AN EFFICIENT TECHNIQUE FOR THE REMOVAL OF RANDOM VALUED IMPULSE NOISE IN DIGITAL IMAGES

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Abstract— Digital image processing is important in many areas. Noise removal in digital images is important in many fields .In this paper we propose an efficient method for the removal of random valued impulse noise. Here using a detection process and a filtering process. Detection process detects the noisy pixels by using the absolute difference and median filter for filtering.

Keywords — Fixed value Impulse Noise, Random Value Impulse Noise, Peak Signal to Noise Ratio, Threshold, Median Filter Mean Square Error, Noise Detector

1. INTRODUCTION

Digital image processing has important in many areas such as digital telecommunication, remote sensing, robotics, graphic printing, and medical imaging, defense and security applications[1]. During the transmission and acquisition, images are corrupted by the different type of noise. Because of the noise, quality of image is reduced and other features like edge sharpness and pattern recognition are also badly affected. There may be different types of noise like Gaussian type noise, impulse type noise, shot noise. The impulse noise that affects the contents of the image[2]. Impulse noise is normally produced as a result of various reasons, including electromagnetic interference, errors and scratches on recording disks, and erroneous synchronization in digital recording and communication equipment. It also occurs during image acquisition, transmission due to malfunctioning of pixel elements in the camera sensors, faulty memory locations, and timing errors in analog-to-digital conversion and bit errors during transmission.

Noise may be modeled as impulse noise or salt and pepper noise. The pixels corrupted by any of the fixed valued impulse noise (0 or 255). The corrupted pixels take either 0(black) or 255 (white) with equal probability distribution. For images corrupted with impulse noise, the noisy image 'u⁰' is related to the original image 'u' by

$$u^0(i,j)=\begin{cases} n(i,j), \text{with probability p} \\ u(i,j), \text{with probability } (1-p) \end{cases} \tag{1}$$

where n(i,j) is the noisy pixels with probability p. For noise free image, p=0.

Impulse noise is characterized by replacing a portion of an image pixel with noise values, leaving the remainder unchanged. An important characteristic of this type of noise is that only part of the pixels are corrupted and the rest are noise free. The impulse noise has generally two types: fixed value impulse noise[3] and random value impulse noise. The fixed value impulse noise is also known as salt and pepper noise which can be either 0 or 255 (0 for black and 255 for white). It is generally reflected by pixels having minimum and value in gray scale image. The random value impulse noise is random in nature can have any value between 0 and 255 and it is very difficult to remove this noise. To remove the effect of noise, we have several algorithms but removal of noise and restoration of original image causes blurring the edges of image. Impulse noise causes random black and white dots on the image so impulse noise reduction is very important phenomena of image processing. The basic idea of image de-noising has two parts:

1. Detection
2. Filtering

Detection of noise determines that the image is corrupted by noise or not, and noise removal part remove the noise from the image while preserving the other important detail of image. Filters are better option to remove the noise from the image because their implementation is very easy. The filters can be divided in two types: linear filter and non-linear filter. Linear filters are like average filter or called averaging low pass filter. But linear filter tends to blur edges and other details of image, which may reduce the accuracy of output[2]. On the other hand non-linear type filter like median filter has better results than linear filter because median filter remove the impulse noise without edge blurring[1]. The standard median filter[3] mostly used because of its good performance and preservation of image details. A median filter is an example of a non-linear filter and it is very good at preserving image detail.

The following three steps are used to calculate median:

1. Process every pixel in the image one by one.

2. Select the size of filtering window and sort the all pixels of window in order based upon their intensities.

3. Replace the central pixel with the median value of sorted pixels.
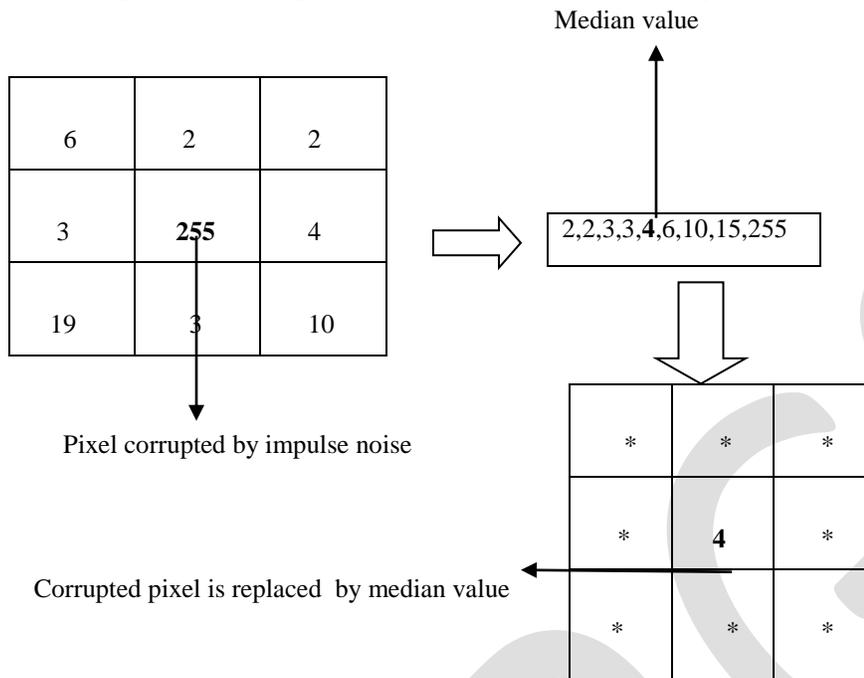

Fig.1.Evaluation of Standard Median Filter

The center value is taken for odd number of pixels and for even number of pixels calculates the mean of center pixels. The performance of median filter also depends on the size of window of filter. Smaller window preserve the details but it will cause the reduction in noise suppression. Larger window has great noise reduction capability but image details (edges, corners, fine lines) preservation is limited. With the improvement in the standard median filters, there were so many filters has designed like weighted median filter[4], centre weighted median filter[5] , adaptive median filter[6], rank order median filter[7] . In SDROM [8] method, for removing IN the nature of the filtering operation is conditioned on a state variable defined as the output of a classifier that operates on the differences between the input pixel and the remaining rank-ordered pixels in a sliding window. Different median filters uses different sorting algorithm [2] like merge sort, quick sort, heap sort to sort the elements in the window. Whether the pixel is noisy or noiseless can be identified in the detection phase, so that only noisy pixel will be replaced by the median value and noiseless pixel will be unaffected. This technique reduce the processing time and also improve the quality of image.

2.PROPOSED METHOD

The proposed methodology is divided into 2 phases.In the first phase, a 9x9 window which includes the center pixel and its neighboring pixels .ie, total 81elements is considered.Then the absolute difference in the intensity of the center pixel and each neighbouring pixel is calculated

$$\text{ie,AbsoluteDifference(AD)} = \left| I_{center\ pixel} - I_{neighboring\ pixel} \right| \qquad (2)$$

Then mean of the five smallest AbsoluteDifference values are taken

$$\text{ie, Mean} = \frac{1}{5} \sum_1^5 AD \qquad (3)$$

If the Mean is greater than the threshold value, the tested pixel is considered as noisy and supresed by using Standard Median Filter.
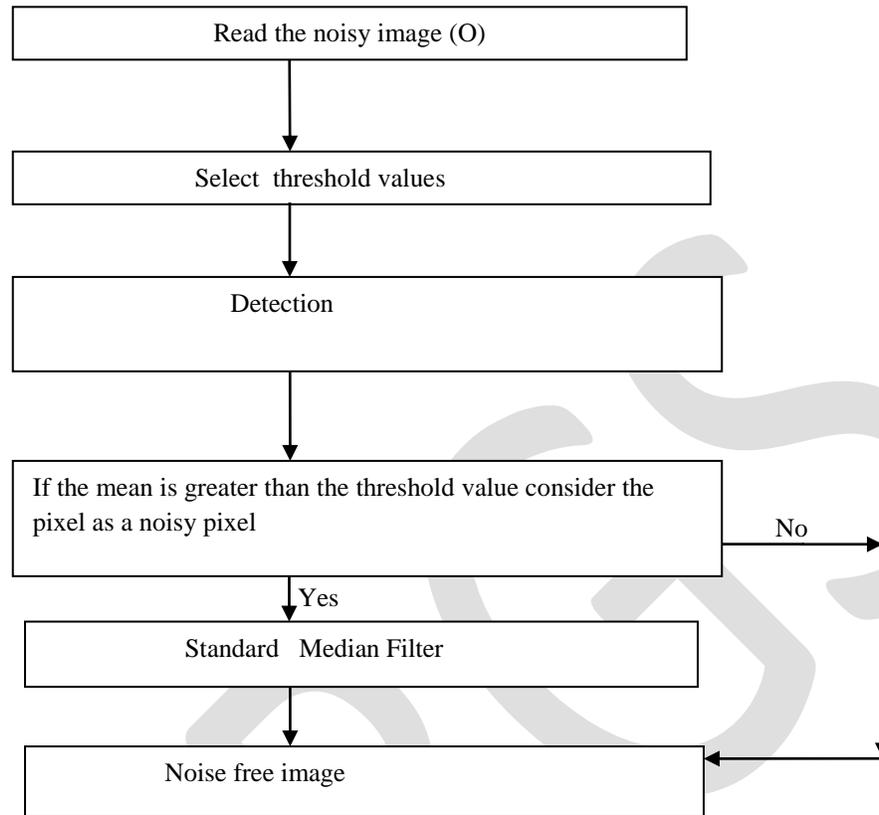
The proposed architecture is given below,

Fig.2. Flow chart of proposed method

A. Selection of Threshold

The threshold values used must be selected based on the previous knowledge or experimental results of different digital images and is inversely proportional to noise density .Three different threshold values are used to get better results[15].

B. Evaluation Metrics

Our main aim is to obtain an output image that is close to the original image. This can be done by comparing the Peak Signal to Noise Ratio (PSNR) values of both the output image and the original image. To measure the quality of restored image, Mean square error (MSE) and peak signal-to-noise ratio (PSNR) quality measure is used.

1. Mean square error (MSE)

The mean square error or MSE[2] of an estimator is one of many ways to quantify the difference between values implied by an estimator and the true values of the quantity being estimated. The MSE of the restored image is given by

$$\text{MSE} = \frac{1}{mn}\sum_{i1-1}^{m}\sum_{i2-1}^{n}|u(i_1\ i_2) - I(i_1\ i_2)|^2 \tag{4}$$

2. Peak Signal to Noise Ratio (PSNR)

The Peak Signal-to-Noise Ratio (PSNR) is an important metric to measure the objective dissimilarity of the filtered output from the original uncorrupted image[15].

$$\text{PSNR} = 10log_{10}\frac{(255)^2}{MSE}(\text{dB}) \tag{5}$$

C.Experimental results

Results of different methods included in comparison for test image Lena with 80% of random-valued impulse noise.
(a)Original image (b) Gray scale image (c) Noisy Image (d) WMF(e) CWMF(f) AMF(g) ROMF (h) SDROM (i) PA

D.Tabulation

In order to analyze the various de-noising methods quantitatively, TABLE 1 shows the Peak Signal-to-Noise Ratio (PSNR) of the various de-noising methods. PSNR does not always reflect the actual human perception of image quality because it is based on the log ratio of the signal to noise. TABLE 1 shows the comparison of PSNR values for restored image of Lena image affected by impulse noise with different noise ratios for different de-noising methods.

Table 1

Comparison of PSNR values for restored image of Lena image affected by impulse noise with

different noise ratios for different de-noising methods.

Noise Ratio	Peak signal to noise ratio					
	WMF	CWMF	AMF	ROMF	SDROM	PA
10%	**31.9535**	28.7013	30.3484	30.3565	29.9640	31.5089
20%	27.0922	26.4133	25.8988	27.2061	27.0950	**28.0955**
30%	23.3156	22.8368	22.3629	22.9127	23.8967	**25.5397**
40%	19.3500	19.6114	19.0939	19.9864	20.8678	**22.7452**
50%	16.9189	17.1028	16.8717	17.3967	18.2817	**20.5162**
60%	15.2140	14.9498	14.9014	15.3538	16.0753	**19.2017**
70%	13.6335	13.3965	13.4848	13.8791	14.2011	**17.7907**
80%	12.4300	12.0779	12.3467	12.8804	13.0436	**16.7176**

The de-noising method consists of both detection and filtering schemes. In TABLE 1, the filtering method used is the standard median filter and the detection schemes used are WMF (Weighted Median Filter), CWMF (Center Weighted Median Filter), Adaptive Median Filter(AMF), ROMF (Rank Ordered Median Filter), and SDROM (Signal Dependent Rank Ordered Median Filter) and the PA (Proposed Algorithm) respectively. The restored images using these de-noising methods for the Lena image with different impulse noise ratios 10%, 30%, 50%, 70% and 80% are analyzed. The highest PSNR value among the PSNR values of denoised Lena image obtained for different de-noising methods is highlighted by bold digits. The restored images using these de-noising methods for the Lena image with different impulse noise ratios 10%, 30%, 50%, 70% and 80% are analyzed.

3.CONCLUSION

Several methods have been proposed for restoration of images contaminated by random valued impulse noise, which includes the detection and filtering which are done separately on the images. Some existing methods provide good results for low noise density images whereas only a few provide good results for high noise rates. These methods are more time consuming and may result in execution complexity. Suppose if the original image itself contains more number of noise added pixels, then the existing filters fail to distinguish the original pixel from the corrupted one. The main advantage of the proposed method is that it effectively removes Random Value Impulse Noise from images and it gives better image compared to other filters in case of high noise density.

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