ISSN 2250-3153

Fuzzy Approach to Detect and Reduce Impulse Noise in RGB Color Image

Isita Bose*, Debashis Mishra*, Bishwojyoti Pradhan* and Utpal Chandra De**

*M.Tech.(CSE), School of Computer Engineering, KIIT University,
(isitabose89 , debashis.engg, bishwojyoti2)@gmail.com
** Asst. Professor, School of Computer Application, KIIT University,
utpal@kiit.ac.in

Abstract- This paper mainly focuses on image enhancement technique using soft computing approach like fuzzy sets. Image enhancement primarily covers noise detection and reduction from digital color image. To overcome the color disorder on edge and texture pixel, here each color component of a pixel is correlated to the other two corresponding color components of the same pixel. Here filtering is applied to only the corrupted pixels found by the fuzzy approach to improve the complexity and to avoid the color disorder at edges. An experimental result shows that the proposed method in this paper provides significant improvement as compared to the other non-fuzzy and fuzzy filters.

Index terms- Image processing, impulse noise, RGB Color, fuzzy logic, fuzzy rule based system, membership function.

I. INTRODUCTION

Image processing is one vital part of signal processing, which takes an image as input and produces processed output image or image information. Now-a-days image processing is used in various fields as essential features of technology. Where image is used one major source of information then finding the accurate data is very essential. So here comes the need of image enhancement or improvement. The image is mainly corrupted by different kind of noises generally produced while transmitting it through various medium.

One color image is the 3 dimensional data storing in image form where Red, Blue and Green are the three dimension. Each component like Red, Green and Blue of the image is one 2D image like one gray scale image having two spatial co-ordinates. These image elements are called pixels and the amplitude of the pixels are called intensity of that pixel. Noise reduction is a vital problem in image processing as after the noise reduction any other image processing techniques can be applied like image segmentation, edge detection etc. Noise generates in an image due to various reason basically during acquisition and transmission in channels, faulty memory location in hardware, high energy spikes generates during transmission. various types of noises are there like Gaussian noise, impulse noise, speckle noise etc. Impulse noise i.e. salt & pepper noise is very common type of noise generated in image. Salt & pepper noise is an impulse noise that digitized the original image pixel values to two extreme intensities. Before processing the noisy image to any further steps of image processing field this corrupted image should be filtered to remove those noise to get good quality image. The conventional median filters and its further modifications generally used to filter this salt & pepper kind of noise but it produces blurring effect in the image. the filtering technique to all the pixels in the image which creates a blurring effect in the image. Many vector based noise reduction technique has also been introduced later for removal of impulse noise but they have some disadvantage that is they consider each pixel as a whole vector in vector based approach and their capacity of noise reduction is inversely proportional to noise level. A better way to come out from these drawbacks is to apply some technique to differentiate between noisy pixel and noise-free pixel[10] so that the filtering technique can only be applied to those noisy pixels.

Fuzzy logic is introduced in 1965 by L. A. Zadeh professor in Computer science at the University of California in Berkelay[20]. It is a fastest growing area which is applied to many research areas. It processes human knowledge in the form of fuzzy if-then rules which have a partial truth value ranging between 0 and 1[1].Fuzzy logic deals with both qualitative and quantitive kind of problem domain. Fuzzy logic is applied in image processing as it can differentiate between image characteristics and noise characteristics . Fuzzy theory is employed as an extensions to the modified median filter which is giving better result in noise removal. Fuzzy based filters are capable of removing noise from an image by keeping the details of image intact and preserving the edge sharpness. Many fuzzy based filters has been introduced so far like Fuzzy Similarity-based filter (FSF) [6], Fuzzy Random Impulse Noise Reduction Method (FRINRM) [8] , Adaptive Fuzzy Switching Filter (ASFS) [2], Histogram Adaptive Fuzzy filter (HAF) [7], Fuzzy Impulse Noise Detection & Reduction method (FIDRM) [18], Fuzzy Adaptive Noise Filter[14],Fuzzy based Median Filter[19], etc. But these filters are well suited for 2-D grey scale images. Basic problem with these approaches were that it causes disorderness in the texture of the image and also affects the edge sharpness this is due to the filtering algorithm of 2-D grey scale is applied to each color component of color image as each component R, G, B are one 2-D images. In this paper we are using fuzzy technique for detection and removal of impulse noise using color components of the color image by co-relating them with each other with the help of R-G-B color model. In this paper Fuzzy technique is used efficiently to differentiate between noisy and noise-free pixels and the filtering technique is applied only to the corrupted or noisy pixels without affecting the color, the age sharpness and the image details.

In the section II of this paper detection technique i.e. to detect the noisy pixels and filtration or we can say de-noising part of this detected noisy pixels is described using fuzzy logic. In the section III we described final results of this experiment and compared with other techniques so far. And lastly we conclude this paper in section IV with conclusion.

II. PROPOSED IMAGE FILTERATION TECHNIQUE

A. Noisy Pixels Detection Phase using Fuzzy Technique

Detection phase is the vital stage in the filtering process as the filtering will be applied only to those detected noisy pixels.
In the detection part two steps are followed to detect the noisy pixel
1.each pixel is processed by taking a 3 X 3 window filter where its value is compared with its neighbours to calculate similarity level in each color component pixels individually
2. then comparing similarity level of each pixel of each color component with the other two components at the same position.
Each pixel is processed here by taking a 3 X 3 sliding window to test each pixels with its neighbours shown in the figure 1.

	-1	0	1
-1	P_1	P_2	P_3
0	P_4	P_0	P_5
1	P_6	P_7	P_8

Figure-1 : 3 X 3 Sliding Window

In this above 3 X 3 sliding window P_o is the test pixel which is processed and its similarity degree is calculated with its neighbours P_1 to P_8 to know the similarity level between them. By going through the proper steps specified in the algorithm, these generated absolute value differences are converted to fuzzy values to know the similarity level i.e. if pixels have 'LARGE' similarity level or 'SMALL' degree of similarity level[5]. To convert them to fuzzy values absolute value differences are added with membership function[1] which gives us the similarity degrees. Here to convert the absolute values to fuzzy values we are using Z-membership function as when the absolute values differences[16] are relatively small then membership degree will be high and it gradually decreases with increasing differences and after a certain value it decreases faster as compared to previous rate and finally becomes zero[5]. Z-membership function[1]can be defined as

$$\text{Z-MF}(x, [a\ b]) = \begin{cases} 1, & \text{if } x \le a \\ 1\text{-}2\left(\frac{x\text{-}a}{b\text{-}a}\right)^2, & \text{if } a \le x \le \frac{a+b}{2} \\ 2\left(\frac{x\text{-}a}{b\text{-}a}\right)^2, & \text{if } \frac{a+b}{2} \le x \le b \\ 0, & \text{if } x \ge b \end{cases}$$

Algorithm For The Detection Phase

1. Calculating absolute value differences
 $\Delta P_k^R = | P_0^R - P_k^R |$, $\Delta P_k^G = | P_0^G - P_k^G |$, $\Delta P_k^B = | P_0^B - P_k^B |$ (1)

2. Calculating similarity degree in each color component pixel with its neighbour pixels by adding membership function Z-MF as M_1 having parameter values as a= 20, b=75 with the absolute value differences.
$$SIM^R = \prod_{i=1}^{k} M_1(\Delta P_i^R) \ ,\quad SIM^G = \prod_{i=1}^{k} M_1(\Delta P_i^G) \ ,\quad SIM^B = \prod_{i=1}^{k} M_1(\Delta P_i^B) \quad (2)$$

3. Calculating similarity degree of each color component pixel with the other two color component pixel at the same position by adding membership function M_2 having parameter values a=0.01 , b=0.15 with the differences

$$SIM_k^{RG} = M_2\left(\left|M_1\left(\Delta P_k^R\right) - M_1\left(\Delta P_k^G\right)\right|\right)$$
$$SIM_k^{RB} = M_2\left(\left|M_1\left(\Delta P_k^R\right) - M_1\left(\Delta P_k^B\right)\right|\right)$$
$$SIM_k^{GB} = M_2\left(\left|M_1\left(\Delta P_k^G\right) - M_1\left(\Delta P_k^B\right)\right|\right)$$

4. Now calculating the joint similarity for all till k^{th} pixel can be given as by taking the conjunction(AND) i.e. t-norm operation

$$SIM^{RG} = \prod_{j=1}^{k} SIM_j^{RG}\ ,\ SIM^{RB} = \prod_{j=1}^{k} SIM_j^{RB}\ ,\ SIM^{GB} = \prod_{j=1}^{k} SIM_j^{GB} \quad (3)$$

5. After calculation of similarity degrees Noise-freeness of the test pixel P_0 for all RED, GREEN, BLUE component is calculated using fuzzy If-Then rules

IF *((SIM^R is large)* ***AND*** *(SIM^G is large)* ***AND*** *(SIM^{RG} is large))*
OR
((SIM^R is large) ***AND*** *(SIM^B is large)* ***AND*** *(SIM^{RB} is large))*
Then *(Noise-free (P_0^{RED}) is large)* (4)

IF *((SIM^G is large)* ***AND*** *(SIM^R is large)* ***AND*** *(SIM^{GR} is large))*
OR
((SIM^G is large) ***AND*** *(SIM^B is large)* ***AND*** *(SIM^{GB} is large))*
Then *(Noise-free (P_0^{GREEN}) is large)* (5)

IF *((SIM^B is large)* ***AND*** *(SIM^R is large)* ***AND*** *(SIM^{BR} is large))*
OR
((SIM^B is large) ***AND*** *(SIM^G is large)* ***AND*** *(SIM^{BG} is large))*
Then *(Noise-free (P_0^{BLUE}) is large)* (6)

The detection phase is explained by taking standard image of Lena as example using this proposed fuzzy approach given in the following figure i.e. Figure-2

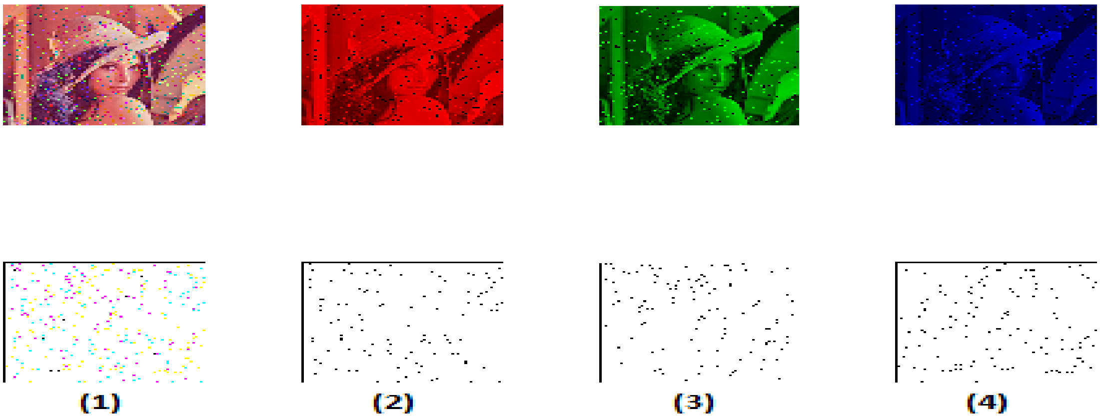


Figure-2: First rows (1) Lena image with 5% noise (2) RED-component of noisy image (3) GREEN-component of noisy image (4) BLUE-component of noisy image; second row (1) Membership degree *Noise-free* of original image (2) Membership degree *Noise-free(RED)* (3) Membership degree *Noise-free(GREEN)* (4) Membership degree *Noise-free(BLUE)*

B. Removal of Detected Noisy pixels By Applying Fuzzy Filtering Technique

In this paper main focus is on the detection of the noisy pixels after getting those noisy pixels filtering technique is applied to those pixels only. When some components of a color are found noisy, it is filtered in a proportional degree that is calculated by comparing with other color components which give the estimated values to evaluate the de-noising process. In the paper "A New fuzzy color correlated impulse noise reduction method" by S. Schulte et al. published in IEEE Transaction, a new de-noising technique is introduced which we are following for de-noising technique to reduce noise.

To calculate the noise-free output, for each pixel of all the three color components RED, GREEN & BLUE each time a weighted average is calculated by considering a 3 X 3 filtering window for the test pixel in the window. This weight calculation process involves calculation of the weighted average of all the neighbour pixels in the filtering window for that test pixel which gives the filter output. If that processed pixel of the color component is noise-free then its neighbours are assigned with a value zero and that test pixel remains unchanged. Weight will be large if the noise-free degree is large of its neighbours.

Let in the filtering window P_0 is the processed pixel and $w_{P_0^{RED}}$ is the weight for RED component. Similarly for GREEN and BLUE $w_{P_0^{GREEN}}$ and $w_{P_0^{BLUE}}$ respectively. $w_{P_K^{RED}}$ is the neighbour weights for RED component for k=1,........,n^2-1. To filter the pixel values according to their noise-freeness the weight of the central pixel or processed pixel corresponds to its membership degree in the fuzzy set Noise-free[5].

In first step weight value of the processed pixel is calculated let for $w_{P_0^R}$ the calculation will be as follows

***IF** (Noise-free (P_0^{RED}) is Large) **Then** ($w_{P_0^{RED}}$ is Large)*

***IF** (Noise-free (P_0^{GREEN}) is Large) **Then** ($w_{P_0^{GREEN}}$ is Large)*

***IF** (Noise-free (P_0^{BLUE}) is Large) **Then** ($w_{P_0^{BLUE}}$ is Large)*

The weight value for k[th] neighbour for RED , GREEN and BLUE components $w_{P_K^{RED}}$, $w_{P_K^{GREEN}}$, $w_{P_K^{BLUE}}$ can be calculated as follows

IF *((Noise-free (P_0^{RED}) is Not Large)* **AND** *(Noise-free (P_k^{RED}) is Large)* **AND** *($M_1(\Delta P_k^{GREEN})$ is Large) & (Noise-free (P_k^{GREEN}) is Large)) OR*

(Noise-free (P_0^{RED}) is Not Large) **AND** *(Noise-free (P_k^{RED}) is Large)* **AND** *($M_1(\Delta P_k^{BLUE})$ is Large)& (Noise-free (P_k^{BLUE}) is Large)*

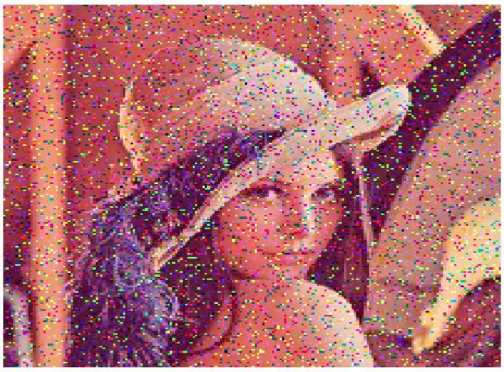
Then *($\boldsymbol{w_{P_K^{RED}}}$ is large)*

Similarly it will be calculated for GREEN and BLUE components for k[th] neighbour . If that processed pixel is noisy then that is being replaced with this weighted average value of that pixel as given below. Now to replace the noisy pixel value can be done by calculating weighted average ,for RED ,GREEN and BLUE components this can be given as $W_{P_0}^{RED}$, $W_{P_0}^{GREEN}$ and $W_{P_0}^{BLUE}$ respectively

$$W_{P_0}^{RED} = \frac{\sum_{k=0}^{n^2-1} w_{P_k}^{RED} P_k^{RED}}{\sum_{k=0}^{n^2-1} w_{P_k}^{RED}}, \quad W_{P_0}^{GREEN} = \frac{\sum_{k=0}^{n^2-1} w_{P_k}^{GREEN} P_k^{GREEN}}{\sum_{k=0}^{n^2-1} w_{P_k}^{GREEN}}, \quad W_{P_0}^{BLUE} = \frac{\sum_{k=0}^{n^2-1} w_{P_k}^{BLUE} P_k^{BLUE}}{\sum_{k=0}^{n^2-1} w_{P_k}^{BLUE}}$$

III. EXPERIMENTAL RESULTS

We have inputted standard image of Lena to examine this proposed method with impulse noise level of 10% to it and also calculated the PSNR value for the noise level of that de-noised image which is given in the following Table-1, where it is compared the results with the other filter results which values are taken from the reference papers[2] [3] -[19] related to those filters. Below in the Figure-3 the output of the filtered image is given by adding 10% noise level to the standard images of Lena.


(1)


(2)

Figure-3: (1) Lena image with 10% impulse noise (2) Filtered image using proposed method

Table 1: PSNR values of different filters with the proposed filter considering Lena image with different percentage of impulse noise .

PSNR values of colored Lena image with different noise levels							
Filters	**5%**	**10%**	**15%**	**20%**	**25%**	**30%**	**40%**
None	22.15	19.61	17.82	16.72	15.91	14.62	13.41
ASVMF	24.87	24.12	22.79	21.98	21.91	21.63	20.88
FIDRMC	26.04	25.33	24.67	23.88	23.32	22.76	20.54
HAF	23.54	23.77	23.96	22.96	21.43	20.89	20.02
Proposed Method	**31.78**	**29.15**	**27.43**	**26.23**	**25.05**	**24.44**	**21.95**

ISSN 2250-3153

IV. CONCLUSION

In this paper we have applied fuzzy based approach to detect and reduce noise in an image to get a good quality image by keeping image details preserved .We have examined and explained noise detection phase and filtering of that noisy pixels by using standard color image of Lena by giving specified noise level to it. Main focus in this paper is the fuzzy based noisy pixel detection phase using the RGB color components of the digitized color image and their co-relations to detect the noise. Here We have find that this proposed method detection phase detects the noisy pixels very efficiently by using fuzzy approach and it reduces the noise in the image without affecting the color and the edge sharpness of that image by preserving the image details.

REFERENCES

1. J.-S.R. Jang, C.-T. Sun, and E. Mizutani. *Neuro-Fuzzy And Soft Computing*.PHI Learning Pvt., Ltd.
2. H. Xu, G. Zhu, H. Peng, and D.Wang, "*Adaptive fuzzy switching filter for images corrupted by impulse noise*," Pattern Recognit. Lett., vol. 25,pp. 1657–1663, Nov. 2004.
3. S. Morillas, S. Schulte, E.E. Kerre, G. P.-Fajarnes, "*A New Fuzzy Impulse Noise Detection Method for Colour Images*", Image Analysis LNCS, Vol.4522,pp. 492-501, 2007
4. M. Nachtegael, D. Van der Weken, V. De Witte, S. Schulte, T. Melange, E.E. Kerre, "*Color Image retrieval fuzzy similarity measures and fuzzy partitions*", IEEE, ICIP, vol-VI, 2007
5. Debashis Mishra, Isita Bose, Madhabananda Das, B.S.P Mishra ,"*Detection and Reduction of Impulse Noise in RGB Color Image Using Fuzzy Technique"*, Distributed Computing and Internet Technology , Lecture Notes in Computer Science Volume 8337, 2014, pp 299-310 .
6. L. Kalaykov and G. Tolt, M. Nachtegael, D. Van der Weken, D. Van De Ville, and E.E. Kerre, Eds., "*Real-time image noise cancellation based on fuzzy similarity*", in Fuzzy filters for Image processing, 1st ed. Heidelberg, Germany: Physica Verlag, 2003, vol. 122, pp. 54-71.
7. J.H. Wang, W.J. Liu, and L.D.Lin, "*Histogram-Based fuzzy filter for image restoration"*, IEEE Trans. Syst., Man, Cybern. B, Cybern., vol. 32, no. 2, pp. 230-238, Apr. 2002.
8. S. Schulte, V. De Witte, M. Nachtegael, D. Van der Weken, and E. E. Kerre, "*Fuzzy random impulse noise reduction method*", Fuzzy Sets Syst., vol. 158, no. 3, pp. 270-283, Jan. 2007.
9. K.N. Plataniotis and A.N. Venetsanopouls, "*Color image processing and Applications"*, Berlin,Germany:Springer,2000.
10. R. Lukac,*"Adaptive vector median filter"*, Pattern Recognit. Lett., vol.24, No. 12, pp. 1889-1899, Aug. 2003.
11. R. Lukac, K.N. Plataniotis, A.N. Venetsanoloulos, and B. Smolka, *"A statistically-switched adaptive vector median filter"*, J. Intell. Robot. syst., vol. 42, no. 4, pp. 361-391, Apr. 2005.
12. Harish Kundra, Monika Verma & Aashima, *" Filter For Removal Of Impulse Noise Using Fuzzy Logic "*, International Journal of Image Processing(IJIP) . vol. 3.issue. 5.
13. S. Schulte, V.D. Witte, M. Nachtegael, D.V. Weken, "*Fuzzy Two-step Filter for Impulse Noise Reduction from Color Image*", Image Processing, IEEE Trans., vol. 15, issue.11, pp. 3567-3578, 2006.
14. Jaspreet Kaur, Preeti Gupta, *" Fuzzy Logic Based Adaptive Noise Filter For Real Time Image Processing Applications "*, International Journal of Computer Science Issues(IJCSI), vol.9, issue.4, no. 2, july 2012.
15. S. Schulte, S. Morillas, V. Gregori, and E.E. Kerre "*A New fuzzy color correlated impulse noise reduction method*", IEEE Trans. on image processing, vol. 16, no. 10, Oct 2007
16. M. Barni, V. Cappellini, and A. Mecocci, *"Fast Vector median filter based on Euclidean norm approximate"*, IEEE signal process. Lett., vol. 1, no. 6, pp. 92-94, Jun. 1994.
17. G.V. Rao, S.P.K. Somayajula, and C.P.V.N.J. Mohan Rao, "*Implementation of Impulse noise reduction method to color images using fuzzy logic."*, Global Journal of Computer Science and Technology, vol. 11, no. 22, pp. 72-75, Dec 2011.
18. S. Schulte, M. Nachtegael, V. De Witte, D. Van der Weken, and E.E. Kerre, "*A fuzzy impulse noise detection and reduction method*", IEEE Tans. Image Process., vol. 15, no. 5, pp. 1153-1162, May 2006.
19. Bhavana Deshpande, H. K. Verma & Prachi Deshpande, " Fuzzy Based Median Filtering For Removal Of Salt & Pepper Noise ", International Journal of Soft Computing and Engineering(IJSCE), vol. 2, issue. 3, july 2012.
20. L.A. Zadeh, "Fuzzy sets and Information Granularity", Comp. Sc. Div, Dept. of Elect. Engg. & comp. sc. and the Electronics Research Lab, University of California, Berkely", 1979.

AUTHORS

First Author-

Isita Bose is continuing her Master of Technology degrees in Computer Scince & Engineering in Kalianga Institute of Industrial & Technology (KIIT University), Bhubaneswar (2012-2014). She received her BTech degree in Computer Science & Engineering from BPUT, Odisha in 2010.She is doing research in image processing, soft computing like fuzzy, PSO etc. **email id- isitabose89@gmail.com**

Second Authors-

Debashis Mishra is continuing his Master of Technology degrees in Computer Scince & Engineering in Kalianga Institute of Industrial & Technology (KIIT University), Bhubaneswar (2012-2014). He received his BTech degree in Electronics & Telecommunication Engineering from BPUT, Odisha in 2011. He is doing research in image processing, soft computing like fuzzy, PSO, ACO etc. **email id-debashis.engg@gmail.com**

Bishwojyoti Pradhan is continuing his Master of Technology degrees in Computer Scince & Engineering in Kalianga Institute of Industrial & Technology (KIIT University), Bhubaneswar (2012-2014). He received his BTech degree in Electronics & Telecommunication Engineering from BPUT, Odisha in 2011. He is doing his research in wireless sensor network, networking, image processing etc. **email id- bishwojyoti2@gmail.com**

Utpal Chandra De is serving as Asst. Professor in School of Computer Application, KIIT University since last six years. He is also continuing his Ph.D. in School of Computer Engineering, KIIT University. He is recently working in Cryptography, Networking, Image processing etc. **email id- utpal@kiit.ac.in**