# Optimal Fuzzy Based Noise Removal from Colored Images

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***Abstract-*** In various fields and application use of images becoming increasingly popular but the problem is that noise will be inevitably introduced in the image during image acquisition process. In this paper we introduced a proposed filter for impulse noise reduction i.e. salt-and-pepper noise in binary as well as colored images that is based on decision based algorithm. We implemented an cluster-based advanced fuzzy switching median filter(CAFSM) by DBA. By applying DBA we enhanced the image quality with respect to its Peak Signal to Noise Ratio (PSNR value). In this a comparison is shown between the result of CAFSM and our proposed filter, called the Advanced fuzzy Switching Decision Based (AFSDB) filter with respect to its PSNR and MSE values. Initially the impulse detector detects the impulsive noise. Subsequently, they are removed in filtering phase. In addition, the filtering phase employs fuzzy reasoning to deal with the present uncertainties i.e. border correction is applied. We are implementing this on MATLAB.

***Keywords—****Impulse noise; Salt-and-pepper noise; Decision based Algorithm; AFSDB; MSE; PSNR; Border Correction.*

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## I. INTRODUCTION

An image may be defined as a two dimensional function, f(x, y), where x and y are spatial coordinates, and the amplitude of f at any pair of coordinates (x, y) is called intensity or gray level of the image at that point. When x, y and the amplitude values of f are all finite, discrete quantities, we call the image a digital image which is processed by means of a digital computer in digital image processing.

Any form of signal processing having image as an input and output (or a set of characteristics or parameters of image) is called image processing. In image processing we work in two domains i.e., spatial domain and frequency domain. We are working on spatial domain which refers to the image plane itself, and image processing method in this category are based on direct manipulation of pixels in an image [2].

The principal sources of noise in digital images arise during image acquisition and/or transmission [2]. It can be produced by the sensor and circuitry of a digitalcamera or scanner. Noise degrades the image quality for which there is a need to denoise the image to restore the quality of image.

Traditionally, median filter which is the most popular non-linear filter is used to remove the impulse noise. However, the performance of standard median filter [3] is poor for the images which are corrupted by higher density impulse noise. A simple median filter utilizing a window of 3×3 or 5×5 pixel is only sufficient in case when the noise intensity is less than approx. 10-20%. Whenever the intensity of noise increased, a simple median filter left many unfiltered shots. Adaptive Median Filter (AMF) [4] also performs well in case of low noise densities only. At high noise densities there is a need to increase window size which may lead to blurring of image. In case of switching median filter [6], [7] the filtering decision is based on a pre-defined threshold value. The major drawback of this method is that defining a robust decision is difficult. Also these all filters will not bother about the local features due to which it results in unsatisfactory details and edges recovery, especially when the noise level is high. To overcome this drawback, a decision based algorithm is proposed. In this algorithm, image is denoised by using a 3×3 window. If the value of processing pixel is either 0 or 255 it is processed or else it is left unchanged. The selected 3×3 window elements are arranged in either increasing or decreasing order. This whole processing is done in two different cases that is described in next section of DBA description.

In this paper we focus on developing a robust filter that caters for impulse noise i.e., salt and pepper noise. We propose a new recursive filter, called the Advanced Fuzzy Switching Decision Based (AFSDB), for detail preserving restoration. This filters works for wide range of impulse noise. Its simulation results show that the performance of AFSDB is much better than the CAFSM[5] filter. In addition, the proposed filter is showing excellent results in denoising color images.

The rest of this paper is organized as follows. Section 2 outlines theimpulse noise introduction. Then, Sections 3$^{rd}$ and 4$^{th}$ discuss, in brief the technique of Decision Based Algorithm for noise removal and our proposed approach for filtering with result analysis showing the comparison between CAFSM and proposed AFSDB filter. The last section consists of the conclusion.

## II. IMPULSE NOISE DESCRIPTION

*A. Impulse Noise*

- *Fixed-Valued ImpulseNoise (Salt-and-Pepper noise)*– Fat-tail distributed or "impulsive" noise is sometimes called salt-and-pepper noise [1].Any image having salt-and-pepper noise will have dark pixels in bright regions and bright pixels in dark regions. In salt-and-pepper noise corresponding value for black pixels is 0 and for white pixels the corresponding value is 1. Hence the image affected by this noise either have extreme low value or have extreme high value for pixels i.e., 0 or

1.Given the probability r (with 0<= r<=1) that a pixel is corrupted, we can introduce salt-and-pepper noise in an image by setting a fraction of r/2 randomly selected .pixels to black, and another fraction of r/2 randomly selected pixels to white. This type of noise can be caused by analog-to-digital converter errors, bit errors in transmission, etc. Elimination of salt-and-pepper noise can be done by using dark frame subtraction and interpolating around dark/bright pixels. The effect of salt-and-pepper noise is shown in fig 1. below:

Fig. 1. Comparison of 'Lena' test image with another image corrupted with Salt-and-Pepper noise.

*B. Impulse Noise Model*

In impulse models for images, all corrupted pixels are often replaced with values equal to or near the maximum or minimum of the allowable dynamic range. For 8-bit images, pixel intensities lie in the dynamic range near 0 or 255 i.e., minimum and maximum intensities. Regardless of its origin, impulse noise exhibits non stationary statistical characteristics [8], [9] and only a certain percentage of pixels in the image are contaminated by impulse noise [10].We consider a general noise model inwhich noisy pixels can take on arbitrary values in the dynamic range according to some underlying probability distribution.

Based on this fact the model for impulse noise with probability[2] ρ is defined as:

$$x(i,j) = \begin{cases} o(i,j) : with\ probability\ 1-\rho \\ f(i,j) : with\ probability\ \rho \end{cases} \quad (1)$$

where*x(i, j)* represents the pixel at location *(i, j)* with x intensity, *o(i, j)* and *f(i, j)* denote the original and noisy image, respectively.

## III. DECISION BASED ALGORITHM DESCRIPTION (DBA)

The algorithm used in CAFSM is based on detection of impulsive noise pixels followed by the filtration process using median filtering and then in addition, the filtering phase employs fuzzy reasoning to deal with uncertainties. In our method we used DBA for removal of noisy pixel instead of median filter followed by the same fuzzy reasoning which improves the performance compared to CAFSM.

Here is the description of Decision Based Algorithm and its working also shown in fig 2. below:

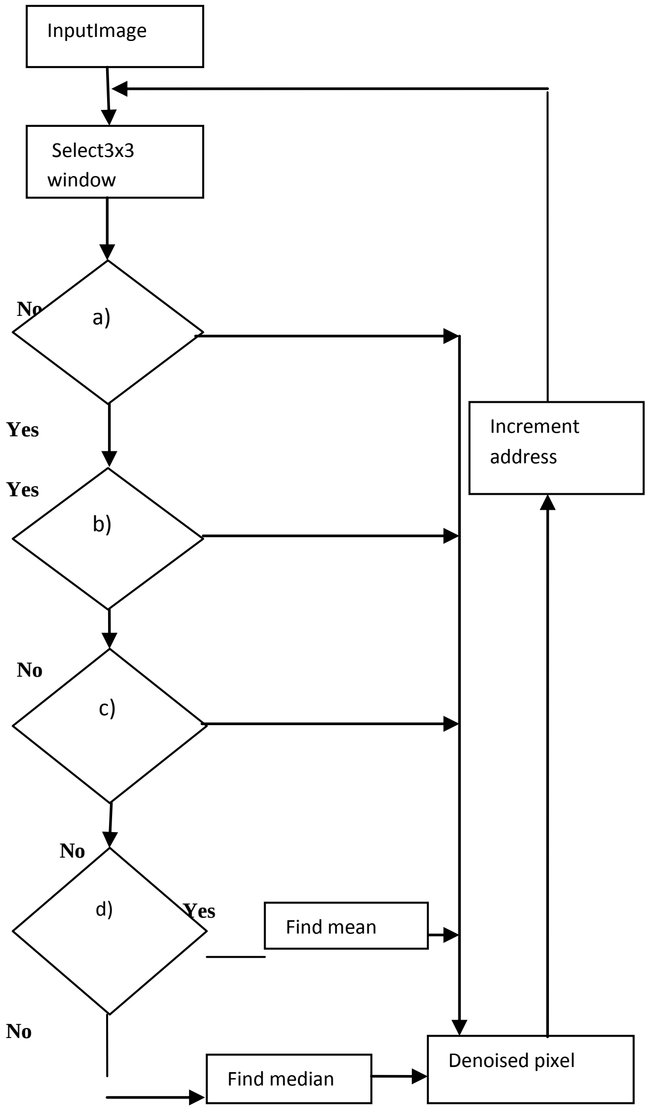
**Step 1**:
Select 2-D window of size 3× 3. Assume that the pixel being processed is Pij

**Step 2**:
If centre pixel 0<Pij<255 then Pij value is left unchanged.

**Step 3**: If Pij =0 or Pij =255then check for next condition

**Step 4**:
If processing pixel is 0 or 255 & also surrounding all elements has same value then processing element is an information instead of noise as there is high co-relation between neighboring pixels so pixel value should keep as it was. Otherwise check for next condition.

**Step 5**: Pij is a corrupted pixel then two cases are possible as given in Case i) and ii).




a) Check whether processing pixel is faulty, b) if all window elements are zero, c) if all window elements are 255, d) if window elements are combination of 0 & 255.

Fig.2. Flowchart of DBA process

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Case i): If the selected window contains all the elements as 0's and 255's. Then replace Pij with the mean of the element of window.
Case ii): If the selected window contains not all elements as 0's and 255's. Then eliminate 255's and 0's and find the median value of the remaining elements. Replace Pij with the median value.

**Step 6**: Repeat steps 1 to 5 until all the pixels in the entire image are processed.

## IV. PROPOSED APPROACH AND SIMULATION

### *A. Fuzzy Switching Decision Based*

The algorithm runs in separate steps:

1. First basic step of this algorithm is the conversion of image from RGB to grayscale.
2. Implementation of DBA. It runs in 6 separate steps discussed above in 3rd section.
3. Border Correction

It comes in fuzzy reasoning which used to deal with uncertainties present in the local information. These uncertainties, e.g. thin lines or pixels at edges being mistaken as noise-pixels, are caused by the nonlinear nature of impulse noise. In this step window size is expanded from each side but when filtering is applied, only that pixels which comes under the image are being processed. These are the steps for border correction.

Y(1,:) = Y (2, :) (2)
Y(R,:) = Y(R-1, :) (3)
Y (:,1) = Y(:, 2) (4)
Y(:,C) = Y(:, C-1) (5)

where Y is the restored image variable, R×C is window size.
4. Calculation of MSE and PSNR value. Higher PSNR value indicates better image restoration.

$$\text{PSNR(dB)} = 10\log_{10}\left(\frac{255^2}{\frac{1}{M\times N}\sum_{i=1}^{M}\sum_{j=1}^{N}(Y_{ij}-\hat{Y}_{ij})^2}\right) \quad (6)$$

$$\text{MSE} = \frac{\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}|y(i,j)-o(i,j)|^2}{M.N} \quad (7)$$

5. MAE is calculated to focus on the detail preserving characteristic of the filter.

$$\text{MAE} = \frac{\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}|y(i,j)-o(i,j)|}{M.N} \quad (8)$$

### *B. Result Analysis*

In this section, we assess the performance of our proposed AFSDB filter using colored images of lena, peppers and pentagon of size 512x512 and 24 bit resolution. Each of the test images is corrupted with impulse noise model described above, i.e., salt and pepper noise and its density ranges from 10% to 50% noise. For comparison, we took the result of CAFSM filter for lena and peppers image in grayscale and compare them with the result of our proposed AFSDB filter which is implemented on colored image of lena and peppers and after they are converted into grayscale image. All result values are shown in the Table 1., and Table 2. After that comparison through images are also shown. In fig.3. and fig.4. Restoration results of 'Lena' image corrupted with 10% and 30% of impulse noise are shown using CAFSM and Proposed filter. After that restoration results for 'Pepper' is shown in fig.5. for 30% of impulse noise. And at last the result of AFSDB is shown on test image 'Lena' in fig.6.

Table 1. a) Comparison Result for 'Lena' Test Image in PSNR(dB)

| **PSNR (dB)** | | | | | |
|---|---|---|---|---|---|
| Methods | **10%** | **20%** | **30%** | **40%** | **50%** |
| Corrupted | 16.93 | 13.91 | 12.15 | 10.92 | 9.96 |
| CAFSM[5] | 38.64 | 36.40 | 34.50 | 32.52 | 29.32 |
| **Proposed** | **65.30** | **64.2** | **63.56** | **62.11** | **59.31** |

Table 1. b) Comparison Result for 'Lena' Test image in MAE

| **MAE** | | | | | |
|---|---|---|---|---|---|
| **Methods** | **10%** | **20%** | **30%** | **40%** | **50%** |
| Corrupted | 10.04 | 20.10 | 30.14 | 40.08 | 50.04 |
| CAFSM[5] | 0.74 | 1.31 | 2.00 | 2.50 | 3.14 |
| **Proposed** | **0.032** | **0.07** | **0.12** | **0.292** | **0.38** |

Table 2. a) Comparison Result for 'Peppers' Test image in PSNR (dB)

| **PSNR (dB)** | | | | | |
|---|---|---|---|---|---|
| **Methods** | **10%** | **20%** | **30%** | **40%** | **50%** |
| Corrupted | 16.51 | 13.44 | 11.70 | 10.46 | 9.47 |
| CAFSM[5] | 37.33 | 35.93 | 33.97 | 31.13 | 28.74 |
| **Proposed** | **54.12** | **53.19** | **53.51** | **53.67** | **52.96** |

Table 2. b) Comparison Result for 'Peppers' Test Image in MAE

| **MAE** |
|---|

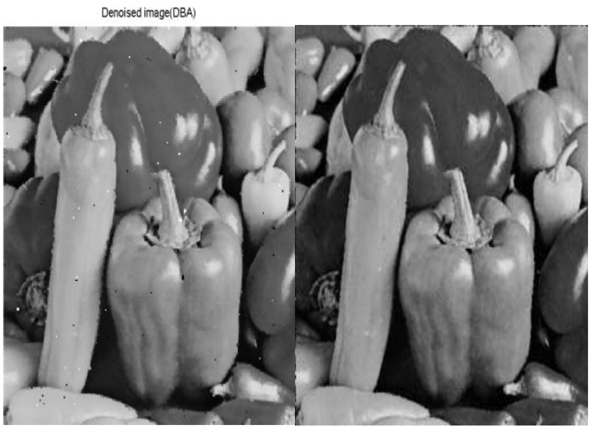
| **Methods** | **10%** | **20%** | **30%** | **40%** | **50%** |
|---|---|---|---|---|---|
| Corrupted | 10.24 | 20.66 | 30.96 | 47.18 | 51.63 |
| CAFSM[5] | 0.85 | 1.49 | 2.23 | 3.09 | 4.74 |
| **Proposed** | **0.123** | **0.201** | **0.22** | **0.29** | **0.32** |


**a)** **b)**

Fig.3. Restoration results of 'Lena' image corrupted with 10% salt and pepper noise by the: a) CAFSM filter, b) proposed AFSDB filter


**a)** **b)**

Fig.4. Restoration results of 'Lena' image corrupted with 30% salt and pepper noise by the: a) CAFSM filter, b) proposed AFSDB filter




**a)** **b)**

Fig.5. Restoration results of 'Peppers' image corrupted with 30% salt-and-pepper noise by the: a) proposed AFSDB filter, b) CAFSM filter

Result of AFSDB on Lena

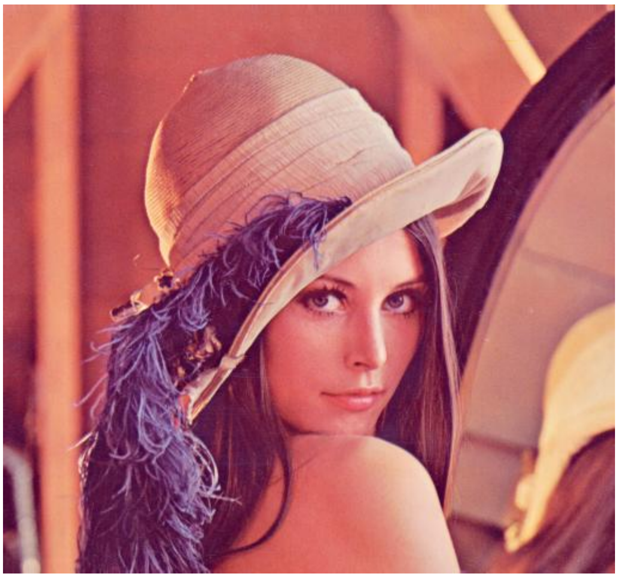


Fig.6. a) Input colored image of 'Lena',


b) Image corrupted with 20% noise, c) Restored image after applying DBA

## V. CONCLUSION

Digital images are often corrupted by Salt and Pepper noise due to errors generated in noisy sensor, errors that occur in the process of converting signals from analog-to-digital and also errors that are generated in the communication channels. In order to remove salt and pepper noise and enhance the affected image quality, Advanced Fuzzy Switching Decision Based (AFSDB) filter is applied.

Several filtering algorithms and filters are applied on the standard impulse noise images, and one of them is CAFSM which was also one of the good filter in comparison to number of other filters. To get more optimum result then CAFSM we proposed a new filter based on DBA technique.

In this paper work we compared the performance of these two filters i.e., CAFSM and proposed AFSDB. After doing the result analysis, it is concluded that our proposed filter is more efficient and better in performance with respect to its Peak Signal to Noise Ratio and Mean Absolute Error. It increases the performance of degraded image with higher difference comparative to previously proposed filters. This concluded that our proposed filter gives much higher performance and is more efficient.

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