Image Filtering Through Improved Switching Median Filter Based on Fuzzy Logic Gain Factor for Mixed Noise

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Abstract: ***Switching median filter is actively used and is continuously modified by the research scholars to remove noise out of the corrupted image. Fuzzy based filters are under development to improve the performance. In survey, fuzzy based switching median filter is considered and modified in our research paper. Output of the fuzzy system is set to vary the value from 0 to 1 and is considered as a gain factor for filtering process. After putting gain factor into the filtering equation, the results are improved in terms of PSNR value as revealed in results. The simulation is applied on mixed noise. Mixed noise is considered as a combination of salt & pepper noise which varies from 1% to 10% and Gaussian noise with zero mean and 0.01 variance.***

Keywords: **Switching median filter, Fuzzy logic, Gain factor, Rule editor, Mixed noise, PSNR, Fuzzification, Image filtering, Defuzzification.**

I. Introduction

Digital image is a combination of pixels and their intensity ranges from 0 to 255. 0 representing black colour and 255 representing white colour. Non-linear sensors corrupt the pixel intensity resulting in corrupted image as output. The frequently added noises are impulse noise (Salt & Pepper noise) and Gaussian noise. A mixture of these two noises is termed as mixed noise [1] [3]. To remove these corrupted pixels, image filtering algorithms based on median filter are used. Switching median filter is used to remove noise. The procedure of switching median filter consists of two components, first being noise detection and second being image filtering [2]. In noise detection method, noisy pixels are detected out of the complete image while in filtering process only corrupted pixels are altered by implementing simple median filter.

Salt & pepper noise is frequent noise in the digital images. The pixels which are polluted by this noise are replaced by high contrast values like 0 or 255. Where 0 representing black colour that is pepper and 255 representing white colour that is salt [5]. Mixed noise can be removed from corrupt image in a two step process, first by applying the filter which is most suitable to remove salt & pepper (impulse) noise and then applying suitable filter to remove Gaussian noise [2]. But applying two different filters increase the computation cost, hence instead of two, only one filter, i.e. switching median filter is applied. Switching filters use the concept that they first identify impulses and then eliminate them using an appropriate method [3].

Fuzzy logic controller is shown in fig.1. The Fuzzification block converts crisp sets into the fuzzy sets. Pre-defined membership functions are used for procedure of conversion [8]. Where Inference Engine uses if-then rules which are defined in rule editor to study fuzzy sets and then gives the output based on these rules. The Defuzzification module converts fuzzy sets back to crisp form so that the user is able to understand the output [1] [7].

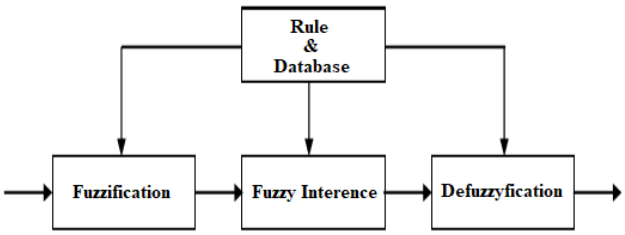


Fig. 1: General Fuzzy Logic Controller

II. Switching Median Filter

Switching median filter use a threshold value to identify the noise in the pixel. If the intensity difference between the centre pixel value and median value in the window is greater than the threshold value then centre pixel is considered as a noisy pixel and replaced by median value, otherwise centre pixel is considered as non-noisy and remain unchanged [10]. Difference in intensity between the centre pixel value and median value in the window is measured by,

$$\Delta x = |x(i,j) - x\_med| \quad (1)$$

here median value in the window x_med is

$$x\_med = \{x(i-N,j-N), \ldots w\_c * x(i,j), \ldots x(i-N,j-N)\} \quad (2)$$

where w_c is the weight of the centre pixel.

Suppose {X} is the noisy image and (2N+1) × (2N+1) is the sliding window size, centred at (i, j).
The adjustment of the centre pixel is given by following equation,

$$y(i,j) = \begin{cases} x_{med}, & \Delta x \geq T_i \\ x(i,j), & \Delta x < T_i \end{cases} \quad (3)$$

y(i,j) is the recovered image with preserved edges [9].

III. Proposed Work

In the proposed technique, algorithm for fuzzy based switching median filter is produced. Switching median filter is a two part process. First is noise detection and second is noise filtration. In the proposed technique, noise is detected by means of fuzzy logic controller. Fuzzy logic system with name fuzzysystem_f1 is developed in MATLAB which consists of two inputs and one output as shown in fig. 2.

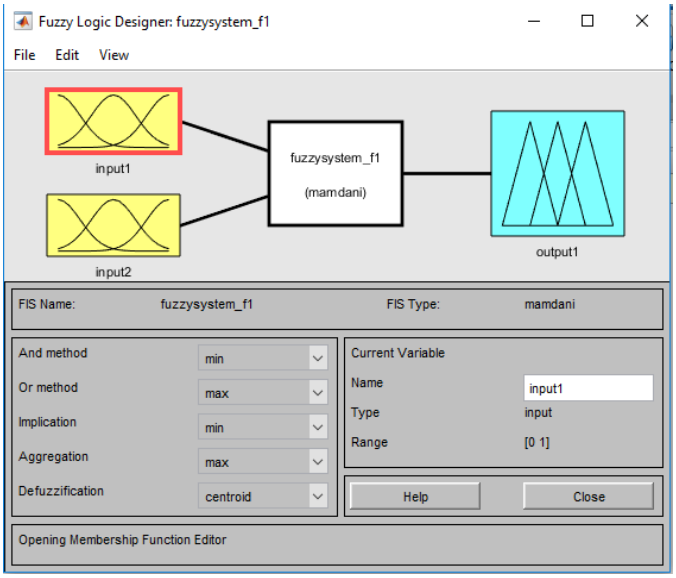
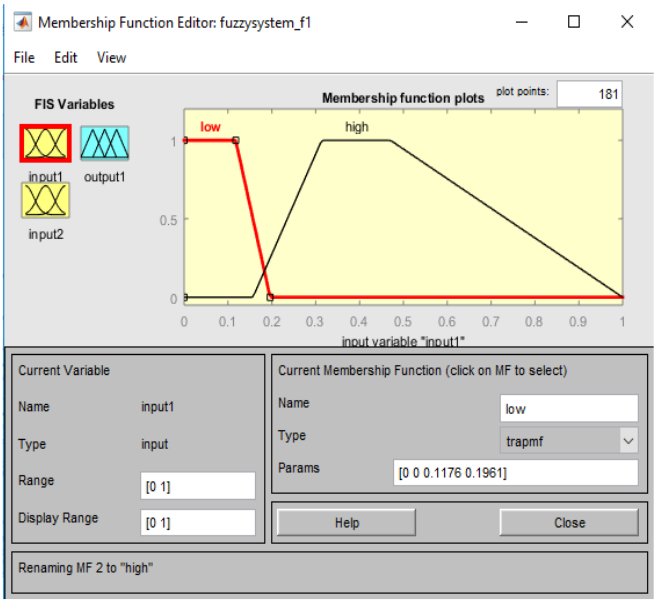
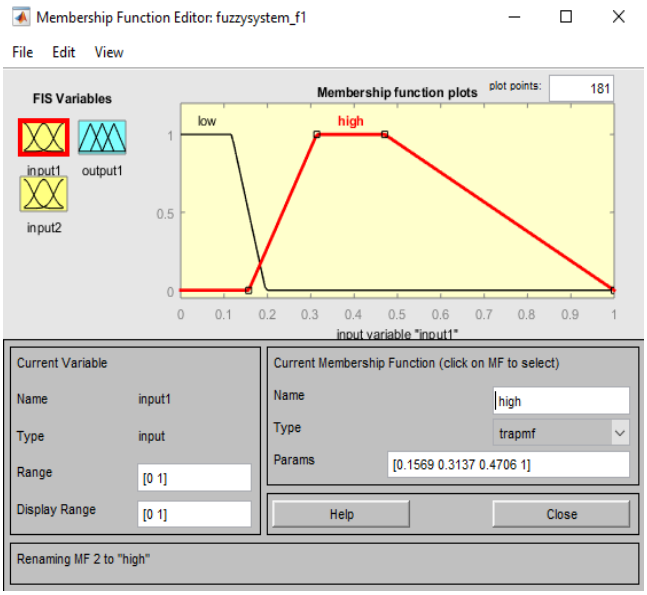


Fig. 2: Fuzzy logic system



(a)

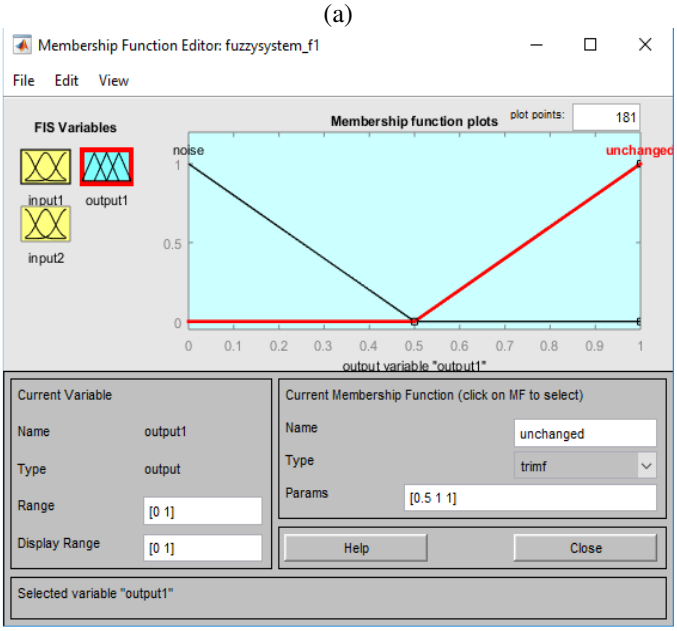


(b)

Fig. 3: Membership functions for inputs in Fuzzy logic system (a) display parameters of low (b) display parameters of high

Fig. 3 contains the membership functions for input. Fig. 3(a) demonstrates the parameters for "low", i.e. range is [0 1] and values are [0 0 0.1176 0.1961], it means input to fuzzy system in this range will be treated as "low". For "high", range is [0 1] and values are [0.1569 0.3137 0.4706 1], it means input to fuzzy system in this range will be treated as "high".

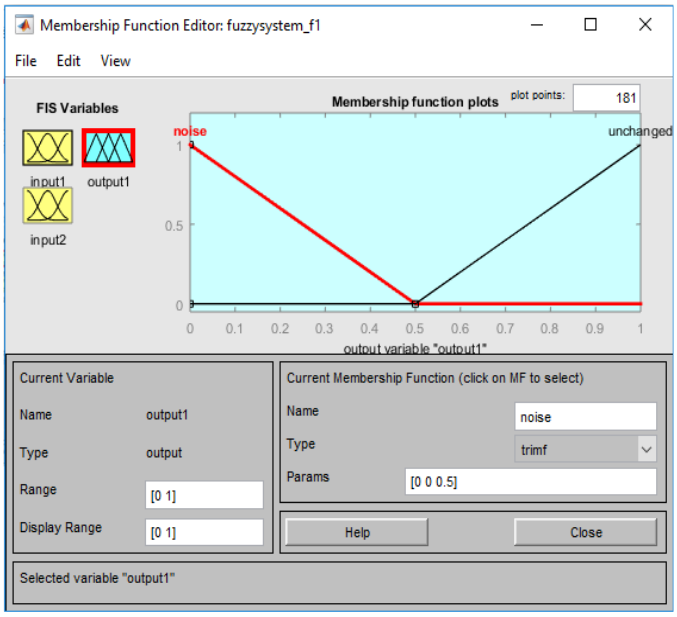
(a)



(b)

Fig. 4: Membership functions for output in Fuzzy logic system (a) display parameters of noise (b) display parameters of unchanged.

Fig. 4 shows the membership functions for output. Fig. 4(a) show the parameters for "noise", i.e. range [0 1] and values are [0 0 0.5], which means if the output is "noise" then values will be in this range. Similarly, Fig. 4(b) for "unchanged", range is [0 1] and values are [0.5 1 1], which means if the output is unchanged, the values will be in this range.



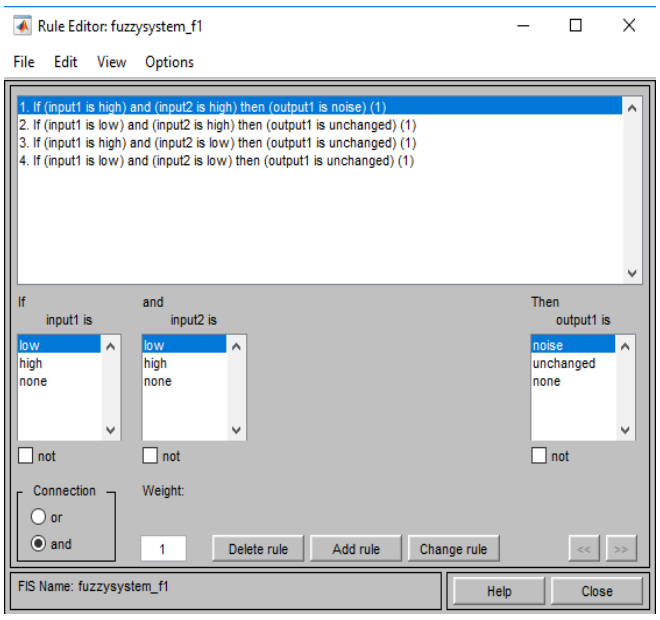


Fig. 5: Rule editor window

Fig.5 shows the rule editor window. Rule editor contains the fuzzy rules which are used for the fuzzy system. Rules can be edited and new rules can be added with the rule editor. Fig. 5 shows the rules for the projected system.

Input to fuzzy logic will be the difference of centre pixel and its neighbouring pixels. i.e,

If centre pixel is Z(i,j), the input to fuzzy system will be Z(i,j)-Z(i-1,j) & Z(i,j)-Z(i+1,j).

Then the output of fuzzy system will be y1, that will be in the range of [0 1] as defined in the membership function for output. For further filtering process, this output parameter of fuzzy system y1 is considered to be a gain factor. Then the final filtered output of the proposed algorithm will be,

$$f=(1-y1).*Z2+(y1.*m1) \quad (4)$$

where,
f=recovered image
y1=gain factor from fuzzy logic
Z2=noisy image
m1=output of median filter

IV. Simulation Results

Table1 contains the statistics of PSNR corresponding to change in noise density for the proposed and the previous work. It can be inferred from the table that PSNR numeric values for proposed work are enhanced than previous work.

TABLE I PSNR of Fuzzy, Non- Fuzzy Based Filter and Proposed Filter for Noise Density from 1 to 10%

SNo	Noise (in %)	PSNR PREVIOUS ALGO	PSNR PROPOSED ALGO
1	1	22.53	22.77
2	2	20.72	22.58
3	3	19.48	22.39
4	4	18.59	22.05
5	5	17.84	21.79
6	6	17.29	21.58
7	7	16.70	21.38
8	8	16.19	21.01
9	9	15.75	20.73
10	10	15.50	20.58

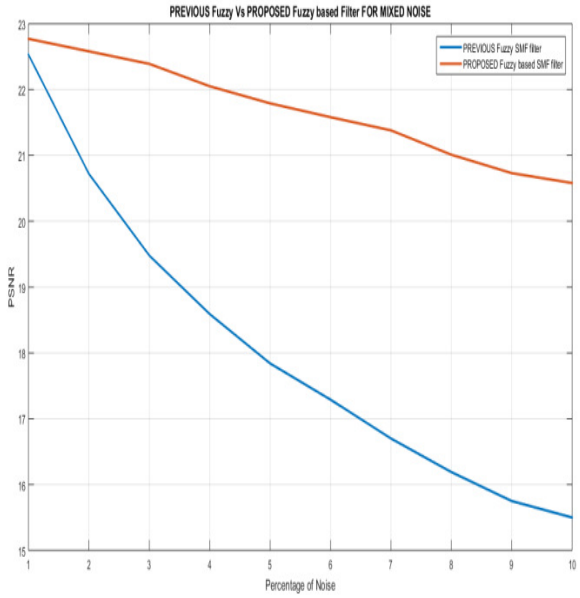
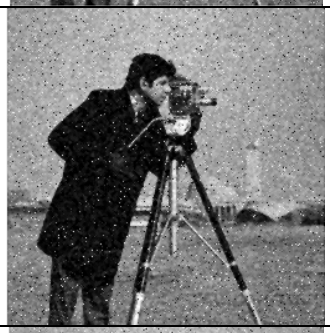
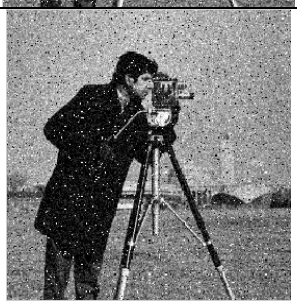
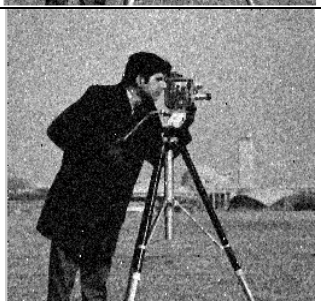
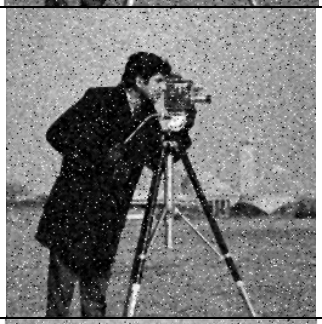
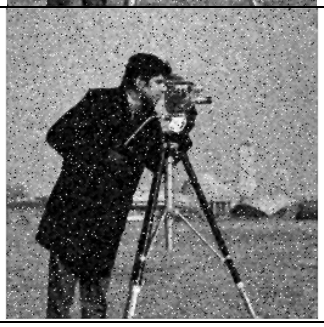


Fig. 6: Plot of PSNR vs Noise for previous and proposed work

Fig. 6 is a graph representation for the values of Table 1. It is a PSNR vs Noise graph for previous and proposed work. Here noise density changes from 1% to 10% and corresponding PSNR values are plotted. It is obvious from the graph that the proposed work is enhanced than the previous work.

TABLE II Output Images of Previous and Proposed Work for Noise Density from 1 to 10%

Noise %	Noisy image	PREVIOUS WORK	PROPOSED WORK
1			
2			
3			
4			
5			

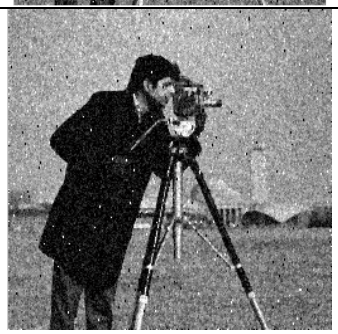
6			
7			
8			
9			
10			

Table2 contains the output images with change in percentage of noise from 1% to 10% for previous and proposed work. It can be inferred from the images, that the filtration of images of the proposed work are better than the earlier work.

V. Quality Parameters

PSNR calculation, if the actual image is represented by $o(i,j)$, corrupted image by $x(i,j)$ then the PSNR is given by,

$$PSNR = 10\log_{10}\frac{(Imax)^2}{\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(o(i,j)-x(i,j))^2} \quad (5)$$

Where M and N denotes resolution of the image. Imax is the maximum gray scale intensity level that is 255 which actually represent white color [4][6].

VI. Conclusion

Median filter is popular in eliminating noise in the field of image filtration. Fuzzy based switching median filter was studied and an improved version is proposed in our research paper. The output of fuzzy system output is taken as a gain factor which is used for filtering process. In the proposed research, images are polluted with mixed noise. Mixed noise consists of salt & pepper noise and Gaussian noise. Salt & pepper noise varies from 1% to 10% while Gaussian noise is considered with zero mean and 0.01 variance. From the above tables and graphs, it is obvious that the proposed fuzzy logic based algorithm provides better quality images. The PSNR of proposed algorithm is an improvement with higher noise densities.

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