FUZZY BASED MEDIAN FILTER FOR GRAY-SCALE IMAGES

Sukomal Mehta[1], Sanjeev Dhull[2]

[1] Department of Electronics & Comm., GJU University, Hisar, Haryana, ***sukomal.mehta@gmail.com***
*[2]Assistant Professor, Department of Electronics& Comm., GJU University,Hisar,Haryana,****sanjeevdhull2011@yahoo.com***

Abstract

Digital image processing is a subset of the electronic domain wherein the image is converted to an array of small integers, called pixels, representing a physical quantity such as scene radiance, stored in a digital memory, and processed by computer or other digital hardware. The application of median filter has been investigated. As an advanced method compared with standard median filtering, the Adaptive Median Filter performs spatial processing to preserve detail and smooth non-impulsive noise. Fuzzy logic represents a good mathematical framework to deal with uncertainty of information. Fuzzy image processing [4] is the collection of all approaches that understand, represent and process the images, their segments and features as fuzzy sets.In this paper, we propose a Fuzzy based median filter, to achieve improved filtering performance in terms of effectiveness in removing salt-and-pepper noise while preserving image details and smooth non-impulsive noise. Proposed method work in two steps, in first step we detect noisy pixels using fuzzy reasoning with lowest uncertainty, and in second step we replace noisy pixels with a adaptive noise filter, our this filter is combined with human knowledge for select best replacement. Experimental results show that our proposed method outperforms the standard median based techniques in term of PSNR values.

Index Terms: *Pixel, Median filter, PSNR, impulsive Noise, Mean Filter, Adaptive.*

-- *** --

1. INTRODUCTION

In many different kinds of digital image processing, the basic operation is as follows: at each pixel in a digital image we place a neighbourhood around that point, analyze the values of all the pixels in the neighbourhood according to some algorithm, and then replace the original pixel's value with one based on the analysis performed on the pixels in the neighbourhood. The neighbourhood then moves successively over every pixel in the image, repeating the process when digital images are distorted by impulse noise during acquisition, transmission and storage, when they are taken by a camera with a faulty sensor, or transmitted over a noisy channel [1]. Noise removal is an important pre-processing step followed by other tasks such as object recognition, edge detection, feature extraction and pattern recognition. Generally, linear averaging filters have the ability to remove additive Gaussian noise, but are ineffective against impulse noises. Edges and image details also get blurred due to linear filtering. Conversely, edge-preserving filters will retain the edges and line structures but tend to amplify noise. Different methods have been proposed in literature to address this issue. The most effective approaches are nonlinear and adaptive in nature [2-3]. Depending on the noise type, we are required to apply the optimum choice of filters to obtain the best output for a particular noisy pixel.

1.1 Median Filter

For the case where the impulsive noise is mixed with then signal such as image, it is known that the median filter can effectively remove the noise. Median filtering follows this basic prescription. The median filter is normally used to reduce noise in an image, somewhat like the mean filter. However, it often does a better job than the mean filter of preserving useful detail in the image. This class of filter belongs to the class of edge preserving smoothing filters which are non-linear filters. This means that for two images *A(x)* and *B(x)*:

$$median[A(x)+B(x) \neq median[A(x)+B(x)]$$

These filters smoothes the data while keeping the small and sharp details. The median is just the middle value of all the values of the pixels in the neighbourhood. Note that this is not the same as the average (or mean); instead, the median has half the values in the neighbourhood larger and half smaller. The median is a stronger "central indicator" than the average [7]. In particular, the median is hardly affected by a small number of discrepant values among the pixels in the neighbourhood. Consequently, median filtering is very effective at removing various kinds of noise. Figure 1 illustrates an example of median filtering.

 ISSN: 2250–3676

[IJESAT] INTERNATIONAL JOURNAL OF ENGINEERING SCIENCE & ADVANCED TECHNOLOGY Volume-2, Issue-4, 975 – 980

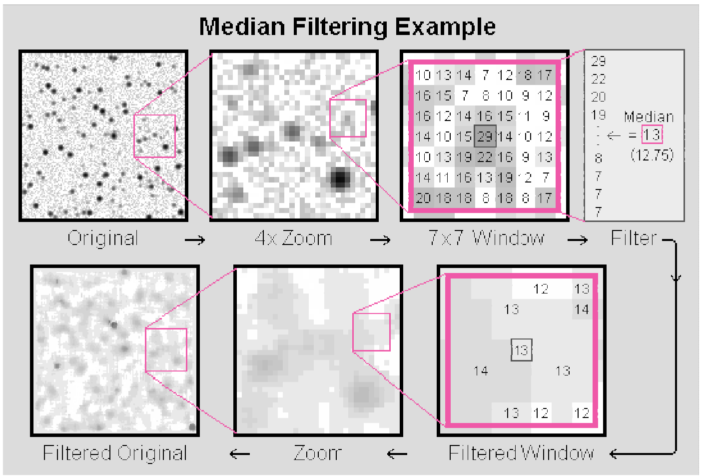


Fig-1 Median Filter

Like the mean filter, the median filter considers each pixel in the image in turn and looks at its nearby neighbours to decide whether or not it is representative of its surroundings. Instead of simply replacing the pixel value with the mean of neighbouring pixel values, it replaces it with the median of those values. The median is calculated by first sorting all the pixel values from the surrounding neighbourhood into numerical order and then replacing the pixel being considered with the middle pixel value. (If the neighbourhood under consideration contains an even number of pixels, the average of the two middle pixel values is used.) Figure 2 illustrates an example calculation.

123	125	126	130	140
122	124	126	127	135
118	120	150	125	134
119	115	119	123	133
111	116	110	120	130

Neighbourhood values:

115, 119, 120, 123, 124, 125, 126, 127, 150

Median value: 124

Fig-2 Calculating the median value of a pixel neighbourhood. As can be seen, the central pixel value of 150 is rather unrepresentative of the surrounding pixels and is replaced with the median value: 124. A 3×3 square neighbourhood is used here- larger neighbourhoods will produce more severe smoothing.

In standard median filters are generally implemented to all pixels in an image. They tend to alter pixels undisturbed by noise. As a result, their effectiveness in noise suppression is often at the expense of blurred and distorted image features. A better way to circumvent this drawback is to incorporate some decision-making processes in the filtering framework i.e. adaptive or fuzzy based median filter is used. In this paper, we propose fuzzy based median filter for soft decision of impulsive noise from Gray-Scale images for checking whether the centre pixel is an impulsive or not.

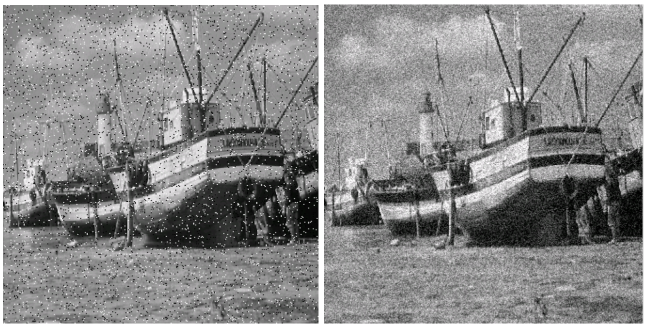
1.2 Noise

Noise in an image is a serious problem or it is any undesirable signal Noise gets introduced into the data via any electrical system used for storage, transmission, and/or processing. The noise embedded in an image manifests in diverse varieties. The noise may be correlated or uncorrelated; it may be signal dependent or independent and so on. The noise could be AWGN, SPN, RVIN, or a mixed noise. Suppression of noise in an image efficiently is a very important issue. Conventional techniques of image de-noising applied are application-oriented. Also, the different procedures are related to the types of noise introduced to the image.The objectives of these schemes are to reduce noise as well as to retain the edges and fine details of the original image in the restored image as much as possible [5]. Also, the different algorithms are related to the types of noise introduced to the image. Some examples of noise are: Gaussian or White, Rayleigh, Shot or Impulse, periodic, sinusoidal or coherent, uncorrelated, and granular.

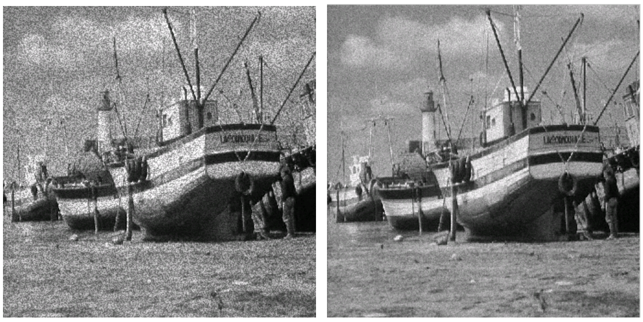
Fig-3 Original Boat Image

Fig.3 shows original boat image as a input for filter .Some examples of noise are: Gaussian, Salt & Pepper, Speckle and Random-valued impulsive Noise as shown in Fig.3

ISSN: 2250–3676
[IJESAT] INTERNATIONAL JOURNAL OF ENGINEERING SCIENCE & ADVANCED TECHNOLOGY Volume-2, Issue-4, 975 – 980



a) Salt & Pepper Noise b) Gaussian Noise



c) Speckle Noise d) Poisson Noise

Fig-4 various types of noise in Boat image

1.3 Impulsive noise in Gray-Scale Images

A gray-scale image represented by a two-dimensional array where a location (m,n) is a position in image and each element is called pixel. This image is stored as an 8-bit integer that giving 256 possible different shades of gray going from black to white, pixels can have value in [0-255] integer interval, but some pixels in an image have not correct value and they are consider as noise that their value's is 0 or 255, thus model for a gray-scale image.

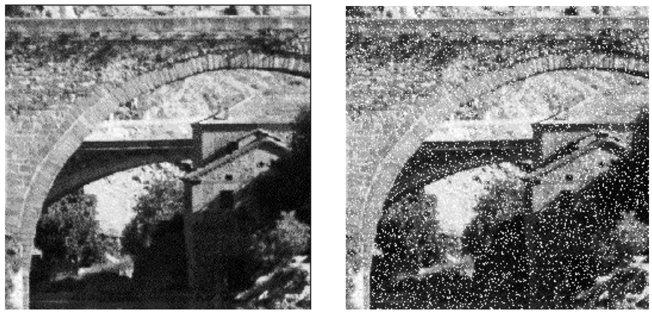
$$Img(m,n)=\begin{cases} Org(m,n) & \text{probability } 1-p \\ 0 & \text{probability } p1 \\ 255 & \text{probability } p2 \end{cases} \quad (1.1)$$

Where Org (m,n) is the original image without any noise, pl is p= pl +p2. On the other hand an image with noisy pixel such as in (1.2) that N (m, n) impulse noises such as 255(pepper) and 0(salt).

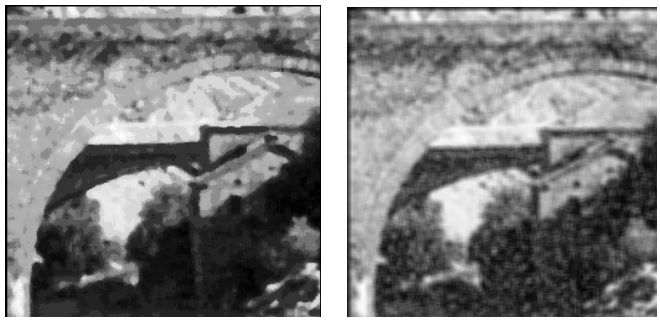
$$Img(m,n)=\begin{cases} Org(m,n) & \text{probability } 1-p \\ N & \text{probability } p \end{cases} \quad (1.2)$$

2. COMPARSION BETWEEN MEDIAN FILTER AND MEAN FILTER

The median filter is a non-linear tool, while the mean filter is a linear one. In smooth, uniform areas of the image, the median and the mean will differ by very little. The median filter removes noise, while the mean filter just spreads it around evenly. The performance of median filter is particularly better for removing impulse noise than mean filter.



a)Original image; b)Added Impulse Noisy at 40%



a) 5x5window Median Filtered b) 5x5window Mean Filtered

3. ADAPTIVE MEDIAN FILTERING

Therefore the adaptive median filtering has been applied widely as an advanced method compared with standard median filtering. The Adaptive Median Filter performs spatial processing to determine which pixels in an image have been affected by impulse noise. The Adaptive Median Filter classifies pixels as noise by comparing each pixel in the image to its surrounding neighbour pixels. The size of the neighbourhood is adjustable, as well as the threshold for the comparison. A pixel that is different from a majority of its neighbours, as well as being not structurally aligned with those pixels to which it is similar, is labelled as impulse noise. These noise pixels are then replaced by the median pixel value of the pixels in the neighbourhood that have passed the noise labelling test [10]. It purposes is to remove impulsive noise,

ISSN: 2250–3676
[IJESAT] INTERNATIONAL JOURNAL OF ENGINEERING SCIENCE & ADVANCED TECHNOLOGY Volume-2, Issue-4, 975 – 980

smoothing of other noise and reduce distortion like excessive thinning or thickening of object boundaries

The standard median filter does not perform well when impulse noise is greater than 0.2, while the adaptive median filter can better handle these noises. The adaptive median filter preserves detail and smooth non-impulsive noise, while the standard median filter does not.

4. IMPLEMENTATION & RESULTS

Fuzzy based median filter were tested on an 8-bit gray-scale images from test image database. Consider pepper image is of size 512x512.Random-valued impulsive were injected into image at various noise ratios. Random-valued impulse noise has range of impulse noise values between 0 and 255. We use MATLAB for implementation and analysis of result. We analysis three parameters for this filter such as: PSNR, MSE, Noise Reduction Time. The phrase peak signal-to-noise ratio, often abbreviated PSNR, is an engineering term for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. Because many signals have a very wide dynamic range, PSNR is usually expressed in terms of the logarithmic decibel scale and the performance of the proposed algorithms was evaluated in terms of the visual quality, the peak-signal-to-noise-ratio (PSNR). The PSNR is given by

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

$$PSNR = 20.\log_{10}\left(\frac{MAX_i}{\sqrt{MSE}}\right)$$

$$PSNR = 20.\log_{10}(MAX_i) - 10.\log_{10}(MSE)$$

Where, MAX_i is the maximum possible pixel value of the image. When the pixels are represented using 8 bits per sample, this is 255. More generally, when samples are represented using linear PCM with B bits per sample, MAX_i is 2^B-1 and MSE is Mean Square Error between the filtered image and the original image. MSE is given by

$$MSE = \left[\frac{1}{MN}\sum_{m=0}^{M-1}\sum_{n=0}^{N-1}[\hat{f}(m,n) - f(m,n)]^2\right]^{\frac{1}{2}}$$

When two images are identical, the MSE will be zero. For this value the PSNR is undefined (Division by zero).

For standard and adaptive mean filtering method, 3x3 window size is used. Algorithm is implemented on noisy image: the estimate of the current pixel being dependent on the new values of the previously processed pixels in the filtering window. The results of the Pepper image are shown in Fig. 5 respectively.

Fig 5.1 Original Pepper image

Fig 5.2 image corrupted with 10% noise

Fig 5.3 Standard Median filter

Fig 5.4 Adaptive Median filter

As Figure 5.1 shown above are the pepper original image and the same image after it has been corrupted by impulse noise at 20% in fig 5.2. 3x3 standard median filter applied to the noisy image in fig 5.3.Filtered image using adaptive median filtering method as shown in fig 5.4.

By visually, we can say that using standard filter, image get blurred and it does not preserve the information of image and by adaptive mean filter, first step we check which pixel is impulsive and apply this median filter on Values of PSNR for pepper image at different noise percentage for both methods i.e. standard median filter and adaptive or fuzzy based median filter is shown in Table 1.

Table-1: PSNR variation w.r.t % of Salt & Pepper noise

PSNR values		
Noise %	**Standard Median Filter**	**Adaptive Median filter**
10%	33.08	39.42
30%	32.49	34.94
50%	29.37	31.91
70%	25.77	29.24

5. CONCLUSION

This paper proposed a median filter which controls the output based on the fuzzy rules concerning the existence nonexistence of the impulsive noise. The effectiveness of the method is demonstrated by the elimination of the impulsive noise from the image. The work concerned with developing fuzzy-based filtering algorithm for removing impulse noise from an image. Standard Median filter is based on impulse noise detection by applying it without detection condition which blurred the image.

Adaptive Median Filter to reduce the probability of detecting a healthy pixel as an impulse and the probability of detecting a noisy pixel as healthy. On the other hand, checks in the images whether impulse noise is present in the sliding window or not, and if present it median filtering is applied. It has been shown experimentally that the adaptive median filter outperformed the standard median filter by large margin in term of PSNR values and visually also. On the other hand, fuzzy-based median filter is soft-thresholding approach that has ability to differentiate between impulse noise and feature points.

The median filter performs well as long as the spatial density of the impulsive noise is not large. However, the adaptive median filtering can handle impulsive noise with ability even larger than 0.2. An additional benefit of the adaptive mean filter is that it seeks to preserve detail and while smoothing non-impulsive noise. Considering the high level of noise, the adaptive algorithm performed quite well. The choice of maximum allowed window size depends on the application, but a reasonable starting value can be estimated by experimenting with various sizes of the standard median filter first. The future plan of the proposed method is to extend it further for removing impulse noise from color images.

ACKNOWLEDGEMENT

The paper is supported by key project of Image processing of India.

REFERENCES

[1] Rafael C. Gonzalez and Richard E. Woods *Digital Image Processing*, 2001, pp.220 – 243.

[2]Mitra,S.K,Sicuranza,G.(eds.):Nonlinear image processing *2001,pp.220-243*.

[3] Pitas, Venetsanopoulos, A.N.: Nonlinear digital filters: Principals and Applications.

[4] A. Marion An Introduction to image processing, Chapman and Hall, 1991, pp.274

[5] S. Sridhar. Digital Image Processing, pp.222-227.71-73, Oxford University press. 2011.

[6] E.Abreu, M.Lightstone, S.K. Mitra and K. Arakawa, A new efficient approach for the removal of impulsive noise from highly corrupted images, IEEE Trans. Image Processing, vol.5, issue no.6, pp.1012-1025, Jun 1996.

[7] Yan Zhou, "Adaptive Fuzzy Median Filter for images corrupted by impulsive noise", Congress on Image and Signal Processing, 2008.

[8] Haixing Xu, "An Adaptive Fuzzy Switching filter for images corrupted by impulsive noise, "Sixth international conference on Fuzzy systems and Knowledge Discovery, 2009.

[9] H.S.Kam and W.H. Tan. "Noise Detection Fuzzy (NDF) for removing salt & pepper noise", IVIC 2009, LNCS 5857, pp.479-486, 2009.

[10] Mahdi Jampour," Impulsive noise detection and reduction using Fuzzy logic and Median Heuristic filter", International conference on Networking and Information Technology, 2010

[11] Kh. Manglem Singh, "Fuzzy Rule based Median filter for Gray-Scale Images, ",Journal of information Hiding and Multimedia signal processing,vol.2,no.2, April 2011.

[12] Harish Kundra," Filter for removal of impulse noise by using fuzzy logic", International Journal of image processing (IJIP), vol.3, issue 3, March 2011

BIOGRAPHIES

Sukomal Mehta received her graduate degree in ECE from Kurukshetra University in 2008. She is pursuing M.Tech. in ECE from GJU, Hisar, India. Her research interests include image processing, fuzzy logic. Her research has resulted in a great no. of contribution in fuzzy set theory.

Mr. Sanjeev Dhull received B.Tech. and M.Tech Degree in Electronics & Communication. He has got a teaching experience of nearly 12 years. Currently, he is working as Assistant Professor ECE in GJU S & T, Hisar, India & simultaneously he is pursuing his Ph.D (Research) in Electronics & Comm. He has published a number of Research papers in various national & international journals & conferences. His area of interests are signal processing, fuzzy logic, image processing, MATLAB, etc.