Fuzzy Logic Based Adaptive Noise Filter for Real Time Image Processing Applications

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Abstract

This paper represents Fuzzy logic based Adaptive Noise filter for real time image processing applications. Initially, the detection is performed using 3x3 scan and then taking a mean of four pixels further scanning is performed. Then histogram approach is applied for improving the image quality, textures and edges. The detection stage will identify the noise pixels. In the second stage of filtering if pixels are noise-free then they are left unprocessed. This filter uses fuzzy reasoning to remove uncertainty present in the information as introduced by the noise. Simulation results outperform salt and pepper noise more than the previous worked filters.

Keywords: *Fuzzy reasoning, salt & pepper noise, fuzzy logic based adaptive noise filter, histogram approach.*

1. Introduction

The two common type of noise in image processing are Gaussian noise and Impulse noise, also known as salt & pepper noise. This type of noise may appear in digital image due to contaminated impulse noise, which is caused by malfunctioning pixels in camera sensors, faulty memory location in hardware, or transmission in noisy channel[1]. One of the simplest ways to remove salt & pepper noise is by windowing the noisy image with the conventional median filter[2]. However, this process of filtering exhibits blurring of filtered images.

Recently, Luo in [3] proposed an efficient detail preserving approach (EDPA) based on alpha-trimmed mean statistical estimator. Also, an efficient edge preserving algorithm (EEPA) was introduced for the removal of salt & pepper noise without degrading fine image details. Then, Chen and Wu[5] proposed the adaptive impulse detector with center-weighted median (ACWN)filter to remove effectively salt & pepper noise. These methods only perform well when an image is corrupted with 50% salt & pepper noise or lower. The decision based algorithm [6] filter and open-close sequence filter (OCS) based on mathematical morphology [7] and noise adaptive fuzzy switching median filter [8] are able to filter high density of salt & pepper noise corruption, but at the expense of fine image details or high computational time[9].

In this letter, a new type of salt & pepper noise filter is proposed called the fuzzy logic based adaptive noise filter for real time image processing applications.

2. Fuzzy Logic based Adaptive Noise Filter

The proposed filter is a three stage filter, where initially it will perform the salt & pepper noise intensities detection. When a noise pixel is identified it is subjected to the next filtering stage. Otherwise, when a pixel is classified as noise-free, it will be retained and the filtering action is spared to avoid altering any fine image details and textures that are contained in the original image.

2.1 The Detection Stage

The detection stage of the proposed filter will search for the two local maximums, Lsalt and Lpepper. The search is directional sensitive and will be directed towards the centre of an image matrix. For an image stored as an 8-bit integer, Lsalt = 255 while Lpepper = 0.

These intensities will detect the noisy pixel. To mark the location of noisy pixel, a mask M(i,j) is created.

$$M(i,j) = \begin{cases} 0, & X(i,j) = \text{Lsalt or Lpepper} \\ 1 & \text{otherwise} \end{cases}$$

Where X(i,j) is the pixel at location (i,j) with intensity X, M(i,j) = 1 represents noise free pixels to be retained from the noisy image while M(i,j) = 0 represents noise pixels

2.2 The Filtering Stage

In the filtering stage, the noise pixels are undergone 3x3 scanning by comparing centred pixel with the rest of the pixels. The algorithm applied for 3x3 scan by considering centre pixel is

$$d(i,j) = \left| X(i+k, j+l) - X(i,j) \right| \text{ with } (i+k, j+l) \neq (i,j)$$

where d(i,j) is the absolute luminance difference, X(i,j) is the noisy pixel.

After the 3x3 scanning process, scanning process is applied by taking a mean of four pixels and comparing with the rest of the pixels. This merge scanning is done in order to remove the noisy pixels that cannot be removed by 3x3 scanning process. The algorithm applied for merge scanning is

$$f(i,j) = \left| d(i,j) - m(i,j) \right| / th$$

where f(i,j) is the merge scanning, d(i,j) is the absolute luminance difference, m(i,j) is the mean of the four pixels that are compared with the rest of the pixels, th is the threshold used for the scanning process.

After the noise is removed, the edges and textures of the image are to be improved. This is done with the help of histogram approach.

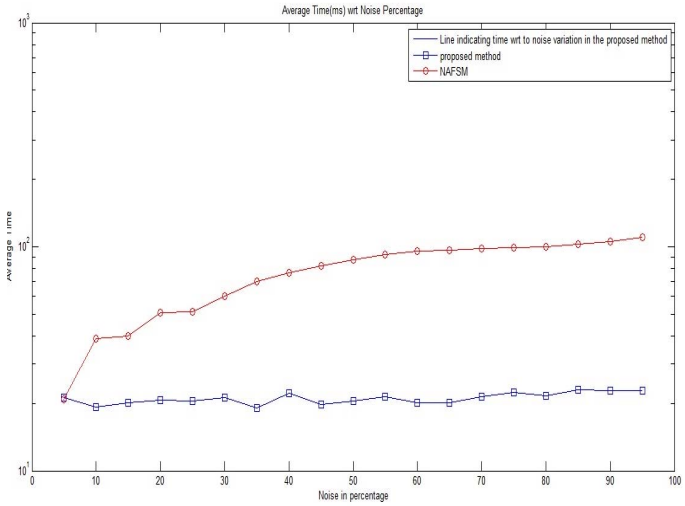
At the end, by using ten standard test images (Baboon, Boat, cameraman, goldhill, lake, lena, lighthouse, parrot, pepper and plane) average PSNR (dB) and average time (ms) is calculated.

3. Simulation and results

In this section, average PSNR (dB) and average time (ms) are calculated using ten standard test images (baboon, boat, cameraman, goldhill, lake, lena, lighthouse, parrot, pepper and plane).

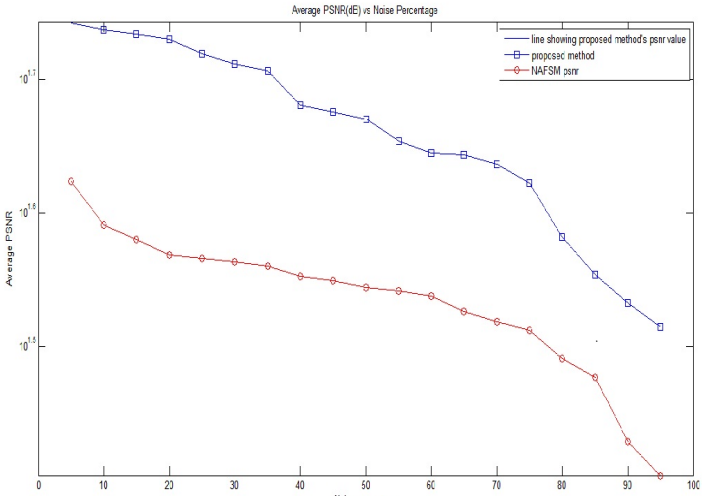
3.1 Average Time(ms):

The proposed filter calculates average time (ms). The average PSNR (dB) is calculated from 5% of salt & pepper noise to 95% of salt & pepper noise by using ten standard test images. The proposed filter shows that proposed filter has less delay in the filtering process than the previous NAFSM filter.



3.2 Average PSNR (dB):

The proposed filter calculates average PSNR (dB). It is calculated from 5% of salt & pepper noise to 95% of salt & pepper noise by using ten standard test images. The proposed filter shows better PSNR (dB) than the previous NAFSM filter.



4. Conclusion

The proposed Fuzzy Logic based Adaptive Noise Filter for Real Time Image Processing Application is able to suppress salt & pepper noise. Moreover, it is also able to preserve fine image details, edges and textures as were of the original image. It does not require any further tuning or training of parameters once optimized. The proposed filter is able to yield good filtering results with efficient processing time, thus obtaining the desired results.

References

[1] K. K. V. Toh, H. Ibrahim, and M. N. Mahyuddin, "Salt-and-pepper noise detection and reduction using fuzzy switching median filter," *IEEE Trans. Consumer Electron.*, vol. 54, no. 4, pp. 1956–1961, Nov. 2008.
[2] R. C. Gonzalez and R. E.Woods, *Digital Image Processing*, 2nd ed. Upper Saddle River, NJ: Prentice-Hall, 2002.
[3] W. Luo, "An efficient detail-preserving approach for removing impulse noise in images," *IEEE Signal Process. Lett.*, vol. 13, no. 7, pp. 413–416, Jul. 2006.
[4] P. Y. Chen and C. Y. Lien, "An efficient edge-preserving algorithm for removal of salt-and-pepper noise," *IEEE Signal Process. Lett.*, vol. 15, pp. 833–836, 2008.
[5] T. Chen and H. R. Wu, "Adaptive impulse detection using center-weighted median filters," *IEEE Signal Process. Lett.*, vol.8, no. 1, pp. 1–3, Jan. 2001.
[6] K. S. Srinivasan and D. Ebenezer, "A new fast and efficient decision based algorithm for removal of high-density impulse noises," *IEEE Signal Process. Lett.*, vol. 14, no. 3, pp. 189–192, Mar. 2007.
[7] Z. F. Deng, Z. P. Yin, and Y. L. Xiong, "High probability impulse noise-removing algorithm based on mathematical morphology," *IEEE Signal Process. Lett.*, vol. 14, no. 1, pp. 31–34, Jan. 2007.
[8] Kenny Kal Vin Toh, Nor Ashidi Mat Isa, "Noise Adaptive Fuzzy Switching Median Filter for Salt & Pepper Noise Reduction", IEEE Signal Processing letters, vol.17, no.3, march 2010.
[9] X. Zhang and Y. Xiong, "Impulse noise removal using directional difference based noise detector and adaptive weighted mean filter," *IEEE Signal Process. Lett.*, vol. 16, no. 4, pp. 295–298, Apr. 2009.
[10] www.wikipedia.org
[11] www. Google.com