High density impulse denoising by a fuzzy filter Techniques:Survey

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ABSTRACT

Noise reduction is a well known problem in image processing several filters have already been developed for reducing noise from colour images. Since each filters is design for a particular noise type these filters reduce only single noise .traditional median filters perform well in restoring the images corrupted by low density impulse noise ,but fail to restore highly corrupted images.This paper presents a detailed survey of various impulse noise reduction techniques. The techniques are all based classical filters and on Fuzzy logic. Different types of noises and their causes are discussed first and then various fuzzy filters are discussed about. The Fuzzy techniques are studied and their performance is analyzed based on various image quality assessment parameters.

Keywords- Fuzzy logic, fuzzy switching median, gradient estimation, salt & pepper noise

1 INTRODUCTION

The most frequently occurred types of noise are i) additive noise (e.g. Gaussian noise, ii) impulse The fundamental task of image processing is to remove noise from the digital images. noise, iii) multiplicative noise (e.g. speckle noise) [1]. Addition of noise in an image depends on how the image is created. If the image acquisition is direct in digital format, the mechanism i.e. CCD detector can introduce noise. Other reasons may be electronic transmission of image data or if the image is scanned the film grain is a source of noise. In Gaussian noise, the value of each pixel in the image is changed from its original value with a small amount. Salt-and-pepper noise is a form of impulse noise also known as Figure 1 shows the original flower image and the images corrupted with varying proportions of impulse noise. It can be analyzed from the images that the impulse noise gets distributed

spike noise. In this case, noisy pixels are very different from their surroundings. Salt-and-pepper noise is caused by sharp & sudden disturbance in the signal. The image contains dark and white dots and hence the name salted-pepper [2]. Typical sources include faulty or overheated CCD elements and flecks of dust inside the camera. A grayscale 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 grayscale 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 modeled 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.
A variety of techniques have been proposed in the literature to remove the impulse noise from images. Noise reduction techniques can be classified into linear techniques and non-linear techniques. In linear techniques, noise reduction formula is applied for all the pixels in the image linearly. For e.g. average and mean filters. On the other hand, non-linear noise reduction is a two-step process i.e. noise detection stage and noise filtering stage. For e.g. Min-Max median filter, Center-weighted median filter, adaptive median filter, progressive switching median filter, tri-state median filter, decision based algorithm and

uniformly over the whole image in the form of dark and white spots.

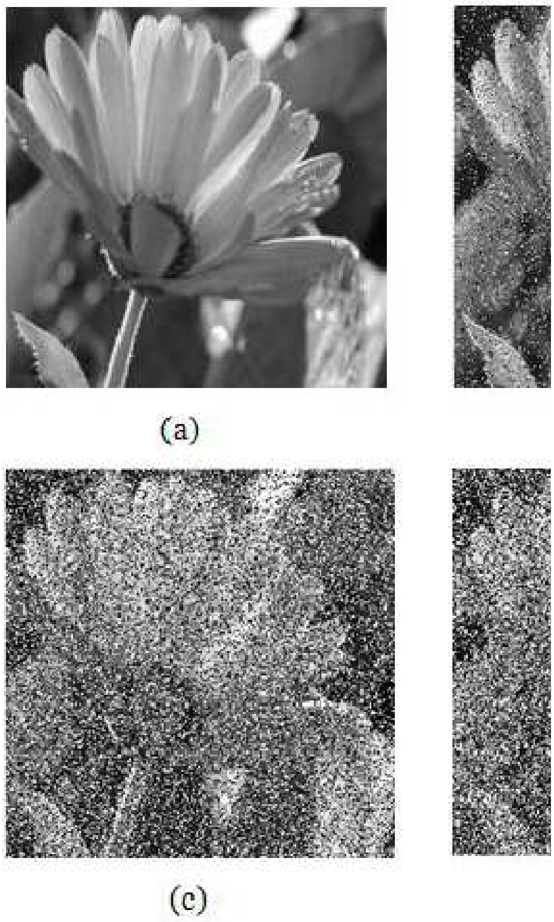

Fig 1. (a) Original Flower Image (b) Flower image with 10%
Impulse Noise (c) Flower image with 40% Impulse Noise (d)
Flower image with 50% Impulse Noise

LINEAR FILTERS

AVERAGE FILTER

A square window of size 2s+1 is used in an average filter. The value of s changes from 1 to n. Window size (2s+1) is taken only because window width and height must be odd so that we get exactly central pixel (s+1, s+1). The original image is scanned row wise and column wise. Each time the value of
Central pixel is replaced by the average value of its neighboring pixels that constitute the window.

MEAN FILTER

In case of mean filter, the value of the central pixel is replaced by the mean value of the pixels that constitute the window. Mean filters are unable to remove impulse noise but reduces Gaussian noise up to certain levels of noise.

MEDIAN FILTER

Working of Median Filter is same as Average filter but here central pixel value is replace by the median value of its neighboring pixels that comes within the window. Median filtering is very effective in reducing the low levels of impulse noise. However with increasing levels of noise, the image gets blur and also edge details are lost at high noise.

NON-LINEAR FILTERS

MIN MAX MEDIAN FILTER

Min-Max filter (MMF) [4] is conditional non-linear filter. In this filter (3x3) window is used for scanning the image left to right and top to bottom. The center pixel of window (2, 2) is considered as a test pixel. If the test pixel is less than minimum value present in rest of pixel in window and greater Than maximum value present in rest of pixel in window. Then center pixel is treated as corrupted pixel and its value is replaced by median value of pixels present in window otherwise pixel is non corrupted pixel and kept unchanged.

ADAPTIVE MEDIAN FILTER

The adaptive median filter (AMF) [6] is non linear conditional filter. It uses varying window size to noise reduction. Size of window increases until correct value of median is calculated and noise pixel is replaced with its calculated median value. In this filter two conditions are used one to detect corrupted
Pixels and second one is to check correctness of median value. If test pixel is less than minimum value present in rest of pixels in window and greater than maximum value present in rest of pixels in window then center pixel is treated as corrupted pixel. If calculated median value is less than minimum value present in window and greater than maximum value present in window then median value is treated as
Corrupted value. If calculated median is corrupted then increase the window size and recalculate the median value until we get correct median value or else window size reach maximum limit.

FUZZY FILTERS

Fuzzy logic represents a good mathematical framework to deal with uncertainty of information. Although image enhancement techniques such as mean and median filters have been
Employed in various applications for impulse noise removal but they were unable to preserve the edge sharpness and could not achieve good contrast. Thus employing fuzzy techniques to the existing classical filters proved useful and effective in noise removal domain in image

processing. Fuzzy techniques have already been applied in various fields of image processing, e.g. interpolation, filtering, and morphology etc. and have numerous applications in industrial and medical image processing. Fuzzy filters such as FIRE filter, weighted fuzzy mean filter, FIDRM, fuzzy switching median filter etc. are able to outperform rank-order filter schemes such as the standard median filter. Fuzzy filters are non-linear filters and are usually two stage filters. The first stage is the noise detection step 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 neighboring pixels. In the following sections, some of the recent fuzzy filters are discussed and analyzed.

DS-FIRE FILTER

Fabrizio Russo and Giovanni Ramponi proposed an enhanced version of FIRE filter known as DS-FIRE filter [10]. The dual step FIRE filter was able to outperform many standard filters in literature. The filter operates in 7 x 7 window. The operator adopted three triangular fuzzy sets namely negative (NE), zero (ZO) and positive (PO) to distinguish between the noisy pixels

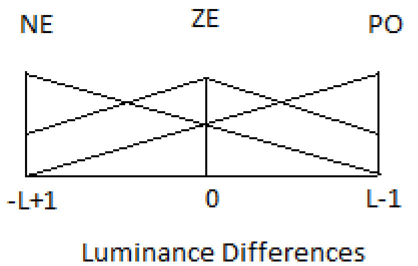

Fig.2 – Triangular-shaped fuzzy sets PO, ZE and NE,
represented in the interval [-L+l, L-1]. [10]

FUZZY IMPULSE NOISE DETECTION & REDUCTION METHOD

Another method presented by Stefan Schulte et al was FIDRM (Fuzzy impulse noise detection & reduction method) [3]. In this method fuzzy gradient values were calculated for all the eight directions relative to the central pixel. The gradient values calculated were basic & two related gradient values as shown in Fig. 3.The filter operates in two stages i.e. noise detection and noise removal. One basic & two related gradients are calculated for each of the eight directions as shown in Fig 3.

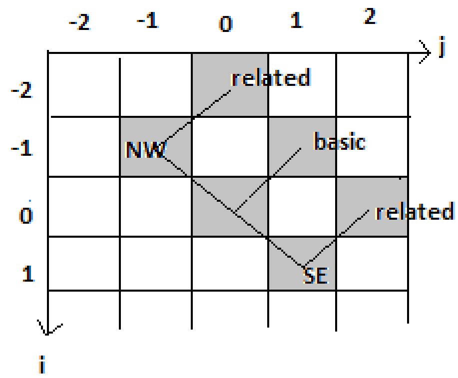

Fig 3. Involved centers for the calculation of related gradient
values in the NE direction.[3]

The decision rule is simple & decides that the pixel is noisy if more than half of the fuzzy derivative values are large.

INTEGRATED FUZZY FILTER

Integrated fuzzy filter [11] was presented for the reduction of two types of noise i.e. additive noise and impulse noise from digital color images. In the proposed filter an impulse noise detector was used initially to detect the impulse noise present in the filter. Impulse noise detector divides the set of pixels into two point sub-sets: impulse noise contaminated points and clean points without impulse noise. To select the corresponding filters with respect to the noise types, a filter selection module is designed.The filters reduce the noise and the enhanced image is obtained as the output of integrated filter after reducing both the type of noise. The proposed approach combined the advantages of both the additive and impulse noise filter.

IMPULSE DETECTION ADAPTIVE FUZZY FILTER

An Impulse Detection Adaptive Fuzzy (IDAF) [14] filter was proposed to achieve improved filtering of impulsive noise while preserving image details. It is a spatial filter which operates in 2-stage 3x3 windows where the update value of the central pixel is a function of the median value of the pixels in the window. The proposed IDAF filter operates as follows. First, an impulse detection method classifies each pixel to be noisy pixel or image pixel. Then, if a pixel is assumed to be noisy, it is not used for deciding the new value of other pixels.A scheme is introduced to obtain a good replacement pixel value, which is then stored. The median of the stored values is a considered a good estimate of the image pixel. Finally, the adaptive fuzzy filter will then assign weights to the stored pixel values to produce the central pixel's new value. Weights are assigned to remove impulse noise or preserve the image details, depending on the pixel's characteristics.

NOISE ADAPTIVE FUZZY SWITCHING MEDIAN FILTER

Modifications to Fuzzy switching median filter were made by Kenny Kal VIN To teal in a new filter named Noise-adaptive fuzzy switching median filter. The NAFSM filter [15] works on the same principle of Fuzzy switching median filter in the fact that both use the noise histogram to detect the noisy pixels from the original image. The basic and more advanced feature of NAFSM is that it adapts itself according the amount of noise present in the image. In filtering step, the filter works by initializing the window size to 3 x 3 as:

$W_{2s+1}(i, j) = \{X (i + m, j + n)\}$

where m, n € (-s,…0……,s)

(6) And the value of s varies from 1 to 3. Then, the number of "noise-free pixels" $G_{2s+1}(i, j)$ in the filtering window $W_{2s+1}(i, j)$ is counted using

$$g2s + 1(i,j) = \sum N(i + m, j + n)..$$

M,nŰŰ€(-s,,,,0,….s)

If the current filtering window $W_{2s+1}(i, j)$ does not have a minimum number of one "noise-free pixel" (i.e.$G_{2s+1}(i, j) < 1$), then the filtering window will be expanded by one pixel at each of its four sides (i.e. $s \leftarrow s + 1$). This procedure is repeated until the criterion of $G_{2s+1}(i, j) \geq 1$ is met. For each detected "noise pixel", the size of the filtering window is initialized to 3 x 3 i.e.= 1. These "noise-free pixels" will all be used as candidates for selecting the median pixel, M(i,j) given by: M (i, j) = median{X(i + m, j + n)} with N(i + m, j + n) =1

This criterion of choosing only "noise-free pixels" is imposed to avoid selecting a "noise pixel" as the median pixel.

PERFORMANCE ANALYSIS

The performance of various algorithms can be analyzed using various parameters such as mean square error (MSE), peak signal- to-noise ratio (PSNR), signal-to-noise ratio improvement (SNRI), mean absolute error (MAE) etc.

CONCLUSION

Various linear, non-linear and fuzzy techniques for impulse noise detection and reduction are discussed and compared in this paper. In analysis, it found that median filtering is able to outperform the mean and average filters to reduce impulse noise but almost blur the image and affect the edge details. Mean and average filters are unable to cope up with impulse noise. Fuzzy techniques present an efficient approach to deal with uncertain data in order to remove the impulse noise to a great extent. NAFSM filter is able to outperform other fuzzy techniques and works efficiently up to the noise levels of

About 50-60%. The processing time taken by NAFSM algorithm is also less compared to other techniques in literature.

REFERENCES

[1] C. Mythili, "Efficent technique for color image noise reduction", The research bulletin of Jordan ACM, Vol. II(III), 2078-7960.

[2] Rafael.C.Gonzalez, Richard E. Woods 2008. Digital Image processing, 3rd edition, Pearson education.

[3] Subg-Jea KO and Yong Hoon, "Center Weighted Median Filters and Their applications to image enhancement", IEEE Transactions on circuits and Systems vol 38, no 9, September 1991.

[4] H Hwang and R A Haddad,"Adaptive Median Filter: New Algorithms and Results", IEEE Transactions on Image processing Vol 4 No 4 April 1995.

[5] Zhou Wang and David Zhang, "Progressive Switching Median Filter for the Removal of Impulse noise from Highly Corrupted Images", IEEE Transaction on Circuits and systems-II : analog and digital signal processing Vol 46 No 1 January 1999.

[13] Mahdi Jampour, Mehdi Ziari, Reza Ebrahim Zadeh, Maryam Ashourzadeh, "Impulse noise Detection and Reduction using Fuzzy logic and Median Heuristic Filter", 201O International Conference on Networking And Information Technology Impulse.

[14] H. S. Kam and W. H. Tan, "Impulse Detection

Adaptive Fuzzy (IDAF) Filter", 2009 International Conference on Computer Technology and Development.

[15] Kenny Kal VIN To and nor Ashidi Mat Isa, "Noise Adaptive Fuzzy Switching Median Filter for Salt-and-Pepper Noise Reduction", IEEE Signal Processing Letters, Vol. 17, No. 3, March 2010.

[16] Alan C. Brooks, Xiaonan Zhao, and Thrasyvoulos N. Pappas, "Structural Similarity Quality Metrics in a Coding Context: Exploring the Space of Realistic Distortions", IEEE Transactions on image processing, Vol. 17, No. 8, pp.1261-1263, August 2008