor’s and the circuitry of the scanner or digital cameras. Image noise can also originate in film grain and in the unavoidable shot noise of an ideal photon detector. Image noise is generally regarded as an undesirable by-product of image capture. The types of Noise are following:-

- Additive White Gaussian noise
- Salt-and-pepper noise
- Blurredness

6. ADDITIVE WHITE GAUSSIAN NOISE
The Additive White Gaussian noise to be present in images is independent at each pixel and signal intensity. In color cameras where
more amplification is used in the blue color channel than in the green or red channel, there can be more noise in the blue channel.

7. SAL T- AND - PEPPER NOISE
The image which has salt-and-pepper noise present in image will show dark pixels in the bright regions and bright pixels in the dark regions. [2]. The salt & pepper noise in images can be caused by the dead pixels, or due to analog-to-digital conversion errors, or bit errors in the transmission, etc. This all can be eliminated in large amount by using the technique dark frame subtraction and by interpolating around dark/bright pixels.

8. BLURREDNESS
The blurredness of the image is depend on the point spread function (psf). The psf may circular or linear. The image is blurred due to the camera movement or the object displacement.

9. HYBRID FILTER
This hybrid filter is the combination of Median and wiener filter. When we arrange these filters in series we get the desired output. First we remove the impulse noise and then pass the result to the wiener filter. The wiener filter removes the additive white noise or blurring effect from the image.

![Fig. 1.2 Hybrid filter structure](image)

10. MSE & PSNR
The term MSE (mean square error) is the difference between the original image and the recovered image and it should be as minimum as possible. The term peak signal-to-noise ratio, PSNR, is the ratio between the maximum possible power of a signal and the power of corrupting noise signal.

\[
\text{MSE} = \frac{1}{MN} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} [I(i,j) - K(i,j)]^2
\]

The PSNR is defined as:

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

\[
\log \left( \frac{\text{MAX}^2}{\text{MSE}} \right) = 20
\]

MAXI is the maximum possible pixel value of the image.

11. SIMULATION RESULT
We perform the result on the original lena image. We assume that three types of noise are randomly added in to the images. We have to remove these noise from the images. We pass the image from our hybrid filter and calculate the MSE & PSNR parameters of our output image. The MSE is minimum when the blurring effect is less and PSNR is maximum. The following diagram shows the results of the operations:

![Fig. 1: Original lena image. Fig.2: Blurred, Gaussian, Impulse Noisy Image Fig.3: Noisy Image with Blurring Length=40,Blurring Angle=40 & Impulse Noise =0.01%. Fig.4 :Output of Hybrid filter corresponding to the input of fig 3 Fig. 5: Noisy Image with Blurring length=40,Blurring Angle=40, Impulse Noise=0.1%. Fig 6 Output of Hybrid Filter Corresponding to Fig 5 Fig 7 Noisy Image with Blurring Length=21,Blurring Angle=11,Impulse Noise =0.01%.Fig.8 Output of Hybrid filter corresponding to the input of fig 7. Fig 9 Noisy Image with Blurring Length=5,Blurring Angle=5 & Impulse Noise =0.01% Fig 10 Output of Hybrid filter corresponding to the input of fig 9. Now we have to calculate the mean square error for the different conditions to check the performance of our filter.

The Table 1 shows that when the blurredness of the image vary with angle and length and the percentage of impulse noise is constant.

<table>
<thead>
<tr>
<th>Blurring length</th>
<th>Blurring Angle</th>
<th>Percentage of impulse noise (%)</th>
<th>Mean square error</th>
<th>Peak Signal to Noise ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>45</td>
<td>0.01</td>
<td>0.019</td>
<td>65.379</td>
</tr>
</tbody>
</table>

Table 1
From the above table we conclude that when the blurring effect is varying and impulse noise is fixed the MSE is decreasing and PSNR is increasing. Next Table 2 shows the results of MSE & PSNR when the blurriness of the image is same and the percentage of the impulse noise is increased, then the following results are obtained:

<table>
<thead>
<tr>
<th>Blurred length</th>
<th>Blurring Angle</th>
<th>Percentag e of impulse noise(%)</th>
<th>Mean square error</th>
<th>Peak Signal to Noise ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>40</td>
<td>0.01</td>
<td>0.019</td>
<td>65.379</td>
</tr>
<tr>
<td>40</td>
<td>40</td>
<td>0.03</td>
<td>0.023</td>
<td>64.619</td>
</tr>
<tr>
<td>40</td>
<td>40</td>
<td>0.05</td>
<td>0.035</td>
<td>62.715</td>
</tr>
<tr>
<td>40</td>
<td>40</td>
<td>0.07</td>
<td>0.037</td>
<td>62.522</td>
</tr>
<tr>
<td>40</td>
<td>40</td>
<td>0.09</td>
<td>0.053</td>
<td>60.954</td>
</tr>
<tr>
<td>40</td>
<td>40</td>
<td>0.1</td>
<td>0.054</td>
<td>60.127</td>
</tr>
</tbody>
</table>

From the above table we conclude that when the percentage of impulse noise is increasing the PSNR is decreasing. More is the noise less is the signals strength. We cannot exactly recover the original image.

Next when the blurredness and impulse noise is Simultaneously varying means both the parameters are varying in that case, we get the following results

<table>
<thead>
<tr>
<th>Blurred length</th>
<th>Blurring Angle</th>
<th>Percentag e of impulse noise(%)</th>
<th>Mean square error</th>
<th>Peak Signal to Noise ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>11</td>
<td>0.01</td>
<td>0.019</td>
<td>65.457</td>
</tr>
<tr>
<td>15</td>
<td>09</td>
<td>0.02</td>
<td>0.022</td>
<td>64.676</td>
</tr>
<tr>
<td>10</td>
<td>05</td>
<td>0.01</td>
<td>0.011</td>
<td>67.819</td>
</tr>
<tr>
<td>10</td>
<td>05</td>
<td>0.03</td>
<td>0.018</td>
<td>65.654</td>
</tr>
<tr>
<td>05</td>
<td>03</td>
<td>0.01</td>
<td>0.010</td>
<td>68.031</td>
</tr>
<tr>
<td>05</td>
<td>03</td>
<td>0.04</td>
<td>0.018</td>
<td>65.726</td>
</tr>
</tbody>
</table>

12. CONCLUSION
We used the Lena image in .jpg format. Adding three noise (impulse noise, gaussian noise, blurriness) and apply the noisy image to hybrid filter. The final filtered image is depending upon the blurring angle and the blurring length and the percentage of the impulse noise. When these variables are less the filtered image is nearly equal to the original image. The MSE is decreasing and PSNR is increasing when the noise percentage is less.

13. REFERENCES