Applied Mathematics & Information Sciences
An International Journal

http://dx.doi.org/10.18576/amis/100339

Application of Fuzzy Logic Detector to Improve the Performance of Impulse Noise Filter

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Received: 5 Nov. 2015, Revised: 5 Feb. 2016, Accepted: 6 Feb. 2016
Published online: 1 May 2016

Abstract: Images and pictures are required as sources of information for analysis and interpretation in various fields such as medicine, remote sensing etc., These images are prone to impulse noise as a result of errors in the image acquisition or transmission process. Thus, the output image needs to be enhanced. This work presents a novel fuzzy logic based impulse detector to guide the noise filter to improve their performance and to restore images corrupted by impulse noise. The proposed scheme is based on the sugeno type and its parameters are trained using genetic algorithm. Simulation results show that this proposed detector can be effectively used to improve the performance of the impulse noise filter.

Keywords: Fuzzy Logic, Genetic Algorithm, Salt & Pepper Noise, Noise Filter, Impulse Noise Detector.

1 Introduction

The wide usage of multimedia material increases the usage of high quality of digital images in many application areas including astronomy, biology, medicine, remote sensing, material science etc. During image acquisition, the digital images are often corrupted by impulse noise due to transmission error, malfunctioning of pixel elements in camera and due to error in analog to digital conversion. Apart from this, it is also corrupted due to an imperfect medium between the original scene and the imaging system. The noise can be classified as substitutive noise and additive noise. Removal noise from image plays an important role in image processing application, because the performance of the image processing tasks dependent upon the noise removal operation. Hence in order to remove noise from the image, variety of techniques has been introduced. [1–5] Specifically, for removal of impulse noise, median filter [6] is proposed. The standard median lter is a simple rank selection lter and attempts to remove impulse noise from the center pixel of the analysis window by changing the luminance value of the center pixel with the median of the luminance values of the pixels contained within the window. This approach provides a reasonable noise removal performance with the cost of introducing undesirable blurring effects into image details even at low noise densities. Since its application to impulse noise removal, the median lter has been of high research interest and a number of rank- order-based lters trying to avoid the inherent drawbacks of the standard median lter. Weighted order statistic lters, such as the weighted median lter [7] [8] and the center-weighted median lter, employ a mechanism for appropriately weighting pixels of the analysis window to control the transaction between the noise suppression and detail preservation. These lters yield better detail preservation performance than the median lter Stack lters are a class of order statistic lters consisting of some other rank order based impulse noise lters as subclasses. Rank conditioned rank selection lters are another large class of order statistic lters comprising many other rank order based impulse noise lters, including the stack lters. Different implementations of these lters were used for impulse noise suppression. Conventional order statistic lters usually distort the uncorrupted regions of the input image during restoration of the corrupted regions, introducing undesirable blurring effects into the image.

The signal-dependent rank-ordered mean lter is an other median-like lter, which also utilizes the rank order information of the pixels contained within the ltering window. The lter exhibits better detail preservation and noise removal performance than the standard median lter. It is also applied for the removal of impulse noise from

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color images. There are also similar ltering methods for the detection and removal of impulse noise from color images. As all the conventional methods have the disadvantage of introducing undesirable distortions into image during noise reduction, the research is moved towards a design of non-linear filtering techniques based on soft computing method.

The filtering methods based on soft computing techniques will improve the performance of traditional filtering method. Thus, in this work, a impulse noise detector employing fuzzy method is proposed this detector can be combined with any impulse noise removal operator to reduce the noise present in the image and the performance is evaluated for different images with different noise densities.

2 Proposed Impulse Detector

The fig.1 shown in proposed fuzzy detector consists of two fuzzy based sub-detectors, first one defuzzifier and second one is processor. The luminance value of pixels in the analysis window is given as input to the sub-detector. Each sub-detector is a first order sugeno type system with three inputs and one output. Each input has a Gaussian type membership function and the output is linear for each combination of input and output, rule base is formed. As it contains three inputs, twenty seven rule based are formed. The output of the sub-detector is fed to the defuzzifier and is converted into scalar value. The scalar values obtained from two defuzzifiers are given as input to the processor, which converts then into a single output value. The processor calculates the average value of two defuzzifier and compares the calculated with a value corresponding to half of the dynamic luminance large [9–13]. Thus the value of P i.e. Output of the processor is expressed as follows.

$$P = \begin{cases} 0 if \frac{d_V + d_H}{z} < \frac{L_{\min} + L_{\max}}{2} \\ 1 \; other\, wise \end{cases} \quad (1)$$

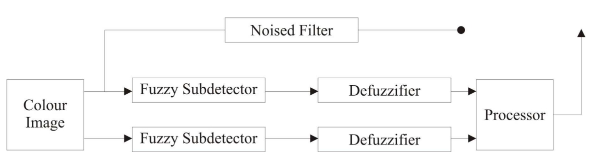

Fig. 1: Proposed fuzzy detector

3 Tracing of Sub detector

The parameters of input and output membership functions of the two sub detectors are optimized using genetic algorithm [14, 15]. The parameters of the subdetector under training are adjusted according to the ideal impulse detector. The designed process includes three training images namely original training image, the noisy training image and the noise detection image. The original image is generated by using data base in a computer. The noisy image is obtained by the corrupting the original using a impulse noise. The third image is obtained by subtracting noisy image from the original image. The pixels which are same in both the images are considered as zero and the difference in pixels are considered as one. The noise detection image replace zeros with black pixels and replaces one with white pixel from this, it is inferred that the location of noisy pixels and the black pixels represents the uncorrupted pixels.

4 Processing Of Input Image

The procedure for processing the noisy input image with a noise filter is as follows.

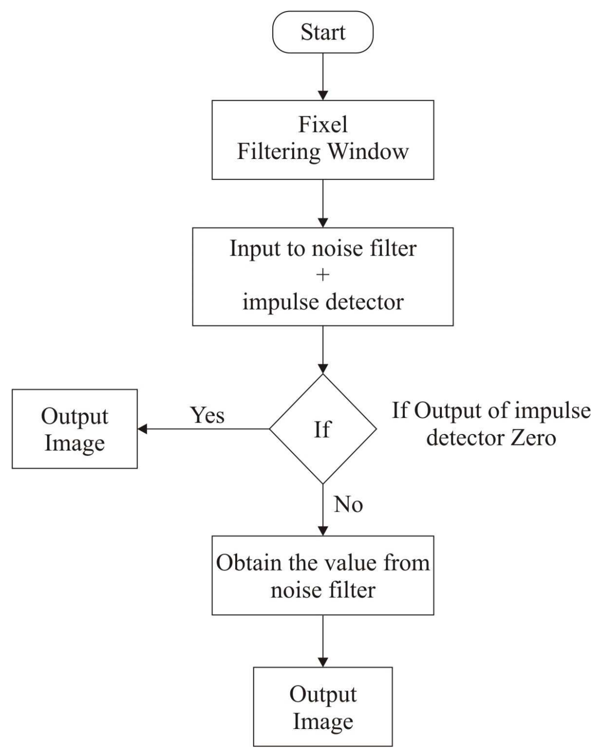

Fig. 2: Procedure for processing the noisy input image

In fig.2 the design of operational flow diagram, the procedure for processing the noisy input image for detecting efficient impulse noise as well as remove unwanted noise density, fixed filtering window is opened to get the test image and a noisy pixel density. The captured test image has been applying to noise filter with combined detector. the performance of combined work, the test image noisy pixels is detect and filtered in effective manner and certain parameters like mean square error(MSE), mean pixel distance(MPD) for the output image is calculated.

5 Results and Discussion

The proposed impulse detector is implementing and its performance of a filter is evaluated for various coin images noises is added with original image

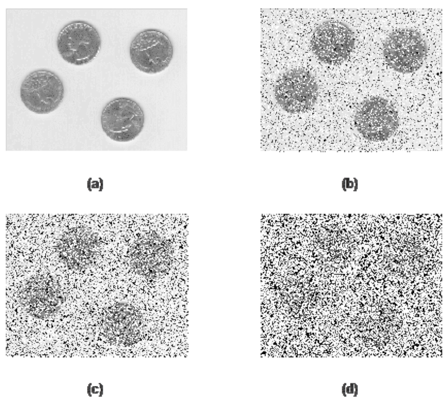

Fig. 3: Example of various noise occurred in original image. (a) Original baby image, (b) Impulse noise occurred with 25%, (c) Impulse noise occurred with 50%, (d) Impulse noise occurred with 75%,

One of the popular test images from the literature is included in filtering experiments. The salt and pepper noise is added with original standard coin test image are shown in fig.3 the noisy test images are obtained by corrupting a test image with the impulse noise. Three different noise densities such as 25%, 50% and 75% are considered. All of these images are 24-bit color images and have size of 256 by 256 pixels. The performance of the proposed detection with a noise filters is compared with other filters such as standard median filter(SMF) and edge detecting median filter(EDMF).

5.1 Mean Squared Error (MSE)

The Mean Squared Error (MSE) has its merits and is widely accepted in image processing research, it only measures gray- level difference between pixels of the ideal and the distorted images without considering correlation between the neighboring pixels. Distorted images with equal MSE may have significantly different visual quality.

The MSE of an estimator measures the average of the squares of the ”errors”, that is, the difference between the estimator and what is estimated. MSE is a risk function, corresponding to the expected value of the squared error loss or quadratic loss. The difference occurs because of randomness or because the estimator doesn’t account for information that could produce a more accurate estimate. The MSE may also be regarded as a measure of signal quality. The mean-square error is defined by:

$$E\{\hat{a},a\} = \frac{1}{MN}\sum_{m=0}^{M-1}\sum_{n=0}^{N-1}\left|\hat{a}[m,n]-a[m,n]\right|^{2} \qquad (2)$$

In equation 2, where a (m, n) - MN initial noisy image a (m, n) - MN size of restored image.

5.2 Mean Pixel Difference (MPD)

The distance between that pixel and the nearest nonzero pixel of binary image. The mean or average distance from pixel with color k is defined as follows:

$$m(k,i) = \frac{1}{c(k)-1}\sum_{\substack{j=i\\ j\neq i}}^{c(k)} d(pi,pj) \qquad (3)$$

In equation. 3, the average distance can be regarded as a characteristic of pixel, which expresses the degree of distance from pixel pi to other pixels with color k. Each filtering experiment represents a combination of a noise filter, a test image and a noise density. The noise filter combined with the detector is applied to the test image of the experiment corrupted with noise density. The noise coin test image is filtered using a noise filter and the MSE and MPD value for the output image is calculated. Following this, the test image is processed with the proposed detector and then the final image is constructed from the input image and restored output of the filter. Finally, the MSE and MPD values for the test image with the proposed detector is calculated and compared with the previous value.

The performance of the introduced detector method will be evaluated for filtering noisy images, which is removed by impulse noisy density. Fig.4 represents the original test image, which is generated from data base of the computer, fig.5 shows the noisy test image for noise level has added with various range. Fig.6 shows the output image of the noisy input using proposed detector for detected and removed the added impulse noise in best resolution compared from previous methods.

Table.1.Comparison of MSE values calculated for the output images of the filter without and with proposed detector.

Table 1and 2 show the average MSE and MPD values calculated for the output images of the filter without and with proposed detector, the numerical results presented by

Fig. 4: Original image

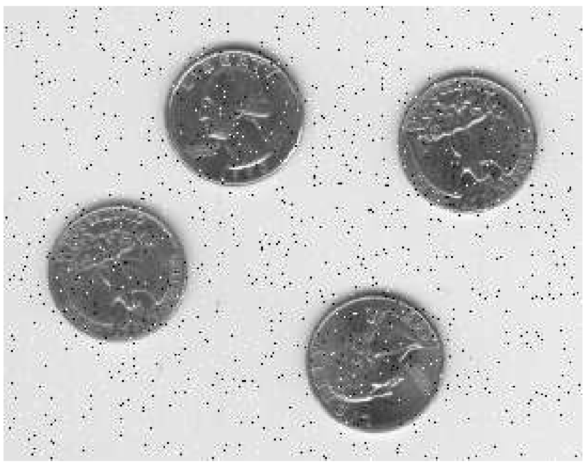

Fig. 5: Noisy image with Salt & Pepper noise

Fig. 6: Image with Noise Removed by proposed Filter

Table 1: Comparison of MSE values calculated for the output images of the filter without and with proposed detector.

Filter	Noise Level			condition
	25%	**50%**	**75%**	
SMF	301.66	2284.20	8690.23	Without detector
EDMF	220.20	903.74	4912.60	
SMF	48.23	27.99	15.90	With detector
EDMF	38.27	15.98	8.01	

Table 2: Comparison of MPD values calculated for the output images of the filter without and with proposed detector.

Filter	Noise level			Condition
	25%	50%	75%	
SMF	85.23	149.98	202.01	Without detector
EDMF	16.20	49.56	140.05	
SMF	6.87	35.68	122.56	With detector
EDMF	7.95	25.03	87.45	

MSE for coin image corrupted by salt and pepper noise with various noise ratios ranging from 25% to 75%. In the above represented numerical values are two different cases, without detector and with detector. As the noise ratio increases, the method of proposed work is enhanced performance than various types of earlier designed filter work.

6 Conclusion

In this work, a novel efficient impulse noise detector based on fuzzy logic technique is implemented and its parameters are trained using genetic algorithm for this proposed noise detector can be used as an efficient tool for detecting maximum contaminated noise in color images. This reduction of the noise is undesirable distortions and blurring effects for proposed by the filter without detector and with detector.

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