Image Denoising Using Adapted Median Filter Technique

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ABSTRACT

Adopted filtering approach is proposed to restore images corrupted by an impulse noise. The proposed algorithm eliminates salt & pepper noise from corrupted grayscale image while preserving its details. The former phase of this research is executed by computing the average difference between the current central pixel and its neighborhood pixels in current mask. In the following stage, Pixel values in current mask are sorted using the standard median filter approach. Findings obtained from phase one is then compared with central pixel acquired from phase two. Central pixel of phase two is replaced by the measurement taken from phase one if the comparison is greater than certain amount. The amount was carefully chosen based on the average gray level of each particular selected standard image. Simulation results indicate that proposed filtering technique is better able to preserve 2-D edge structures of the image. Least mean square error (MSE) is used to evaluate the proposed approach. Findings Also reveals that the proposed method delivers better performance with less computational complexity as compared to other denoising algorithms existing in literature.

Keywords: Image denoising, Impulse noise, Adapted Median Filter, MSE

1. Introduction

The principle objective of image enhancement techniques is to process a given image so that the resultant image is more suitable than the original image. Several digital imaging systems may introduce noises, which cannot be avoided. In the reality, signals do not exist without noise. Film grain, electronic noise and quantization are some of key noise sources in digital imaging. Image acquisition and transmission are also known as crucial noise source in digital image. Removing noise from images is an important problem in image processing [1]. The prime step to discard noise from digital image is to know the type of noise influencing the image. Source of noise should also be determined and modelled properly. The resultant filtered image should be as closer as possible to the ground truth image [2]. In the past work of image enhancement and restoration, linear filters were the fundamental tools used to eliminate noise. Linear filters offered satisfactory performance in many applications. However, they have poor performance in the presence of non-additive noise and in situations where system nonlinearities or Gaussian statistics are encountered [3]. In image processing applications, linear filters tend to blur the edges and do not remove Gaussian and mixed Gaussian impulse noise effectively. The research presented in this paper explores the possibility of altering median filter to efficiently produce a filtered image while preserving image details. Grayscale images affected by impulse noise have been used in the experimental work. Care was taken when choosing images to ensure different levels of brightness, contrast and sharpness. Impulse noise with different percentage were also used to generate the degraded image. In this study, results of the proposed technique are measured by comparing with various noise removal techniques reported in the literature.

2. Background

Median filtering is a nonlinear method used to remove noise from images. It is widely used as it is very effective at removing impulse noise while preserving edges. The median filter works by moving through the image pixel by pixel, replacing each value with the median value of neighboring pixels. The pattern of neighbors is called the "window", which slides, pixel by pixel over the entire image. The median is calculated by first sorting all the pixel values from the window into numerical order, and then replacing the pixel being considered with the middle (median) pixel value [4]. Utilizing median filter can be traced back when standard linear median filter (SMF) was introduced [5]. Weighted median filter (WMF) was then presented in order to improve the performance of noise elimination [6,7]. In WMF, weights are assigned to scanning window pixels [8]. Later, The adaptive median filter (AMF) was fabricated. (AMF) is intended to eliminate the problems faced with the SMF and WMF. The basic difference here is that, in the (AMF), the size of the window surrounding each pixel is variable. This variation depends on the median of the pixels in the present window. If the median value is an impulse, then the size of the window is expanded [9-11]. Recently, certain filters, such as AMF and adaptive fuzzy filter were combined with median filter in order to produce better performance. AMF adjust the window size adaptively according to the noise density [12-14]. A disadvantage of the AMF method is that when the window size is enlarged, it moves away from the original pixel information [15]. Thus, image enhancement, filtering and denoising techniques have been contributing various image applications and still open area of research [15,16]. The proposed method presents in this paper suggests a different way of running median filter. The technique is described in the following section. The quality of the proposed technique was determined by measuring mean squared error (MSE) for each particular undertaken image. MSE is calculated between filtered and ground truth images. The performance of the proposed technique was compared with some denoising techniques reported in the literature.

3. Materials and Methods

The main methods comprise adding noise to an original grayscale image; inspecting the central pixel value of a particular filter mask to observe if it is suspected; sort the mask values numerically and then decide whether the central value is replaced. Each of these aspects is discussed in the following sections. To produce degraded image; impulse noise was inserted to noise free image. Noisy image was then used as an input image to the anticipated method. Mask of size 3X3 was used in this experimental work. Assuming that mask shown in Figure 1 was taken from a noisy image. Initially, Pixels are sorted in ascending order according to the standard median filter.

x_6	x_2	x_7
x_4	x_9	x_1
x_3	x_8	x_5

Figure 1. Particular mask with central pixel of x_9

Standard median filter can be formulated as:

$$f_m(i,j) = \underset{(s,t)\in S_{i\,j}}{midean}\{x(i,j)\} \quad (1)$$

where $f_m(i,j)$ is the median filter output. $x(i,j)$ is the degraded input image. (s,t) is the mask size and $S_{i\,j}$ is equal to 256. Taking into consideration pixels in Figure 1, Figure 2 presents pixels sorted in ascending order by employing median filter.

x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9

Figure 2. Data in Figure 1 sorted in ascending order in one-dimensional array

Statistics method known as the Interquartile Range (IQR) was used to measure the disparity between pixels in a precise mask. (IQR) is a method known in the literature as a statistic technique used to compute the variation between elements of a data set [17-19]. (IQR) is used decide whether the central pixel is suspected.

In order to apply IQR consider pixels revealed in Figure 2. IQR algorithm can be condensed in the following equations:

$$Q_1 = (x_2 + x_3)/2 \quad and \quad Q_3 = (x_7 + x_8)/2 \quad (2)$$

$$IQR = Q_3 - Q_1 \quad (3)$$

$$X = Q_3 + (1.5 * IQR) \quad and \quad Y = Q_1 - (1.5 * IQR) \quad (4)$$

Taking into consideration the above X and Y values, central pixel in Figure 1 is considered to be suspected pixel if:

$$x_9 < X \quad \underline{OR} \quad x_9 > Y \quad (5)$$

Correspondingly, any central pixel that lies outside the range X and Y is considered as a suspected pixel and has to be replaced, otherwise it keeps its original place. Equally, if the pixel is counted as a suspected pixel then x_9 in Figure 1 is replaced by x_5 in Figure 2. This procedure is continued until the image if fully scanned. The flowchart presented in Figure 3 summarizes the algorithmic approach adopted in this work.

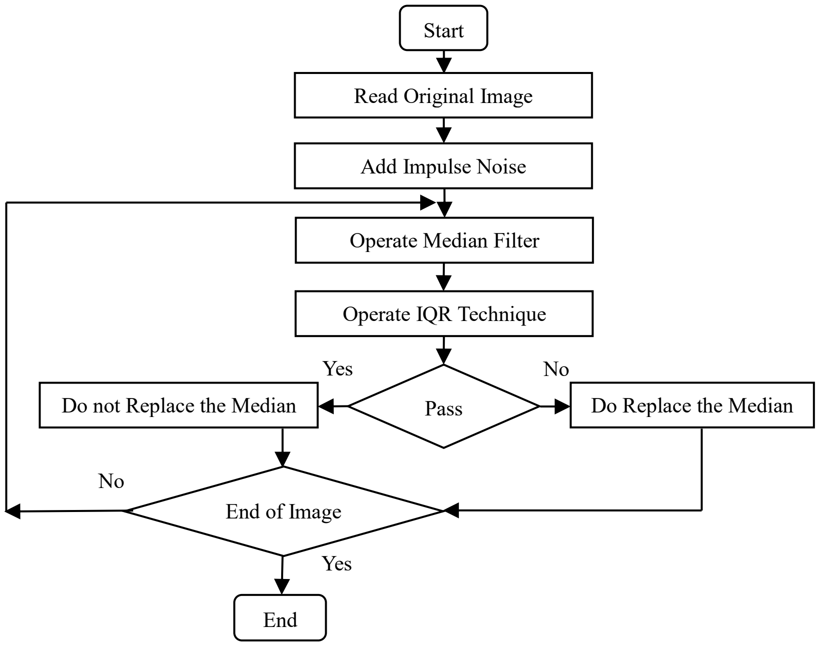


Figure 3. Flowchart for the filtering procedure

4. Results and Discussion

To quantify the performance of the approach, impulse noises of 2%,3% and 4 % were inserted to original images and MSE was recorded. Comparison between proposed technique and other existing filtering technique is reported in the following section. Images in Figure 4 (a) and (b) give a good example of original and its corrupted version effected by amount of 4% impulse noise. Results of average, median and proposed filters are presented in Figure 4 (c), (d) and (e) respectively.

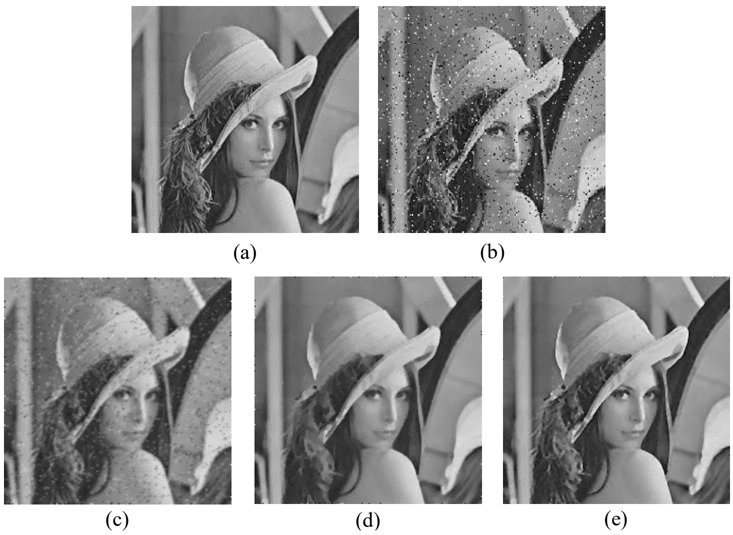
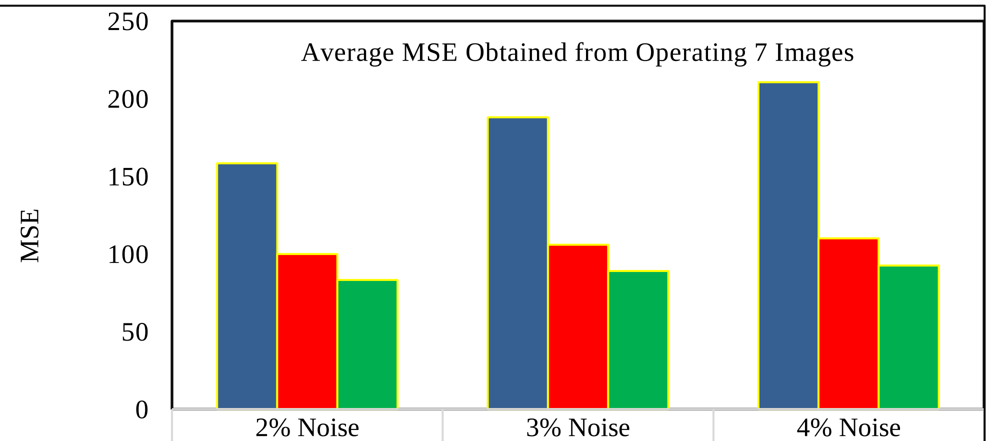


Figure 4. (a) and (b) original and 4% noisy images. (c), (d) and (e) are average, median and adapted median images respectively

From the visual inspection of the images in Figure 4, it is obvious that the proposed method performed better compared to the average and standard median filters. The suggested technique has almost discarded the impulse noise while preserved image details. This finding is supported by the MSE recorded for different 7 images. The average MSE of 7 images obtained at different noise levels is revealed in the bars in Figure 5.



	2% Noise	3% Noise	4% Noise
Average Filter	158.3871429	188.0428571	210.6128571
Median Filter	99.99714286	105.9014286	110.0457143
Proposed Method	83.25142857	89.06714286	92.41857143

Figure 5. Average MSE obtained from different 7 images at different noise ration

It can be observed that there is a strong and consistent trend between the noise level and MSE. As the noise level grows, the average MSE increases. This observation was expected since in general, the dissimilarity between original and filtered images increases. It is obvious from the bars in Figure 3 that the proposed technique has produced the least MSE. For instance, when the noise level was 3%, the average MSE produced by the average filter was almost “188”, this number was later reduced by almost 50%, nearly “89” when the proposed method operated.

5. Conclusions and Future Work

In this paper, a new and simple approach for removing salt and pepper noise from degraded images has been presented. The potential of the proposed technique to filter a noisy image is established and quantified for 7 different structure images. The appropriateness of the suggested technique is supported by the comparable result organized in Figure 4, which demonstrate that Adapted filter performs better in discarding noise while preserving edge sharpness. MSE is used to mathematically evaluate the anticipated method by the finding presented in the bars of Figure 5. Comparison between the new technique and other existing methods indicate that the new approach produced the minimum MSE. The new approach was tested using grayscale images. It is planned to develop a scheme whereby the current algorithm will be modified to enhance color images. This work is left for future investigation.

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