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FUZZY BASED NEW ALGORITHM FOR NOISE REMOVAL AND EDGE DETECTION

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***Abstract**: This paper presents a two stage fuzzy based noise reduction-cum-edge detection filter i.e. INAFSM (image & noise adaptive fuzzy switching median) filter for efficient removal of impulse noise (salt and pepper noise) from grayscale images. So the main objective of this work is to get almost an actual image from the corrupted image. Also, it focuses on the analysis of FIDRM, FSM, NAFSM and the proposed filter (INAFSM) on the basis of PSNR (dB), and the MSE (mean square error). The analyzed results show that INAFSM is able to cope up with all types of grayscale images corrupted with impulse noise.*

***Keywords**: FSM, NAFSM, INAFSM, PSNR, MSE*

I. Introduction

Removing or reducing impulse noise is a very active research area in image processing. Impulse noise is caused by errors in the data transmission generated in noisy sensors or communication channels, or by errors during the data capture from digital cameras. Noise is usually quantified by the percentage of pixels which are corrupted. Corrupted pixels are either set to the maximum value or have single bits flipped over. In some cases, single pixels are set alternatively to zero or to the maximum value. This is the most common form of impulse noise and is called salt and pepper noise. Nevertheless other types of impulse noise are possible as well. An algorithm that is especially developed for reducing all kinds of impulse noise is NAFSM (Noise Adaptive Fuzzy Switching Median Filter) [32]. The result is an image quasi without (or with very little) impulse noise so that other filters can be used afterwards. This nonlinear filtering technique contains two separated steps: an impulse noise detection step and a reduction step that preserves edge sharpness. Experimental results show that NAFSM provides a significant improvement on other existing filters. NAFSM is not only very fast but also very effective for reducing little as well as very high impulse noise. But the limitation is that it cannot perform well with all types of images. A new method INAFSM (image & noise adaptive fuzzy switching median filter) is proposed here for removing impulse noise from almost every type of grayscale image. The work in this paper is based on two image processing steps viz. noise reduction and edge detection as shown below in the block diagram form:

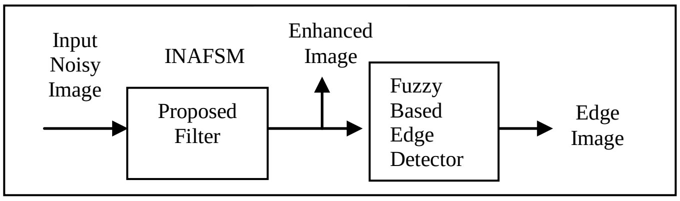


Fig.1 Steps in Proposed Work

The input image corrupted with any amount of impulse noise is applied to the proposed INAFSM noise reduction filter as input. The output of this filter is the enhanced image with very fine details. This enhanced image is then applied to the proposed fuzzy based image edge detector. The output of the system is the edge detected image with very fine edges. In the following sections, the FSM (fuzzy switching median) filter is discussed first with the introduction of NAFSM (noise adaptive fuzzy switching median) filter afterwards. The improvement over NAFSM i.e. the proposed method, INAFSM (image & noise adaptive fuzzy switching median filter) is then explained with the fuzzy logic edge detection algorithm applied to the enhanced image.

II. Fuzzy Switching Median Filter

The digital images that the fuzzy switching median filter [24] deals with are grayscale images whose intensity values are stored as an 8-bit integer. Thus the possible gray level values are 256 in the range [0 256]. The impulse noise takes on minimum and maximum values and appears with certain probability in the digital images [1]. The noise can be either negative or positive. The negative impulse appears as black i.e. peppers with zero intensity and probability p_{b}. Conversely, the white impulse appears with probability p_w and the intensity value equals to 255. If the level of impulse noise lies between zero up to 0.25, the image is considered to be corrupted as low and if it ranges above 0.45, the noise is considered as high otherwise the noise is treated as moderate noise. The fuzzy switching median filter operates in two separate modules viz. noise detection and noise filtering stages.

III. Noise Adaptive Fuzzy Switching Median Filter

The noise adaptive fuzzy switching median filter [32] was proposed after fuzzy switching median filter [24] by the Kenny Kal et al and is a two stage recursive filter. The two impulse noise intensities are found before detecting the noisy pixels in the image. If a pixel is classified as a noisy pixel, the filtering stage is called otherwise the noise free pixel is restored without any alteration. The NAFSM algorithm works similar to FSM except with little advancements. The detection stage works same as in the fuzzy switching median filter. A noise mask N(i,j) is created using the two salt & pepper noise intensities and the noisy image according to the rule mentioned below:

$$N(i, j) = \begin{cases} 0, & X(i,j) = L_{salt} \text{ or } L_{pepper} \\ 1, & \text{otherwise} \end{cases}$$

The noise adaptive fuzzy switching median filter works well with high levels of impulse noise. However there are some problems associated with its processing. The drawbacks that were encountered while experimenting with various types of images are outlined as below:

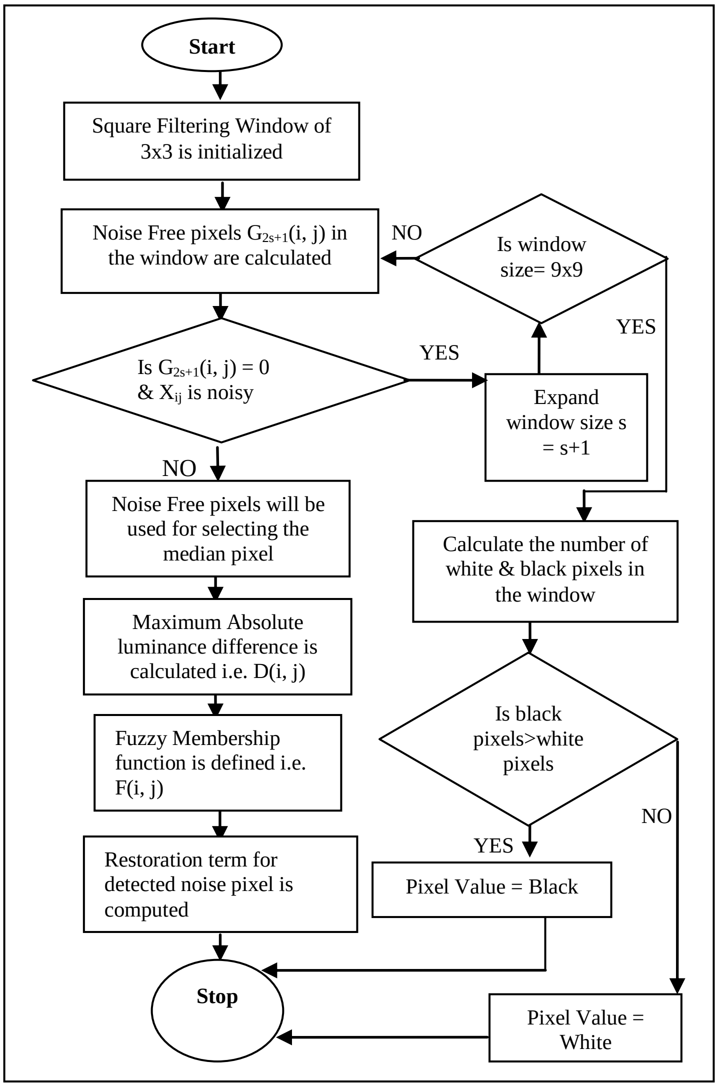
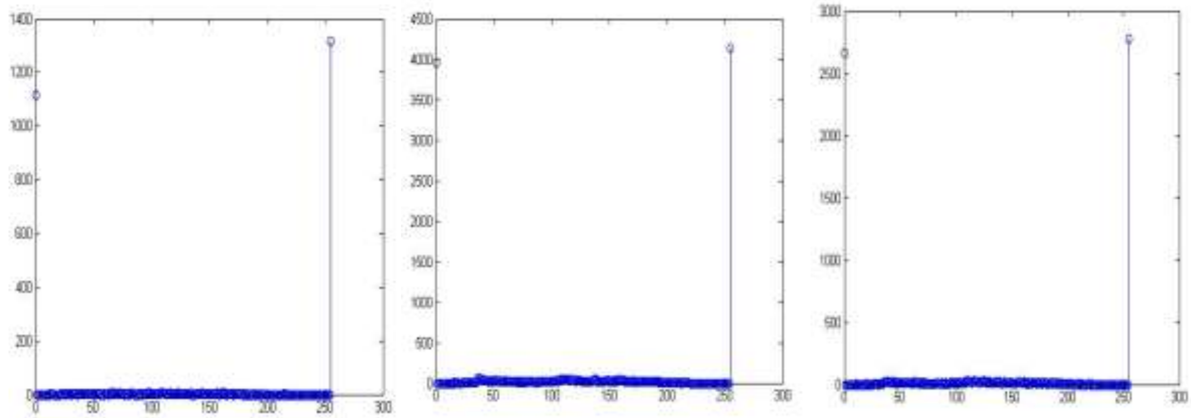


Fig.2: Flowchart for the Proposed Method (INAFSM)

When calculating the number of noise-free pixels in the square filtering window, the filter returns $G_{ij} = 0$ even when the pixel under consideration is noise-free. Due to this reason, the filtering window is expanded unnecessarily up to 7x7 where finally the pixel is restored with the median value of first four pixels even when it is noise-free. The NAFSM filter fails to cope up with images having backgrounds with black or white pixels. Due to the absence of intensities other than impulse noise intensities in the square filtering window up to 7x7, the pixel is restored with median value which can be black when the background is white or vice-versa. These two problems have been considered in what is known as INAFSM, the proposed method i.e. image and noise adaptive fuzzy switching median filter. The noise detection module of the proposed method works according to the method adopted by the NAFSM filter. However the filtering action works differently from the one used by FSM or NAFSM filters. The filtering action begins the same way by considering the 3x3 square window initially. The number of noise-free pixels G_{ij} are then calculated using the noise mask N (i, j). If the square filtering window contains at least one noise-free pixel i.e. the pixel with N(i,j) = 1, the filtering stage then calculates the median using those noise free pixels.

IV. Results

The various standard images were tested for analyzing the performance of the proposed method. For comparative analysis, other fuzzy based filters such as fuzzy impulse noise detection & reduction method (FIDRM), fuzzy switching median filter (FSM), noise-adaptive fuzzy switching median filter (NAFSM) are also tested with the same images. Figure 3.1 shown below are the histogram plots of Lena image corrupted with varying levels of impulse noise i.e. 10%, 50% and 90& respectively. Figure 3.2 shows the standard Lena image corrupted with 10%, 50% and 90% impulse noise respectively. At high levels of noise, the image details are totally invisible and hence very difficult to extract. Figure 3.3 shows the filtering performance of fuzzy impulse noise detection and reduction method. Further, Figure 3.4 analyzes the performance of fuzzy switching median filter at different noise levels. The FIDRM filter works well for low levels of impulse noise but degrades after moderate or high levels of noise. However, the FSM filter works well at low and moderate impulse noise levels but performs poor at high levels of noise.



(a) (b) (c)

Fig. 3.1 Noisy Lena Image Histogram (a) Histogram of 10 % Noisy image, (b) Histogram of 50 % Noisy image, and (c) Histogram of 90 % Noisy image

(a) (b) (c)

Fig 3.2 (a), (b) & (c) Lena Image corrupted with 10%, 50% & 90% impulse noise respectively.

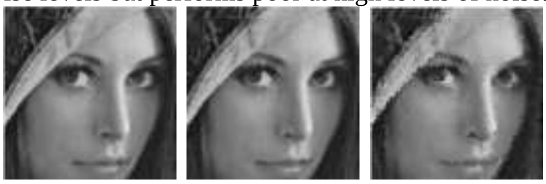
(a) (b) (c)

Fig. 3.3 (a), (b) & (c) Lena Image filtered by FIDRM with 10%, 50% & 90% impulse noise respectively.

(a) (b) (c)

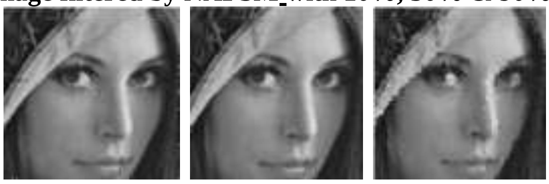
Fig. 3.4 (a), (b) & (c) Lena Image filtered by FSM with 10%, 50% & 90% impulse noise respectively.

Figure 3.2 shows the standard Lena image corrupted with 10%, 50% and 90% impulse noise respectively. At high levels of noise, the image details are totally invisible and hence very difficult to extract. Figure 4.3 shows the filtering performance of fuzzy impulse noise detection and reduction method. Further, Figure 4.4 analyzes the performance of fuzzy switching median filter at different noise levels. The FIDRM filter works well for low levels of impulse noise but degrades after moderate or high levels of noise. However, the FSM filter works well at low and moderate impulse noise levels but performs poor at high levels of noise.



(a) (b) (c)

Fig. 3.5 (a), (b) & (c) Lena Image filtered by NAFSM with 10%, 50% & 90% impulse noise respectively.



(a) (b) (c)

Fig. 3.6 (a), (b) & (c) Lena Image filtered by Proposed Method (INAFSM) with 10%, 50% & 90% impulse noise respectively.

The huge database of standard images has been taken to analyze the performance of various impulse noise reduction filters. The size of the images has been taken to be 256x256, the reason being the appropriate size for short simulation time as well as the processing at this size maintains almost all the image details. The above Figure 3.3 to Figure 3.6 shows the performance of various fuzzy filters. Figure 4.1 shows the histogram of standard Lena image corrupted with 10%, 50% and 90% levels of impulse noise. In Figure 3.3, the performance of FIDRM filter is shown. The FIDRM filter works well with very low levels of impulse noise only and fails to filter out moderate & high noise. Figure 3.4 shows the images filtered out by Fuzzy switching median filter.

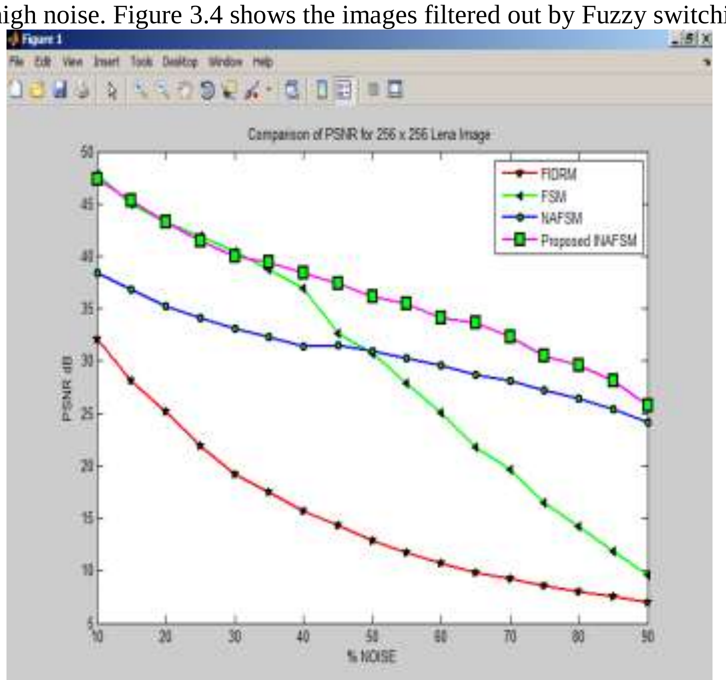


Fig. 3.7 Peak-Signal-to-Noise Ratio Vs % Noise of 256x256 Lena Image

As can be analyzed well, the FSM filter works nice for low levels & moderate noise levels but again the FSM filter also could not perform well in high noise environments.
However, the NAFSM filter works better with low to high levels of noise but still the PSNR value could not achieve betterment at low levels of noise. The NAFSM filter also fails to filter out the noise from the images having backgrounds of black or white pixels. In Figure 3.6, the Lena images filtered with the proposed method are shown. The proposed method works excellent from very low levels of impulse noise to over high noisy environments. Figure 3.7 & Figure 3.8 shows the PSNR & MSE values respectively for various levels of impulse noise for standard Lena image of size 256 x 256.

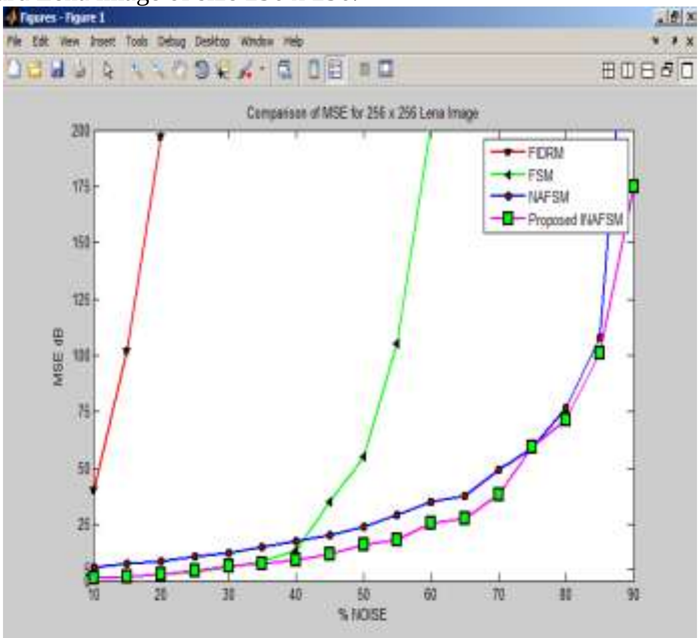


Fig. 3.8 Mean Square Error Vs % Noise of 256x256 Lena Image

V. Conclusion

The proposed filter (INAFSM) is able to suppress very low to very high density of noise from digital images of various types. The visual results along with peak signal-to-noise ratio and mean square error plots explain the excellent performance of the proposed technique over other methods discussed in this report.

References

[1] R.C. Gonzalez and R.E. Woods, Digital Image Processing (Second Edition), Prentice Hall, 2001
[2] K. Teddy, "Fingerprint Enhancement by Spectral Analysis Techniques," in 31st Applied Imagery Pattern Recognition Workshop, Washington DC, WA, pp. 16-18, Oct 2002.
[3] D. W. Armitage, and J. P. Oakley, "Noise Levels in Color Image Enhancement," in Visual Inform. Eng., London, UK, pp. 105-108, July 2003.
[4] P. Fridman, "Radio Astronomy Image Enhancement in the Presence of Phase Errors using Genetic Algorithms," in Int. Conf. on Image Process., Thessaloniki, Greece, pp. 612-615, Oct 2001.
[5] T. Jinshan, K. Jeonghoon, and E. Peli, "Image Enhancement in the JPEG Domain for People with Vision Impairment", IEEE Trans. Biomed. Eng., vol. 51, no. 11, pp. 2013-2023, Nov 2004.
[6] D.Y. Tsai, L. Yongbum, M. Sekiya, S. Sakaguchi, and I. Yamad, "A Method of Medical Image Enhancement using Wavelet Analysis," in 6th Int. Conf. Signal Process., Beijing, China, pp. 723-726, Aug 2002.
[7] M. Annappa Koli, "Review of Impulse Noise Reduction Techniques", International Journal on Computer Science and Engineering, Vol. 4 No. 02 Feb 2012.
[8] T. Chaira, Ajoy Kumar Raj "Fuzzy image Processing and Applications with MATLAB" CRC Press, 2010.
[9] S. Ko and Yong Hoon Lee, "Center weighted median filters and their applications to image enhancement", IEEE Transactions on Circuits & Systems, Vol. 38 No. 9, Sept 1991.
[10] C. Tyan and Paul P. Wang, "Image processing - enhancement, filtering and edge detection using the fuzzy logic approach", 0-7803-0614-7, IEEE, 1993.
[11] R.C. Hardie and Charles G. Boncelet, "LUM Filters: A class of rank-order-based filters for smoothing and sharpening", IEEE Transactions on Signal Processing. Vol. 41, No. 3, March 1993.
[12] F. Russo and Giovanni Ramponi, "A Fuzzy Filter for Images corrupted by Impulse Noise", IEEE Signal Processing Letters, Vol. 3, No. 6, June 1996.
[13] E. Abreu, Michael Lightstone, Sanjit K. Mitra, and Kaoru Arakawa, "A new efficient approach for the removal of impulse noise from highly corrupted images", IEEE Transactions on Image Processing, Vol. 5, No. 6, June 1996.
[14] F. Russo and Giovanni Ramponi, "Removal of impulse noise using a FIRE filter", in Proc. Third IEEE Intern. Conf. on Image Processing, 1996, pp. 975-978.
[15] Tao Chen, Kai-Kuang Ma, and Li-Hui Chen, "Tri-state median filter for image denoising", IEEE Transactions on Image Processing, Vol. 8, pp. 1834–1838, Dec.1999.

[16] T. Chen and Hong Ren Wu, "Adaptive impulse detection using center-weighted median filters", IEEE Signal Processing Letters, Vol. 8, No. 1, Jan. 2001.

[17] Shuqun Zhang and Mohammad A. Karim, "A new impulse detector for switching median filters", IEEE Signal Processing Letters, Vol. 9, No. 11, Nov. 2002.

[18] D. Van De Ville, M. Nachtegael, D. Van Der Weken, E. E. Kerre and W.Philips, "Noise reduction by fuzzy image filtering," IEEE Transactions on Fuzzy Systems, vol. 11, No. 4, Aug. 2003.

[19] W. Luo, "An efficient detail-preserving approach for removing impulse noise in images", IEEE Signal Processing Letters, Vol. 13, No. 7, July 2006.

[20] S. Kannappadyt, Kudret Demirli, Sudhir P. Mudurt, Nematollaah Shirit, "Applications of fuzzy edge detection for fast object-based image retrieval", IEEE, 2006.

[21] K. S. Srinivasan and D. Ebenezer, "A new fast and efficient decision-based algorithm for removal of high-density impulse noise", IEEE Signal Processing Letters, Vol. 14, No. 3, March 2007.

[22] D.Z. Feng, Yin Zhou-Ping, and Xiong You-Lun, "High probability impulse noise-removing algorithm based on mathematical morphology", IEEE Signal Processing Letters, Vol. 14, No. 1, Jan 2007.

[23] P.Y. Chen and Chih-Yuan Lien, "An efficient edge-preserving algorithm for removal of salt-and-pepper noise", IEEE Signal Processing Letters, Vol. 15, 2008.

[24] K.K. Vin Toh, Haidi Ibrahim and Muhammad Nasiruddin Mahyuddin, "Salt-and-pepper noise detection and reduction using fuzzy switching median filter", IEEE Transactions on Consumer Electronics, Vol. 54, No. 4, Nov. 2008.

[25] H. Ibrahim, Nicholas Sia Pik Kong, and Theam Foo Ng," Simple adaptive median filter for the removal of impulse noise from highly corrupted images", IEEE Transactions on Consumer Electronics, Vol. 54, No. 4, Nov. 2008.

[26] H. Xu and Xiaorui Yue, "An adaptive fuzzy switching filter for images corrupted by impulse noise", Sixth International Conference on Fuzzy Systems and Knowledge Discovery, IEEE 2009.

[27] A. Taguchi, Tomoaki Kimura and Hiroyuki Tsuji, "Image enhancement of noisy images by using fuzzy data-dependent bilateral filter", Sixth International Conference on Fuzzy Systems and Knowledge Discovery, IEEE 2009.

[28] H. S. Kam and W. H. Tan, "Impulse detection adaptive fuzzy (IDAF) filter", International Conference on Computer Technology and Development, IEEE 2009.

[29] X. Zhang and Youlun Xiong, "Impulse noise removal using directional difference based noise detector and adaptive weighted mean filter", IEEE Signal Processing Letters, Vol. 16, No. 4, April 2009.

[30] X. Chen and Yujuan Chen, "An improved edge detection in noisy image using fuzzy enhancement", IEEE 2010.

[31] Y. Lin, Bin Fang and Yuanyan Tang, "Image restoration using fuzzy impulse noise detection and adaptive median filter", IEEE 2010.

[32] K.K. Vin Toh 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.

[33] A. Hussain, Qaisar Javaid and Mohammad Siddique, "Impulse noise removal using fuzzy logic and alpha-trimmed mean", IEEE International Conference on Signal and Image Processing Applications, 2011.

[34] K. Somasundaram and K. Ezhilarasan, "Edge detection in MRI of head scans using fuzzy logic", IEEE International Conference on Advanced Communication Control and Computing Technologies, 2012.

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