iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** VI **Month of publication:** June 2021

DOI: https://doi.org/10.22214/ijraset.2021.35454

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

Analysis of Fuzzy Based Directional Median Filter with Mixed Noise

Bhageerath Singh Kaurav[1], Karuna Markam[2], Pooja Sahoo[3]
[1, 2, 3]Department of Electronics Engineering, MadhavInstitute of Technology&Science, Gwalior-474005, India

Abstract: All the sources of digital images like camera as well as communication methods like wireless or wired communication leads to corruption of pixels of digital image. Usually digital image consists of values from 0 to 255 where 0 represents black pixel and 255 represents white pixel. Due to above sources and communication method, these pixels change there value which leads to change in the output values. Mixed noise is popular now a day which is a combination of Gaussian noise and salt & pepper noise. Median filters are popular in removing the noise from the digital images. Fuzzy based controllers are very popular now a day to solve issues better than others. In this paper, we have discussed fuzzy logic, median filter and directional median filter to remove the corrupted pixels out of digital image. Parameters like PSNR (Peak Signal to Noise Ratio) and MSE (Mean Square Error) are used for qualitative analysis of filter.
Keywords: Median filter, Mixed noise, Gaussian noise, Salt&pepper noise, Fuzzy logic rules, Membership functions, PSNR (Peak signal to noise ratio), MSE (Mean Square Error), Fuzzification.

I. INTRODUCTION

Noise in the communication channels corrupts the digital images due to introduction of impulse noise. Due to this reason, there will be poor output of the image processing algorithms like edge detecting, image segmentation, object recognition, and object tracking. Thus this noise has to be removed to perform computer vision algorithms. In salt & pepper noise, each pixel of digital image is corrupted and the value is changed to either 255 or 0 [1].Air is used for wireless communication channels and USB for wired, these channels added noise during the transfer of data.Non linearity of camera sensor also adds noise in the output digital image. Gaussian and salt & pepper noise is corrupted the images very frequently. These two noises combine and termed as mixed noise [2]. Image pre-processing is the initial step for all image processing algorithms because it removes noise. Without pre-processing, noise will go to the further stages of algorithm and final output will be affected. All researchers are using median filters in pre-processing to remove these noises. The most popular image filtering filter which performs effectively on the digital image is standard median filter. The simple median filter may damage the details of lines and edges. And simple median filter don't work on directional corruptions in digital images in denoising process. Therefore another filter that is Directional Weighted Median (DWM) filter is introduced. The method of DWM filter is to find the difference in intensity of neighboring pixels with center pixel in all 4 alignments, this helps in determining the noise in the pixel. For the noisy pixels, alignment of similarity can be determined by using standard deviation and then center pixel is replaced by median of neighboring pixels in that alignment. Correct Edge detection decides the quality of output of DWM filter [3] and performance of DWM will be highly affected if edge detection is failed [1].
Usually images with Gaussian noise are recovered by using least-squares methods based algorithms. Impulse noise fails these filters due to heavy load of noise on image. The filtering process will lead to change in intensity of all the pixels included uncorrupted pixels [3]. AI (Artificial Intelligence) concepts make use of fuzzy logic for its development. Since it was invented, there are lots of criticisms faced by fuzzy logic. But fuzzy logic is still used in almost every branch of science. This makes fuzzy logic a point of importance and that's why it is always a priority choice for any researcher for latest developments [7]. Therefore it is found that introduction of fuzzy logic with directional median filter is results in better removal of mixed noise from the digital images.In this paper, latest median filters and fuzzy logic is studied and discussed in order to find the better results by combining fuzzy logic and DWM filter.

II. FUZZY LOGIC

In fuzzy logic system, linguisticapproach like IF-THEN rules helps in approximating the non-linear functions in real-time [5]. Computation can be performed by using fuzzy logic. Here "degrees of truth" is used where in normal systems "true or false" is used, that's why it is foremost used in development of modern computers. This concept is taken from human brain. It is different than programming where numbers are used to make decision. It helps in replacement of numbers based decision by linguistic based decision to get the output. It is shown in figure 1.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

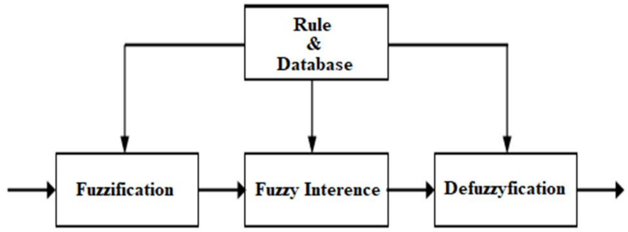


Fig. 1:Representation of Fuzzy Logic Controller

The function of Fuzzification is to transform input to fuzzy set values. This transformation can be done by using membership functions. The work of fuzzy inference is to analyze fuzzy set values with if-then rules and then decided the final output in the form of another membership function. The function of defuzzification is to transform back the output into normal form that will be understandable to user[1] [7].

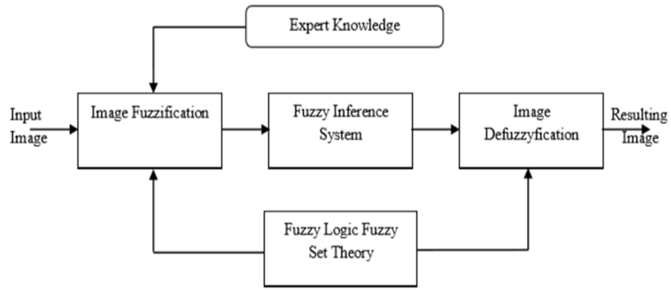


Fig. 2:Fuzzy logic system in Image Processing

The combination of image processing and fuzzy logic is represented by a flow diagram in figure 2. Here the function of block “expert knowledge” is to keep application related information like image processing rules has been provided by this block with requirement.

III. OPERATORS IN FUZZY LOGIC

Crisp set is transform to fuzzy set in fuzzy logic. Binary Boolean is called as crisp set. Fuzzy logic is advance version of Boolean logic because it uses degree of truth represented by decimal numbers between 0 and 1. Fuzzy logic also uses same kind of operators like Boolean logic used. These operations includes NOT, AND & OR [4].

IV. FUZZY LOGIC MEMBERSHIP FUNCTION

These membership functions are basically a way to represent fuzzy set graphically where degrees of membership is represented by y axis in interval of 0 to 1 and while x axis represents universe [10].

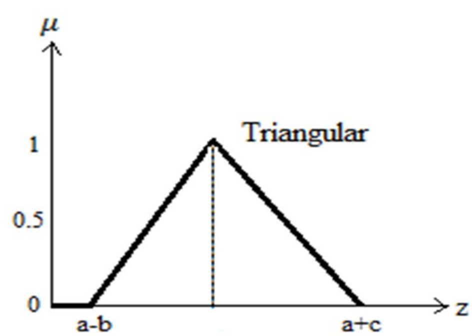


Fig. 3: Triangular shape membership function

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

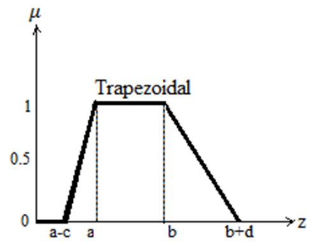


Fig. 4: Trapezoidal shape membership function

Triangle shape membership function is graphically represented in Figure3, it shows 3 sides of triangle in the plot. While Trapezoid shape membership function is graphically represented in Figure 4, it shows 4 sides of trapezoid in the plot. Input and output are represented by these membership functions.

V. NOISES IN IMAGE PROCESSING

A. Impulse Noise or Salt & Pepper Noise

Salt & pepper is very frequently occurs impulse type of noise and intensity spikes is also it's another name.it is caused due to transmission of data. This noise corrupts pixel into only 2 intensities, *255*&0 with probability lower than 0.1. Pixels are corrupted in an alternate sequence and thus gives a look of "salt and pepper" while rest of the pixels remains unchanged. In a 8-bit format, the value of noise can be either 0 or 255 [9][11]. Non-linear sensors in camera, error in timing, bad memory leads to such noise. Noise PDF (probability density function) is shown in Figure 5 (variance = 0.05). This noise in a digital picture is shown in Figure 6.

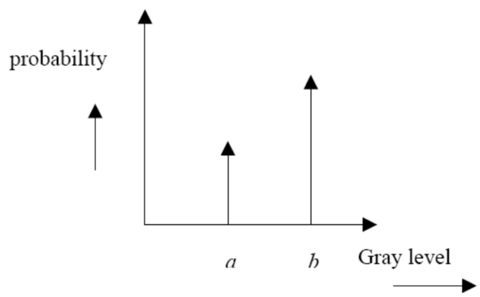


Fig. 5: Salt and pepper noise PDF plot

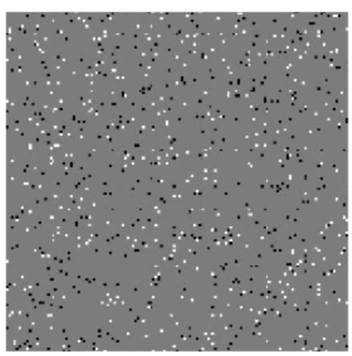


Fig. 6: Digital Image with Salt and pepper impulse noise

B. Gaussian Noise

The noise which is originated in amplifiers is a Gaussian noise, that's why it is also called as electronic noise. Atomic vibrations, warm object radiations etc are the cause of Gaussian noise [11].

Mean value is kept at zero while variance is kept at 0.1. The PDF of Gaussian noise with 256 grey levels is shown in figure 7. The digital image with Gaussian noise is in figure 8.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

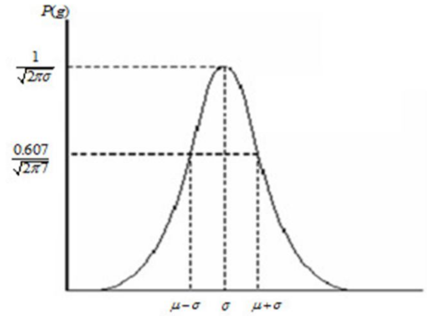


Fig. 7: Gaussian noise PDF plot


Fig. 8:Digital image with Gaussian noise

VI. MEDIAN FILTER

Researchers are using median filter very frequently for image filtering. Its work is to remove all the high frequencies from the digital image that means it works like a LPF (low pass filter). For higher noise density, window size is required to increase in order to accommodate more neighboring pixels [6]. That's why there is always tradeoff between noise density and window size. Thepossible size of window can be 3×3, 5×5, 7×7, and 9×9 etc. the median filter equation is

$Y(i,j)=\text{median}\{I(i-s,j-t),I(i,j)/(s,t)\in W,(s,t)\neq(0,0)\}$ (1)

Here {I} represents noisy image and Y(i,j) represents recovered image [4].

VII.DIRECTIONAL WEIGHTED MEDIAN FILTER

As compared to other median filters, DWM has provided better results and also perform better even in the case when image is distorted by Salt & Pepper noise. It is assumed in DWM that digital images also incldes edges with smoothly carying area both side [3].

Let$P_k$represent a set of pixels aligned with the k-th direction which is centered at (0,0) is given

$P_1 = \{(-2,-2),(-1,-1),(0,0),(1,1),(2,2)\}$

$P_2 = \{(0,-2),(0,-1),(0,0),(0,1),(0,2)\}$

$P_3 = \{(2,-2),(1,-1),(0,0),(-1,1),(-2,2)\}$

$P_4 = \{(-2,0),(-1,0),(0,0),(1,0),(2,0)\}$

Pixels with 5x5 window is,

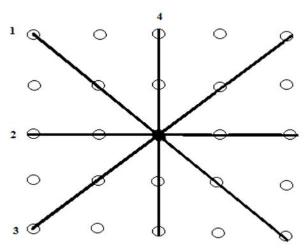


Fig. 5: Four directions for impulse noise detection

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

Now calculate the direction index $d_{i,j}^{(k)}$ using the following formula.

$$d_{i,j}^{(k)} = \sum_{(s,t)\in S_k^0} w_{s,t} \left|y_{i+s,j+t} - y_{i,j}\right| , \qquad 1 \le k \le 4 \tag{2}$$

$$w_{s,t} = \begin{cases} 2, & (s,t) \in \Omega^3 \\ 1, & otherwise \end{cases}, \Omega^3 = \{(s,t): -1 \le (s,t) \le 1\} \tag{3}$$

These direction index are sensitive with the edge in any of the four direction. Impulse can be detected by calculating the minimum value of directional index in all 4 directions and it is represented in the form of equation as,

$$r_{i,j} = \min\{ d_{i,j}^{(k)} \ : 1 \le k \le 4\} \tag{4}$$

Now there are three case possible

1) Noise free flat-region current pixel, then $r_{i,j}$ is small, due to small direction indexes.
2) Current pixel is at edge then $r_{i,j}$is also small, due to small directional index in at least one of the direction.
3) When the current pixel is an impulse then $r_{i,j}$ is large, because of the four large direction indexes.

Output of detection process is equated as:

$$x(i,j)\ is\ a\ \begin{cases} noisy\ pixel, & if\ r_{i,j} > T \\ noise - free\ pixel, & if\ r_{i,j} \le T \end{cases} \tag{5}$$

It can be seen that if the least value of direction index is more than than the pre defined threshold value T, it represents noisey center pixel else pixel is considered as noiselss. As the noise detection process is completed then the median filter is applied on noisy piexel in the window [6].

After it standard deviation $\sigma_{i,j}^k$ is calculated in all 4 directions and then the minimum values is calculated as represented by,

$$l_{i,j} = \underset{k}{argmin}\ \{\sigma_{i,j}^k \ : k = 1\ to\ 4\} \tag{6}$$

Here operator arg min calculate the minimum value. Standard deviation provides information about similarity of all pixel value around the mean value in the neighboring pixels. here $l_{i,j}$ represents the closness of pixels in all 4 directions. So the center pixel will have similar intenstiy to protect edges. Median value can be calculated as.

$$m(i,j) = median\{\tilde{w}_{s,t} \diamond x(i+s,j+t) \ : (s,t) \in \Omega^3\} \tag{7}$$

Where $\tilde{w}_{s,t} = \begin{cases} \tilde{w}_m, & (s,t) \in s_{l_{i,j}}^{(0)} \\ 1, & otherwise \end{cases},$ (8)

operator $\diamond$ denotes repetition operation and normally $\tilde{w}_m = 2$.
The output of the DWM filter is given by following formula.

$$y(i,j) = \alpha(i,j)x(i,j) + (1 - \alpha(i,j))m(i,j) \tag{11}$$

Where $\alpha(i,j) = \begin{cases} 0, & r_{i,j} > T \\ 1, & r_{i,j} \le T \end{cases}$ (9)

VIII. QUALITY PARAMETERS

A. *Mean Square Error (MSE)*

It measures the average of the squares of the errorsthat is, the average squared difference between the estimated values and what is estimated. MSE is a risk function, corresponding to the expected value of the squared error loss [10].

It is a measure of the quality of an estimator. It is always non-negative, and values closer to zero are better.

If $o(i,j)$ represents original image and corrupted image is represented by$x(i,j)$ then MSE is given by,

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(o(i,j) - x(i,j))^2 \qquad (10)$$

Here M x N is the resolution of the corrupted image. Imax is the maximum possible intensity in the gray scale image.

B. *Peak Signal To Noise Ratio (PSNR)*

This ratio is often used as a quality measurement between the original and a recovered image. The higher the PSNR the better will be the quality of the reconstruction of image.

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

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

(11)

Here M x N is the resolution of the corrupted image. Imax is the maximum possible intensity in the gray scale image, in case of unsigned integerthat is 255, here 255 represents color white[8].

IX. CONCLUSION

Digital images are corrupted by salt & pepper noise as well as Gaussian noise due to many sources like camera and communication modes. The combination of Gaussian and salt & pepper noise is called as mixed noise. Directional median filter performs better with directional edges in the digital image as well as replace only corrupted pixels unlike simple median filter which perform filtering on all the pixels. Application of fuzzy logic controllers in the field of image processing is taking out good results. As per latest research, combination of directional median filter and fuzzy logic is giving better results. In this paper, it is concluded that fuzzy logic based directional median filters performs better than other filters for filtering mixed noise corrupted digital image. Quality parameter like PSNR and MSE are also discussed in this paper&PSNR.

REFERENCES

[1] VahidKiani, Iran Abbas Zohrevand, “A Fuzzy Directional Median Filter for Fixed-value Impulse Noise Removal”, Iranian Joint Congress on Fuzzy and Intelligent Systems (CFIS), Jan 2019.

[2] Rita Gupta, AkanshaYadav, “Fuzzy Logic based Switching Median Filter for Mixed Noise in Digital Image”, IJSRD - International Journal for Scientific Research & Development, Vol. 5, Issue 07, 2017.

[3] Zong Chen and Li Zhang,“Multi-stage Directional Median Filter”, World Academy of Science, Engineering and Technology 59 2009.

[4] SweetyDeswal, SurbhiSinghania, Shailender Gupta and PranjalGarg , “An Optimised Fuzzy Approach to Remove Mixed Noise from Images”, International Journal of Signal Processing, Image Processing and Pattern Recognition Vol.9, No.4 (2016).

[5] Chung-ChiaKang, Wen-JuneWang, “Fuzzy reasoning-based directional median filter design”, Signal Processing, Volume 89, Issue 3, March 2009.

[6] BogdanSmolka, Damian Kusnik, “Robust local similarity filter for the reduction of mixed Gaussian and impulsive noise in color digital images”,SIViP, springer, Oct 2015.

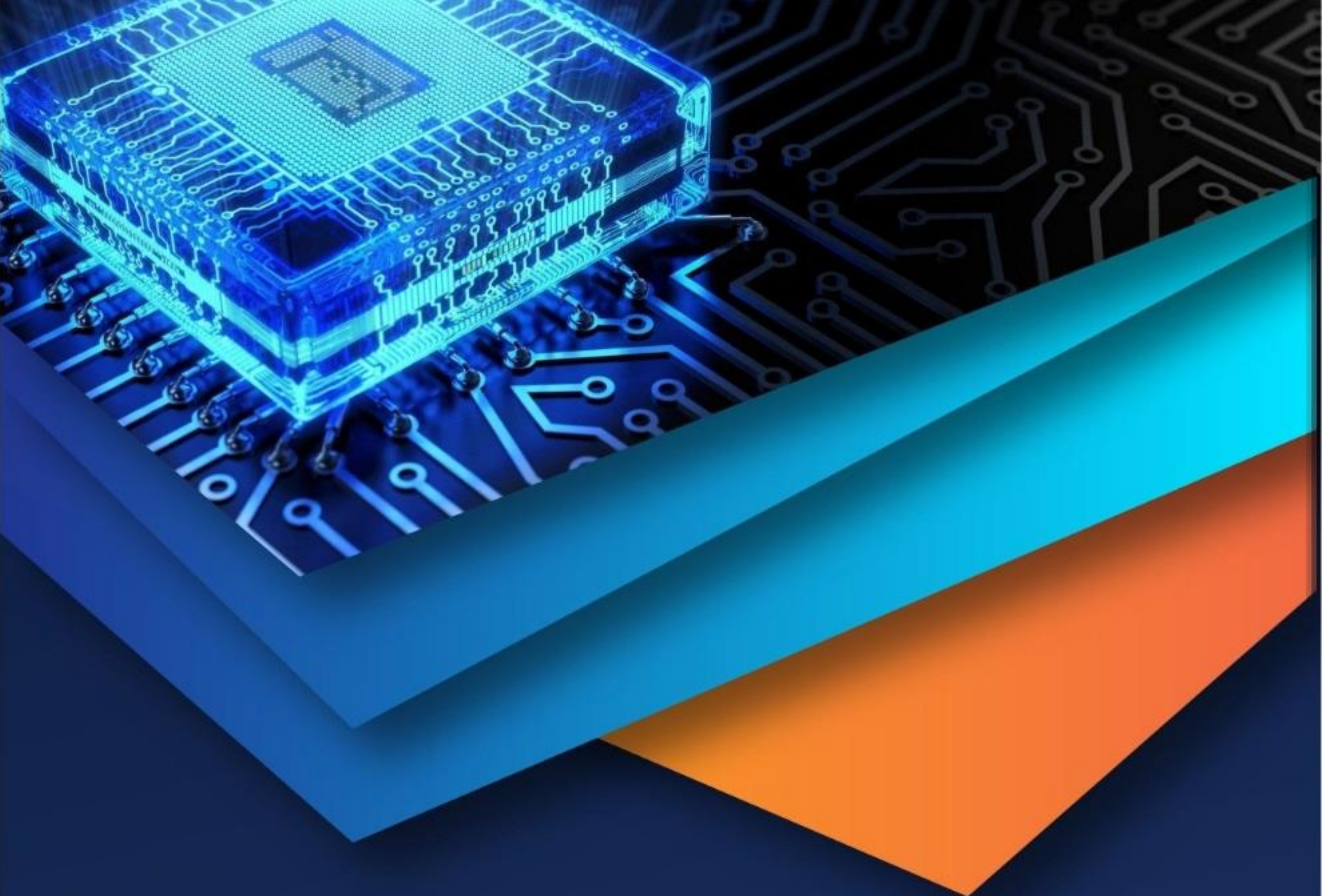
[7] D. V. Murugan, R. Balasubramanian, “An Efficient Gaussian Noise Removal Image Enhancement Technique for Gray Scale Images“, International Journal of Computer, Electrical, Automation, Control and Information Engineering Vol 9, No 3, 2015.

[8] Mahesh Prasanna K and Dr. ShantharamaRai C, “Applications of Fuzzy Logic in Image Processing – A Brief Study “, international journal of advanced computer technology, (Volume 4, Issue 3), March-2015.

[9] Kenny Kal Vin Toh, Haidi Ibrahim and Muhammad NasiruddinMahyuddin, “Salt-and-Pepper Noise Detection and Reduction Using Fuzzy Switching Median Filter”, IEEE Transactions on Consumer Electronics, Vol. 54, No. 4, NOVEMBER 2008.

[10] agashettappaBiradar, M.L.Dewal, Manoj Kumar Rohit, “SPECKLE NOISE REDUCTION USING HYBRID TMAV BASED FUZZY FILTER”, International Journal of Research in Engineering and Technology, Volume 3, Special Issue 3, May 2014.

[11] M. A. P. Chamikara, A. A. C. A Jayathilake, S. R. Kodituwakku, Fuzzy Based Statistical Method for Image Noise Filtering, International Journal of Advanced Research in Computer Science and Software Engineering, Volume 4, Issue 10, October 2014.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY