A comparative study of Impulse Noise Reduction methods in Digital images

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Abstract— Noise hides the important details of images. An efficient noise removal method is an important issue in image processing. Several filters have already been developed in fact special filter is designed to remove only one particular type of noise like Traditional median filter successfully remove the low density impulse noise but fail to remove the high density impulse noise. This paper consists of detailed survey of various impulse noise reduction techniques. We first analyse and then compare the various filter performance such as MSE, PSNR and study its drawback and limitations.

***Keywords*—** Impulse noise, Classical filter, Fuzzy filter, Noise removal

I. INTRODUCTION

Noise is generally added during image transmission like impulse noise, additive random noise etc. For a meaningful and useful processing and to have very good visual display in applications like television, photo-phone, etc., the acquired image signal must be deblurred and made noise free. So, the great challenges of image de-noising techniques are better noise reduction as well as without any unchanged the image values. Digital images are often corrupted by impulse noise during image acquisition, image transmission or recoding in faulty hardware. The important characteristics of impulse of noise [1] are that only part of the pixels is corrupted and the rest are noise-free. . Impulse noise can be classified into two types: fixed-valued impulse noise and random-valued impulse noise. The fixed-valued impulse noise is also called salt-and-pepper noise where the gray-scale value of a noisy pixel is either minimum or maximum and the gray-scale values of noisy pixels corrupted by random-valued impulse noise are uniformly distributed in the range of [0, 255]. In most applications, denoising the image is first step before proceeding to subsequent image processing operations, such as edge detection, image segmentation, object recognition, etc. The goal of noise removal is to suppress the noise while preserving the image details. A greyscale digital image A is represented by a two dimensional array where an address (x,y) defines a position in A called a picture element or a pixel. The greyscale intensity is stored as an 8-bit integer giving 256 possible shades of grey going from black to white. It may be represented as [0, 255] integer interval. In this interval, we, consider several integer values p1, p2, p3… pn. If A(x, y) denotes the value of the image A at position (x, y), then the occurrence of impulse noise can be modelled as [3]:

= A(x, y) with probability 1-pr
= p1 with probability pr1
N(x, y) = p2 with probability pr2 (1)
= pn with probability prn
Where pr is the probability that a pixel is corrupted and N is the corrupted image.

2. LITERATURE SURVEY

Various algorithms have been proposed to filter the image from impulse noise. These techniques are classified in two broad categories i.e. Traditional filters and Fuzzy filters.

2.1 Performance of Traditional Filters

This category includes filters which are traditionally used to remove noise from images. These filters can have several pass band and stop band regions, arbitrary weights can be used and can fixed transmission and attenuation zeros. We further divide traditional filters into two classes: -
Spatial domain and transform domain.

2.1.1 Spatial Domain: These filters work directly on the pixel of the image. These are direct and high speed tools of processing. It is further divided into Linear and Non Linear filter.

A. Linear Filters

In Linear filters, noise reduction formula is applied for all the pixels in the image linearly. In the early development stage of digital image processing, linear filters were the most important tools, their numerical simplicity with suitable performance in various applications made them easy to use. For example

a) Mean filter: It is a simple sliding-window spatial filter that replaces the centre value in the window with the average of all the pixel values in the window [18]. But all the signal processing problems cannot be satisfactorily solved through the use of linear filters. It tends to blur sharp edges, fail to remove heavy tailed distribution noise effectively.
b) Wiener filter the wiener filtering [4] method requires the information about the spectra of the noise and the original signal and it works well only if the underlying signal is smooth. It is able to remove noise when the variance of noise is low but it cause blurring and smoothening of the sharp edges of the image.

B. Non Linear filters

a) Median filter

It is a smoothing technique which is effective in reducing noise in the smooth regions of an image. But this technique affects the sharpness in edges. It is used for reducing small and moderate level of noise.

The draw back and limitation of Median filter [5] is that it gives deteriorating performance at high level of noise and not able to preserve the image details like edges for further post processing.

b) Weighted Median Filter (WMF)

It has weight associated with each of its filter Element. These weights correspond to the number of sample duplications for the calculation of median value [6]. However the results of median filter are highly dependent on the weighting coefficients and the nature of the input image itself. The major drawback of WMF is that it is difficult to find the suitable weighting coefficients for each element and moreover it requires high computational time when the weights are large.

c**) ADAPTIVE MEDIAN FILTER**

It is a non linear conditional filter and uses varying window size for reducing noise. The size of window increases until correct value of median is calculated and noise pixel is replaced with its calculated median value. This filter reduces noise in two steps [7]. In first step, the corrupted pixel is detected and in second step median value of the pixel is calculated. 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 than replaced by the median pixel value of the pixels in the neighbourhood that have passed the noise labelling test.

d) Adaptive Switching Median Filter:

This filtering technique requires two steps i.e. detection of corrupted pixel and filtering [8, 10]. Corrupted pixel is detected into a flag image using a variable sized detection window approach. In the second step, the identified pixel is correct ted by a more suitable median.

e) Improved Progressive Switching Median Filter:

This filter implements noise detection and filtering procedures are progressively repeated for a number of iterations [9]. Firstly, check whether the pixel value is less than the minimum value or greater than the maximum value present in the window then it is a corrupted pixel. Corrupted pixel is replaced by median value. If the calculated median value no is again not fulfil the above condition then increase the window size and recalculate the median value until get correct median value. The limitations of above algorithms are that it damages the image details; retain numerous impulses in the filtered images at high noise ratios. To avoid the above problem, switching median filter with boundary discriminative noise detection (BDND) algorithm is proposed [10]. Advantages of BDND algorithms are that it works well with 90% of noise density and suitable for real time applications.

2.2.2Transform Domain filtering

This filtering is used where one has to analyze the signal. Here, the given signal is transform to another Domain [12] and performs the denoising procedure and afterwards inverse of transformation is done in order to get final output. There are several transforms available like the Fourier transform [12], Hilbert transform, wavelet transform, etc. The Fourier transform is probably the most popular transform. Among different Fourier transforms fast Fourier Transform (FFT) is considered the best. However the Fourier transform does not give high performance in case of image denoising. Wavelet transform [11] is better for this purpose because of the properties like sparsity, multiresolution and multiscale nature.

2.2.3Performance of Fuzzy Based Filters

Fuzzy based filters [13] include the concept of fuzzy logic in their filtering procedure. Fuzzy logic represents a good mathematical framework to deal with uncertainty of information. Traditional filter are unsuccessful in preserving the edge sharpness and could not achieve good contrast. Thus techniques of these filters mix with fuzzy techniques to get better results and effective in noise removal in image Processing. Fuzzy filters are non-linear filters and are usually two stage filters. The first stage is the noise detection step[15] in which the pixels are classified as noisy or non-free pixels. In the next step the detected noisy pixels are filtered and replaced with a new pixel value depending upon the information from the neighbouring pixels. In the following sections, some of the recent fuzzy filters are discussed and analyzed. We here mention only some of them. Popular fuzzy classical filters are: Fuzzy Median Filter (FMF), Fuzzy Random Impulse Noise Reduction method (FRINR)[13], Fuzzy Weighted Mean (FWM)[14], Adaptive Weighted Fuzzy Mean

(AWFM)[15], In fuzzy median filter, and fuzzy weighted mean filter, fuzzy logic is used with traditional median and mean filters. Fuzzy random impulse noise reduction [13] method is two step methods. In first step,noisy pixels are detected from the input image. The fuzzy logic is used in detection step by forming the fuzzy rules to decide whether the pixel is corrupted with noise or not. In filtering procedure, traditional filters like mean filter, median filter, weighted mean filter etc. are extended using fuzzy logic.

3. Comparison of filter performance

The various types of classical [16, 17] and fuzzy filters have been evaluated in this paper. The evaluation of filter performance is carried out by visual results and by computing their performance metrics. Different impulse noise level have been added to the original gray level image and performed by the both filters, the fuzzy filter have best response than classical filters.

3.1 Performance metrics:

a) Peak Signal to Noise Ratio (PSNR):

PSNR simply calculates the peak signal to- noise ratio, in decibels, between two images. This ratio is often used as a quality measurement between the original and a reconstructed image. The higher the PSNR, the better the quality of the reconstructed image. The bigger PSNR means the less distortion.

b) The Mean Square Error (MSE):

The MSE represents the cumulative squared error between the reconstructed and the original image. If MSE is smaller, the performance is better. It the filtered image is close to the original.

TABLE I Performance of Classical Filter

Filter Types	Noise density	MSE	PSNR
Mean filter	70%	169.52	25.12
Average filter	70%	169.52	25.12
Adaptive median filter	52%	30.51	36.71
Improved progressive switching median filter	78%	196.36	37.32

TABLE II Performance of fuzzy Filter

Filter Types	Noise density	MSE	PSNR
Weighted fuzzy mean Filter	50%	176.46	21.30
Adaptive fuzzy median filter	65%	157.72	26.86
FIRE filter**:** (i)DS-fire filter (ii)PWL-fire filter	52% 58%	30.51 29.14	36.71 37.46
Fuzzy logic and median heuristic	46%	186.57	25.38

Table 1 and Table 2 shows the result of various traditional and fuzzy filters with their MSE and PSNR value.

4. Conclusion

The purpose of this paper is to present a survey of digital image deniosing approaches. We have compared different types of linear and non-linear, fuzzy filter techniques with various level of impulse noise removal are discussed.By analyzing the value of the results, the median filtering is better than mean or average filter to remove impulse noise but it affect the edge details. Other classical filters is also used to remove the noise from the image but they destroy the edges and remove smaller percent of noise levels. Fuzzy based filters gives better results both at low level noise and high level noises. In survey of classical and fuzzy filter techniques the DS-FIRE and PWL-FIRE filters are better performance than other filters.

References:

1. K.Manivel1, Dr. R.Samson Ravindran2, A Comparative Study Of Impulse Noise Reduction In Digital Images For Classical And Fuzzy Filters, International Journal of Engineering Trends and Technology (IJETT) – Volume 4 Issue 10 - Oct 2013
2. 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.
3. 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
4. Astola and P. Kuosmanen, Fundamentals of linear and Nonlinear Digital Filtering, Boca Raton, Florida: CRC Press, 1997..
5. T. Nodes and N. Gallagher, "Median Filters: Some modifications and Their Properties," IEEE Trans. Acoustics, Speech, Signal Processing, vol. ASSP-30, no. 5, pp. 739-746, Oct. 1982.
6. R.K. Brownrigg, "The weighted median filter," Commun Assoc. Comput., pp. 807–818, Mar. 1984.
7. H. Hwang and R.A. Haddad, "Adaptive Median Filters: New Algorithms and Results,"IEEE Trans. Image processing, vol. 4,no. 4, pp. 499-502, Apri1995
8. J.Alavandan, Dr. S.Santhosh Baboo. Enhanced Switching Median Filter for De-Noising Ultrasound, IJARCE. Volume.3, No.2, March-April 2012.
9. R.H. Chan, C.W. Ho, and M. Nikolova, "Salt-and- Pepper Noise Removal by Median-Type Noise Detectors and Detail-Preserving Regularization," IEEE Trans. Image Processing, vol. 14, no. 10, pp. 1479- 1485, Oct. 2005.
10. P.E. Ng and K.K. Ma, "A Switching Median Filter with Boundary Discriminative Noise Detection for Extremely Corrupted Images, "IEEE trans.ImageProcessing, vol. 15, no. 6, pp. 1506-1516, June 2006.
11. S. G. Chang, B. Yu, and M. Vetterli, "Spatially adaptive wavelet thresholding with context modeling for image denoising," IEEE Trans. Image Processing ,vol. 9, pp. 1522– 1531, Sept. 2000
12. Rafael Gonzalez, Richard Woods,"Digital Image Processing". Pearson Publications, 2002
13. Stefan Schulte, Valerie DeWitte, Mike Nachtegael, Dietrich Van derWeken, Etienne E. Kerre,"Fuzzy random impulse noise reduction method", Fuzzy Sets and Systems, ESLEVIER ,2006, pp. 270-283.
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. 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.
16. Anjali Ojha1, Nirupama Tiwari2, A Study on Image Denoising with its Techniques and Types of Noise, International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 3 Issue VIII, August 2015
17. C. Anjanappa1*, Dr. H. S. Sheshadri2, Survey On Impulse Noise Removal Techniques In Digital Images, International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 7, July – 2013
18. E. Abreu and S. K. Mitra. "A Signal-Dependent Rank Ordered Mean SDROM filter-A new approach for removal of impulses from highly corrupted images". In Proceedings of International Conference on Acoustics, Speech, andSignal processing, volume 4 of ICASSP-95, pages 2371 – 2374, May 1995.