A Comparative Study Of Impulse Noise Reduction In Digital Images For Classical And Fuzzy Filters

K.Manivel[1], Dr. R.Samson Ravindran[2]

Abstract

Efficient impulse noise removal is an important issue in image processing. It is caused error in the data communication generated in noisy sensors or communication channels or by error during the data capture from digital cameras, scanning i.e. one form of image is converted to another form. In this paper we review on generalized classical and fuzzy filters for good impulse noise reduction, analysis and compare the various filter performance such as mean square error, peak signal to noise ratio as well as in terms of visual quality and low execution time.

Keywords-Digital Image, Impulse noise, Noise removal, Classical filter, Fuzzy filter.

1.Introduction

The investigation of the quality image has been extensively used for many consumer applications. The impulse noise reduction is a first preprocessing method in dealing with improve the overall system quality of an image has been corrupted by different types of noise that are likely to contaminate image during analog transmission or storage [1], when the received or storage in signal level. The great challenges of image de-noising techniques is better noise reduction as well as without any unchanged the image values and it give more efficiency of the image.

In a color image to grayscale digital image (Y) is represented by two dimensional arrays for the co inside lines (m, n) defines a position in Y is called as pel or pixel element [2], In the two dimensional gray scale image intensity is stored as an 8-bit value giving 256 possible values from black and white colors represented as 0 or 255 integer values has been represented. Since this period, we considered as multiple integer values p_1, p_2, $p_3 \dots p_n$. Position (m, n) of the image are occurred by the impulse noise can be denoted as [3].

$= Y(m, n)$ with probability $1-p_r$

$= p_1$ with probability pr_1

$N(m, n) = p_2$ with probability pr_2

$= p_n$ with probability pr_n (1)

In equation 1, where pr is the probability that a pixel is corrupted and N is the corrupted image

Digital images acquired through many consumer digital products are often corrupted by impulse noise during image acquisition, image transmission or recording in faulty hardware. There are three important types of noise represented above mentioned image processing functions i) impulse noise, ii) multiplicative noise, and iii) additive noise[4]. In these three noises, the value of each pixel in the image is changed from its original value with a small amount. In this case, noisy pixels are very different from their surroundings area. Salt-and-pepper noise is caused by sharp sudden changes of pixel values of the entire image.

The formation of the paper presents the impulse noise and its types in the first section, the dedicated results of general classical and fuzzy filters for removing impulse noise level and visual experiment in second section. In the survey of both general classical and fuzzy filters, we will investigate whether fuzzy filters perform better than general classical filters and produce better results and also confirmed by good visual results.Figure1 represents the original onion color image and converted into gray image, these images corrupted with varying proportions of impulse noise. It can be analyzed from the images that the impulse noise gets circulated equally over the total image in the form of black and white pixels.

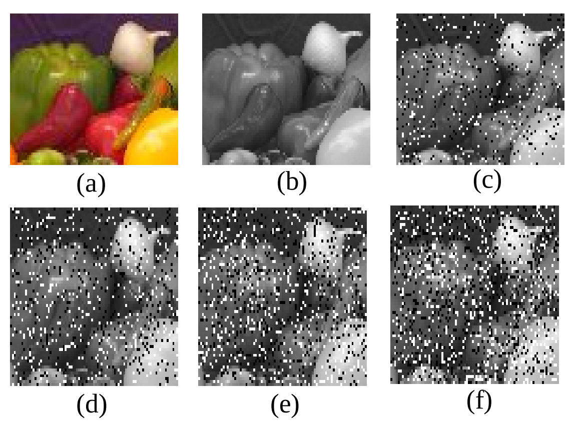

Figure1. (a) original onion image (b) RGB to gray image

(c)impulse noise occurred in onion image with 10% (d) impulse noise occurred in onion image with 15% (e) impulse noise occurred in onion image with 20% (f) impulse noise occurred in onion image with 25%

II.Performance Of Classical Filters

The classical filters is generalizes such that they are still implement using low sensitivity and low noise structure. These filters can have several pass band and stop band regions and arbitrary weights can be used, some transmission and attenuation zeros can be fixed.

A. Linear filter:

Linear filter have been the dominating filter class through the history of signal processing, due mainly to the second theoretical basis provided by the theory of linear systems and the computational efficiency of linear filtering algorithms. Despite the elegant linear system theory, not all signal processing problems can be satisfactorily addressed through the use of linear filters. Linear filters tend to blur sharp edges, fail to remove heavy tailed distribution noise effectively, and perform poorly in the presence of signal depend noise [5]. The gray value of an image pixel (m, n) replaced by linear filter and combination of the gray values in a neighborhood of the pixel is (2s+1) (2s+1).

$$\sum_{K}^{N} = -N \sum_{l}^{N} = -N W(k,l).A(i-k, j-l) \qquad (2)$$

The coefficients w (k, l) is self-determining of the processed pixel (m, n). In the early improvement of digital image processing, linear filters were the most important tools, their numerical simplicity with suitable performance in various applications made them easy to design and implementation for example Mean filter.

The **mean** (average) filter smoothes image data, thus eliminating noise. This filter performs spatial filtering on each individual pixel in an image using the gray level values in a square or rectangular window surrounding each pixel [6]. The mean filter is a simple sliding-window spatial filter that replaces the center value in the window with the average of all the pixel values in the window. The window, or kernel, is usually square but can be any shape

B.Non-Linear Filter:

A non-linear filter has been confirmed very useful is the class of median based filters. During the last few years their theory has also been developing very fast. It is the estimation of the authors that median based filters today give one sound move toward to non linear filtering. The success of median filters is based on two essential properties (i) edge preservation and (ii) efficient noise attenuation with robustness against impulsive type noise. An important shortcoming of the median that has poor to use in many other fields is that the filter output is always constrained, by definition, to be one of the samples in the input window. For example, that the median loses as much as 40% efficiency over the sample mean when used as a position estimator in Gaussian environments.

a. Generalized Min-Max Filter:

The generalized min-max filter [7] method is applied to find darkest points in the image and to reduce salt noise, and to find brightest points to reduce pepper noise in the image, for removing the pepper noise were adapted in midpoint algorithm is used to compute midpoint between minimum and maximum values. This process is for all corrupted pixels in the image and yields improved results for the noise density level up to 72%.

b. Standard Median Filter:

The standard median filter [8] is one of the non-linear filters which modify the noisy image intensity average value for the spatial noise distribution and reduce the normal variance of the output image. In the impulse noise removal operation to performance of this filter uses a two dimensional mask that is implemented to every pixel in the noisy image. To implement the cover means to centre at every pixel value, calculating the covered pixel value of 255 and decide which the value of 255 is the median value

c. Adaptive Median Filter:

The adaptive median filter (AMF) [9] has been applied widely as an advanced method compared with standard median filter for the spatial processing to determine which pixel in an image have been affected by impulse noise and classifies pixel as noise by comparing each pixel in the image to its surrounding neighborhood is adjustable as well as the threshold for the comparison. A pixel that is different from a majority of its neighbors, as well as being not structurally aligned with those pixels to which it is similar is labeled as impulse noise. These noise pixels are than replaced by the median pixel value of the pixels in the neighborhood that have passed the noise labeling test. The median filter performs well as long as the spatial density of the impulse noise is not large, however the adaptive median filter can handle impulse noise with probabilities even larger than median filter.

d. Adaptive Switching Median Filter:

The salt-and-pepper impulse noise removal using adaptive switching median filters [10]. This computationally efficient filtering technique is implemented by a two pass algorithm; the first pass is identification of corrupted pixels that are to be filtered is perfectly detected into a flag image using a variable sized detection window approach. In the second pass is detected flag image, the pixels to be modified are identified and corrected by a more suitable median.

e. Improved Progressive Switching Median Filter:

Improved progressive switching median filter [11] implements noise detection and filtering procedures are progressively repeated for a number of iterations. But improved progressive switching median filter proposed for salt and pepper noise removal from digital images. Results of comparative analysis of this algorithm with other filters for impulsive noise removal show a high efficiency of this approach reasonably to other ones. In this filter to restore images highly corrupted by salt- and –pepper impulsive noise. The algorithm is developed by switching scheme an impulsive detection algorithm is used prior to filtering, thus only a quantity of all the pixels will be filtered and progressive methods both the impulse detection and the noise filtering procedure are progressively applied through various iterations.

III.Performance Of Fuzzy Filters

This section of the paper discusses various fuzzy filter based noise removal techniques used to enhance the quality of images. Fuzzy logic represents a good mathematical frame work to deal with unchanging of information. Most of the enhancement techniques in the classical mean and median filters have been employed in various applications for impulse noise removal but cannot achieve the edge sharpness and contrast of the image [12].

The fuzzy filtering techniques provide very effective noise removal in digital images. Fuzzy filters are non-linear filters and perform to detect the impulse noise and replaced with a new pixel value depending upon the information from the neighboring pixels.

Recent fuzzy filters are used in various fields of image processing, interpolation, morphology and other functions also used in industrial and medical image processing [13].

A. Weighted Fuzzy Mean Filter:

The Weighted fuzzy mean filter [14] is proposed and analyzed for removing heavy additive impulse noises from digital images. By the filtering of each WMF filter, the filtered output signal is the mean value of the corrupted signals in a sample matrix and these signals are weighted respectively by a membership grade of an associated fuzzy member stored in a knowledge base. The high quality of global restoration of WFM filter can recover the noise and better contrast level.

B. Adaptive Fuzzy Median Filter:

Most of the noise removal method implemented in median filter because is an excellent noise removal power. The adaptive fuzzy median filter [15] to perform restoration of salt-and –pepper impulse noise corrupted image and certain efficient at highly corrupted impulse noise. In this filter estimate noise level based on fuzzy set theory and function the corrupted pixel or method of windowing technique is extended, then suitable median value to replace the noisy pixels. This filter has been used in many applications that it is simple and assumes no earlier knowledge of any explicit input image. Various enhancement problems of this filter exhibition and ability very well not only for low level impulsive noise in the image it response also a high level impulse noise.

C. Fuzzy Logic and Median Heuristic Filter:

The Fuzzy logic and median heuristic filter[16] is one of good methods it can implemented in real application with low time consuming and have better results in peak signal to noise ratio. We utilize a heuristic median filter for noisy pixels and its neighborhood, this heuristic filter is similar function to trim median filter but in this method use from average of neighbor pixels by this concept that good replace pixel is to neighbor pixel and remove all pixels that have 0 or 255 values. Then they can use other than noise value of pixel which is average value. Finally replace all noisy pixels. But this filter method used for certain applications only not suitable for all methods.

D. Fuzzy Control Based Filter:

The group of fuzzy filters is depends upon the iterative fuzzy functions [17]. In this type of fuzzy control based filter (FC) are constructed and used to remove the impulse noise and Gaussian noise and iterative fuzzy control filter (IFC) is implemented in iteratively and designed by seven separate categories of classes for gray value difference are considered from negative big to positive pig. Similarly used for another group of FC filter is modified iterative fuzzy control filter (MIFC) for the idea is to iteratively sharpen the shape of the fuzzy set and avoid getting blur images or videos in the restoration operation.

The other type of FC filter is extended iterative fuzzy control based filter (EIFC) is slight modification of IFC filter and constructed to respond to blurring of the image. In this filter the member functions are considered for after use of little iteration.

E. FIRE Filters:

The impulse noise removal function is done by another one better solution is fuzzy inference ruled by else-action filter (FIRE) [18]. In this filter to perform fuzzy rules to estimate the degree of pixel consider as noisy pixel or rounded an error value and determine a rectification of error based on this estimation. However the fire filter presently cannot properly remove impulse noise by estimating a correction term based on a set of fuzzy rule But the important concepts are implemented in the fire filter is to fire rules on different patterns of neighbor pixels, and the time concentration not applicable for surrounding area.

Similarly another noise removal FIRE filter [19] is constructed in the same way for this filter name is dual step FIRE filter and piecewise linear FIRE filter. There are three differences between FIRE filter and DS-FIRE filter, the first one is processed pixel (m, n) is neighborhood function, which the shape of a both sign (positive and negative value) and make 32 neighbor pixels, second one membership functions of fuzzy sets both sign value are consider as linear and instead the shape of triangular, third one is neutralization of little adjustment. In the real time application the DS-FIRE filter do better performance and consequently give more information, and therefore this filter much better compare than other fuzzy filters.

IV Analysis Of Classical And Fuzzy Filters:

The performance of the various types classical and fuzzy filters on a standard onion.png image are used for analysis. Objective comparisons of the performance of these filters on images corrupted by various levels of impulse noise ratios are made with the mean square error (MSE) values and the peak signal to noise ratio (PSNR) of the images restored by them.

The MSE and PSNR value are the two error matrices used to compare image compression quality. The MSE represents the cumulative squared error between the compressed and the original image, whereas PSNR represents a measure of the peak error. To compute the PSNR, we need to calculate the mean squared error using the following equation.

$$\text{MSE}= \frac{\sum_{M,N}[I_1(m,n)-I_2(m,n)]^2}{M \times N} \qquad (3)$$

Where M and N are the number of rows and columns in the input image respectively. Then the block computes the PSNR using the following equation.

$$\text{PSNR}= 10 \log_{10} \frac{[R^2]}{MSE} \qquad (4)$$

Where R is the maximum function in the input image data type.

For example, if the input image has a double-precision floating point date type, then R is 1 if it has an 8-bit unsigned integer data type, R is 255

V. Comparison of filter performance and visual results:

The various types of classical and fuzzy filters have been evaluated by different experiments with different noise level has been added. Evaluation of filter performance is carried out numerical and visual results. Different impulse noise level have been added to the original gray level image and performed by the both filters, the fuzzy filter are considered as best response than classical filters. Because fuzzy filters are perform very clear output image and considerable value of mean square error and peak signal to noise ratio

TABLE I Performance of Classical Filter

Filter Types	Noise density	MSE	PSNR
Mean and average filter	70%	169.52	25.12
Min-max filter	65%	157.72	26.86
Standard median filter	46%	186.57	25.38
Adaptive median filter	52%	30.51	36.71
Adaptive switching median filter	80%	217.57	28.47
Improved progressive switching median filter	78%	196.36	37.32

In table I the evaluated various types of classical filter results are obtained and compared the best performance based on the characterization of mean square error and peak signal to noise ratio. Here original onion image is taken for the reference and add some noise density level with different classical filters. Table I shows the filter method which work fine for the particular noise density level and PSNR rate is shown from 25-40 for minimum noise density level removed by the filters. So in the above compared the resultant value certain classical filters only remove around 68% impulse noise density level.

TABLE II Performance of fuzzy Filter

Filter Types	Noise density	MSE	PSNR
Weighted fuzzy mean filter	50%	176.46	21.30
Adaptive fuzzy	65%	157.72	26.86

median filter			
Fuzzy logic and median heuristic filter	46%	186.57	25.38
FIRE filter**:** (i)DS-fire filter (ii)PWL-fire filter	52% 58%	30.51 29.14	36.71 37.46
FC Filters (i)IFC Filter (ii)MIFC Filter (iii)EIFC Filter	67% 69% 71%	168.57 154.43 146.31	27.12 27.65 28.46

In table II the evaluated various types of fuzzy filter results are obtained and compared the best performance based on the characterization of mean square error and peak signal to noise ratio. The similar original onion image is taken for the reference and adds some noise density level with different fuzzy filters. Table II shows the filter method which work better performance for the particular noise density level and PSNR rate is shown from 20-40 for maximum noise density level removed by the filters. So in the above compared the resultant value certain fuzzy filters only remove around 70% impulse noise density level.

In the above mentioned numerical value of Table I and Table II is summarized to add in the salt and pepper noise for the original onion image, we compared the mean square error and peak signal to noise ratio of both general classical and fuzzy filters. The fuzzy filter (DS-FIRE, PLW-FIRE)is always best one compare than classical filter because it perform better response of low level to high level impulse noise.

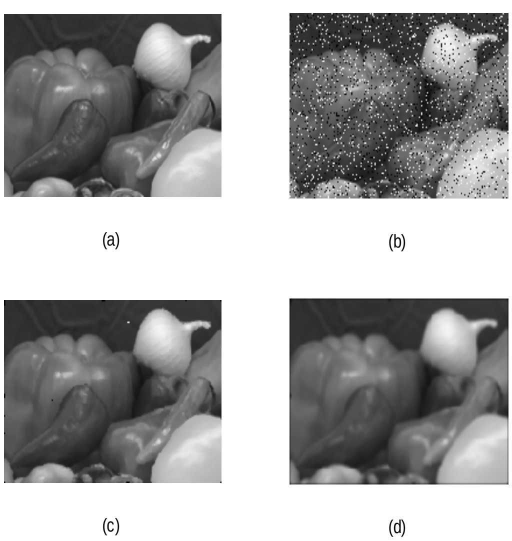

Figure.2. results of DS-FIRE and PWL-FIRE filters. (a) Original onion gray image (b) onion image with 20% impulse noise (c) results of DS-FIRE filter (d) results of PLW-FIRE filter

V. CONCLUSION

In this paper, we have compared different types of linear and non-linear, fuzzy filter techniques with various level of impulse noise removal are discussed. In analysis value of numerical and visual results, it originate the classical filter that median filtering is better than mean or average filter to remove impulse noise but it produce the result is blur image and affect the edge details. At the similar time other classical filters is also used to incorrectly destroys the edges and remove smaller percent of noise levels and find the difficulty with higher level noises. Fuzzy based filters perform better noise removal approach and great deal with low level noise to high level noise corrupted in the images. In survey of classical and fuzzy filter techniques the DS-FIRE and PWL-FIRE filters are better performance than other filters.

VI**. References**

[1] E.E.Kerre and M.Nachtegael, Fuzzy Techniques in Image Processing, 1st ed. Heidelberg, Germany: Physica Verlag, Vol.52, 2000.

[2] M.Nachtegael, D.Van der Weken, D. Van de Ville, and E.E.Kerre, Fuzzy Filter for Image Processing, 1st ed. Heidelberg, Germany: Physica Verlag.Vol.122. 2003.

[3] Stefan Schulte, Mike Nachtegael etal, De Witte,Dietrich Van der weken, and Etienne E. Kerre, A Fuzzy impulse noise detection reduction method. Image processing, IEEE Transactions on volume 15, issue 5, pp: 1153-1162. May 2006.

[4] Gonzalez, R.C, Woods. R.E, Digital Image Processing. Engle-Wood Cliffs, NJ: Prentice- Hall of India Pvt.Ltd.

[5] T.Chen, K.K.Ma, and L.H.Chen, Tri-State Median Filter for Image denoising, IEEE Trans, Image Process., Volume.8, no.12, pp. 1834-1838, December. 1999.

[6] Subg-Jea Ko and Yong Hoon, Center Weighted Median Filters and their Applications to Image Enhancement, IEEE Trans on Circuits and Systems., Volume.38, No.9, September 1991.

[7] M.Sreedevi, C.Vijay Kumar, N.V.S.Pavan Kumar, Removing Impulse Noise in Gray Scale Images Using Mi Max and Mid Point Filters. IJARCS, Volume.2, No.6, pp 377-379, Nov-Dec 2011.

[8] Sheng-Fu Liang, Shih-Mao Lu, Jyh-Yeong Chang, Chin-Teng Lin. A novel two-stage impulse noise removal technique based on neural networks and fuzzy decision. Fuzzy systems, IEEE Transactions on vol.16, issue 4, page(s): 863-873.2008, August 2008.

[9] H Hwang and R A Haddad. Adaptive median filter: new algorithms and results, IEEE Transactions on Image Processing Volume.4, No.4, April 1995.

[10] J.Alavandan, Dr. S.Santhosh Baboo. Enhanced Switching Median Filter for De-Noising Ultrasound, IJARCE. Volume.3, No.2, March-April 2012.

[11] Zhou Wang and David zhang. Progressive switching median filter for the removal of impulse noise from highly corrupted images. IEEE Transaction on circuits and system- II: Analog and Digital Signal Processing Vol.46, No. 1 January 1999.

[12] I. Pitas and A.N.Venetsanopoulos. Non-Linear Digital Filters: Principles and Applications. Kluwer Academic Publishers.

[13] B.Reusch, M.Fathi, L.Hildebrand, fuzzy color processing for quality improvement, in: international forum on multimedia and image processing, 1998, pp.841-848.

[14] C.S.Lee, Y.H.Kuo, P.T.Yu, Weighted Fuzzy Mean Filter for Image Processing. Fuzzy techniques in image processing, fuzzy sets and systems, volume. 89, pp. 157-180, 1997.

[15] H.Kong, L.Guan, A Noise Exclusive Adaptive Filtering Frame Work for removing impulse noise in Digital Image, IEEE Trans. Circuit System. 45(3), pp 422-428, 1998.

[16] M. Jampour, M.Ziari, Reza Ebrahim Zadeh, Maryam Ashourzadeh. Impulse Noise Detection and Reduction using Fuzzy Logic and Median Heuristic Filter, International Conference on Networking and Information Technology, 2010.

[17] F.Farbiz, M.B.Menhaj, A Fyzzy Logic Control Based Approach for Image Filtering, Fuzzy Techniques in Image Processing(E.E. Krerre and M.Nachtegael, Editors), Springer-Verlag, pp.194-221, 2000

[18] F.Russo,G.Ramponi, A Fuzzy Filter for Images Corrupted by Impulse Noise. IEEE Signal Proceedings Letters, Vol.3, No.6, pp.168-170, 1999.

[19] F.Russo, Fire Operator for Image Processing, Fuzzy Sets and Systems, 103, pp. 265-275. 1999.