Image Enhancement by Hybrid Filter

Preeti Beniwal, Tarunjeet Singh

Department Of Electronics & communication,Samalkha group of institution, Samalkha, Panipat,
Kurukshetra University ,krurkshetra, Haryana, India
beniwalpreeti48@gmail.com, tannisingh@gmail.com

ABSTRACT

Image filtering processes are applied on images to remove the different types of noise that are either present in the image during capturing or introduced into the image during transmission. The salt & pepper (impulse) noise is the one type of noise which is occurred during transmission of the images or due to bit errors or dead pixels in the image contents. The images are blurred due to object movement or camera displacement when we capture the image. This pepper deals with removing the impulse noise and blurredness simultaneously from the images. The hybrid filter is a combination of wiener filter and median filter.

Keywords: Salt & Pepper (Impulse) noise; Blurredness; Median filter; Wiener filter

I INTRODUCTION

The basic problem in image processing is the image enhancement and the restoration in the noisy envirement. If we want to enhance the quality of images, we can use various filtering techniques which are available in image processing. There are various filters which can remove the noise from images and preserve image details and enhance the quality of image. Hybrid filters are used to remove either gaussian or impulsive noise from the image. These include the median filter and wiener filters. Combination or hybrid filters have been proposed to remove mixed type of noise during image processing from images.

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 removes with the mean filter. But 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 illustrates an example calculation.

Fig.1:Exp. of median filtering

$$\hat{f}(x, y) = \underset{(s,t)\in S_{xy}}{\text{median}} \{g(s, t)\}$$

Where g(s,t)=sub image area of m*n image. 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.

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 Invarient filter whose output comes to be as closed as to the original signal as possible [1]. Wiener filters are characterized by the following assumption:
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.

Wiener Filter in the Fourier Domain

The wiener filter is given by following transfer function:

$$G(u, v) = \frac{H^*(u,v)P_s(u,v)}{|H(u,v)|^2 P_s(u,v) + P_n(u,v)}$$

Dividing the equation by P_s makes its behaviour easier to explain:

$$G(u, v) = \frac{H^*(u,v)}{|H(u,v)|^2 + \frac{P_n(u,v)}{P_s(u,v)}}$$

Where

$H(u, v)$ = Degradation function

$H^*(u, v)$ = Complex conjugate of degradation function

$P_n(u, v)$ = Power Spectral Density of Noise

$P_s(u, v)$ = Power Spectral Density of un-degraded image.

The term P_n / P_s is the reciprocal of the signal-to-noise ratio.

II 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 camera's. 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

### Additive White Gaussian noise

The Additive White Gaussian noise to be present in images are 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.
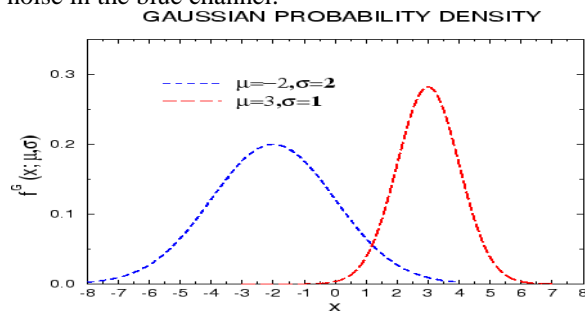
Salt-and-pepper noise

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.
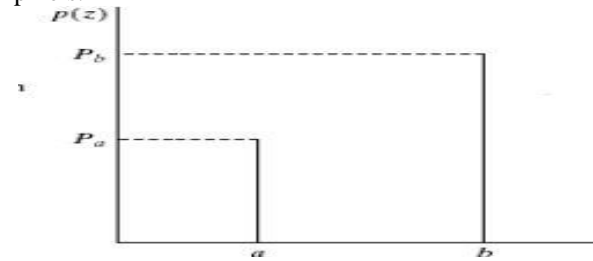

$$P(Z) = \begin{cases} P_a & \text{for } z = a \\ P_b & \text{for } z = b \\ 0 & \text{otherwise} \end{cases}$$

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.

III HYBRID FILTER

This hybrid filter is the combination of Median and wiener filter. when we arrange these filter in series we get the desired output. First we remove the impulse noise and then pass the result to the wiener filter.
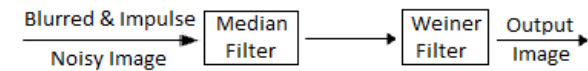
The wiener filter removes the blurredness and the additive white noise from the image. The result is not the same as the original image, but it is almost same.

Algorithm

The following steps are followed when we filtered the image:

• If the image is colored convert it in the gray scale image.
• Convert the image to double for better precision.
• Find the median by sorting all the values of the 3*3 mask in increasing order.
• Replace the center pixel value with the median value.
• Estimate the Signal to Noise ratio.
• Deconvolution function is applied to filtered the image.

IV 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.

$$MSE = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i, j) - K(i, j)]^2$$

The PSNR is defined as:

$$PSNR = 10 \cdot \text{Log}_{10} \left(\frac{MAX_I^2}{MSE} \right)$$

$$= 20 \cdot \log_{10} \left(\frac{MAX_I}{\sqrt{MSE}} \right)$$

where, MAX₁ isthe
maximum possible pixel value of the image.

V SIMULATION RESULT

The Original Image is cameraman image . Adding three types of Noise (Additive white Gaussian noise, Salt & Pepper noise blurredness) and pass this image to our hybrid filter we get the desired result. The result depend upon the blurring angle (thetaa) and the blurring length (Len) and the intensity of the impulse noise. The performance is compared with the MSE & PSNR of the original image and the filter output
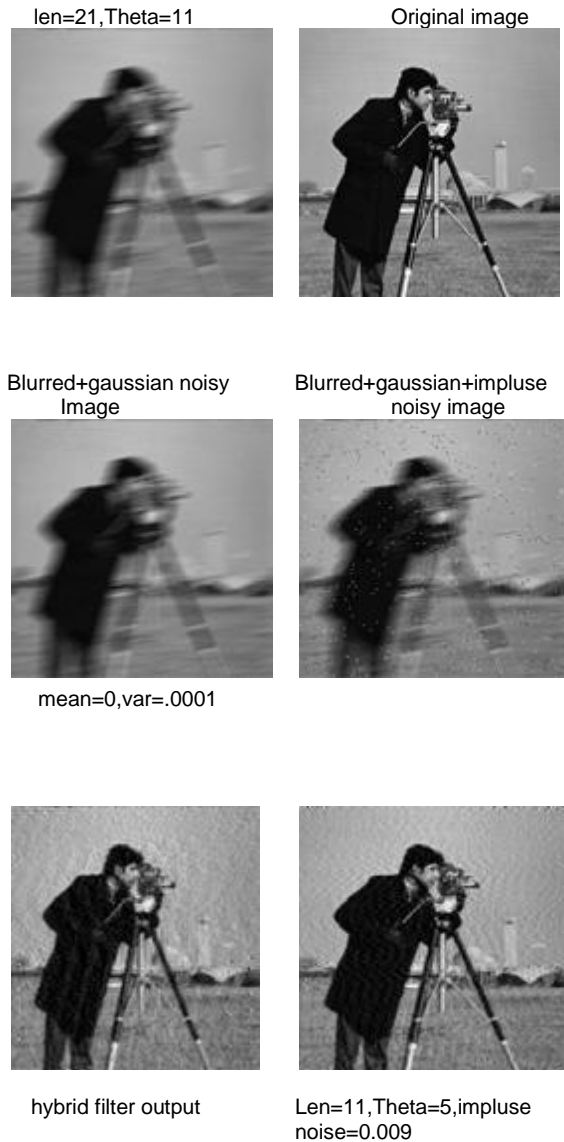
len=21,Theta=11   Original image

Blurred+gaussian noisy Image   Blurred+gaussian+impluse noisy image

mean=0,var=.0001

hybrid filter output   Len=11,Theta=5,impluse noise=0.009

Fig.2 Original Image   Fig.3 Blurred image with Len=21, Theta=11   Fig.4 Blurred image with gaussian noise of mean=0, variance = 0 .001
Fig.5 Blurred or Impulse noisy image
Fig.6 Hybrid Filter output Fig.7 hybrid Filter Output.
Now we calculate the mean square error for the different conditions to check the performance of our filter.

The Table shows the MSE & PSNR when the blurredness of the image varies with angle and length and the percentage of impulse noise is constant.

Table 1:

Blurring length (LEN)	Blurring Angle (Theta)	Percentage of Impulse Noise	Mean Square Error (MSE)	Peak Signal Noise Ratio (PSNR)
5	5	0.01	0.005	70.968
10	10	0.01	0.007	70.016
15	15	0.01	0.008	69.241
20	20	0.01	0.009	68.533
25	25	0.01	0.011	67.758

Next when the blurredness of the image is fixed and the percentage of the impulse noise is varies, then the following MSE & PSNR is obtained:

Table 2:

Blurring length (LEN)	Blurring Angle (Theta)	Percentage of Impulse Noise	Mean Square Error (MSE)	Peak Signal Noise Ratio (PSNR)
5	5	0.01	0.005	70.968
5	5	0.02	0.007	69.684
5	5	0.03	0.009	68.073
5	5	0.04	0.013	67.104
5	5	0.05	0.015	66.880

Now When the blurredness and impulse noise is simultaneously varying, we get the following MSE & PSNR results:

Table 3:

Blurring length (LEN)	Blurring Angle (Theta)	Percentage of Impulse Noise	Mean Square Error (MSE)	Peak Signal Noise Ratio (PSNR)
10	10	0.02	0.103	58.026
50	50	0.03	0.009	68.715
40	40	0.04	0.0089	68.981
30	30	0.05	0.013	67.168
20	20	0.06	0.009	68.533

VI CONCLUSION

We used the cameraman image in .tif format and adding three noise (impulse noise, gaussian noise, blurredness) 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. We can recover noisy image up to 70 percentage.

VII FUTURE SCOPE

There are a couple of areas which we would like to improve on. One area is in improving the de-noising along the edges as the method we used did not perform so well along the edges. Instead of using the median filter we can use the Adaptive median filter. We can also increase the types of noise.

References:

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