A Novel Technique to Improve Impulse Noise from Digital Images

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Abstract: *Digital Images are corrupted by different varieties of noises like Gaussian noise, Impulse noise etc. Impulses are salt and pepper noises which degrade the images quality with black and white spots. Here is an effective algorithm for effectively denoising the extremely corrupted image with the impulse noise. The proposed method works on the principle of duality. First adaptive median filter is applied and then contrast stretching with CLAHE is applied. The corrupted pixels are replaced by value of uncorrupted pixels in the filtering window. The proposed algorithm works well for images with high percentage of impulse noise. A comparison is made between proposed algorithm and other different median filtering algorithms.*

Keywords: Salt and Pepper noise, median filter, contrast stretching, histogram equalization, peak signal to noise ratio.

1. Introduction

Image processing is any form of signal processing for which the input is an image, such as a photograph or video frame; the output of image processing may be either an image or a set of characteristics or parameters related to the image. Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it. Image noise is an undesirable by-product of image capture that adds unwanted information to the original. An image containing salt-and-pepper noise will have dark pixels in bright regions and bright pixels in dark regions. This noise is also known as Fat Tail Distributed noise.

The aim of this work is to implement and compare various image enhancement techniques based on removal of impulse noise such as Median Filter (MF), Adaptive Median Filter (AMF), Proposed Filter and then determining the best one in terms of the performance parameters both in subjective and objective manner. All these techniques are implemented for gray-scale. A new hybrid technique is proposed to improve the contrast enhancement.

Performance parameters used for evaluation of gray scale noisy images are Peak Signal to Noise Ratio (PSNR), Normalized Absolute Error (NAE), Mean Square Error (MSE) and Visual Quality.

2. Literature Survey

O. Y. Harja et al. [1] analyzed the deterministic properties of weighted median (WM) filters. Threshold decomposition and the stacking property together establish a unique relationship between integer and binary domain filtering. The authors presented a method to find the weighted median filter which is equivalent to a stack filter defined by a positive Boolean function. Because the cascade of WM filters can always be expressed as a single stack filter this allows expression of the cascade of WM filters as a single WM filter. A direct application is the computation of the output distribution of a cascade of WM filters. The same method is used to find a nonrecursive expansion of a recursive WM filter. As applications of theoretical results, several interesting deterministic and statistical properties of WM filters are derived.

S. J. Ko et al. [2] studied the center weighted median (CWM) filter, which is a weighted median filter giving more weight only to the central value of each window. This filter can preserve image details while suppressing additive white and/or impulsive-type noise. The statistical properties of the CWM filter were analyzed. It was shown that the CWM filter can outperform the median filter. Some relationships between CWM and other median-type filters, such as the Winsorizing smoother and the multistage median filter, were derived. In an attempt to improve the performance of CWM filters, an adaptive CWM (ACWM) filter having a space varying central weight was proposed. It was shown that the ACWM filter was an excellent detail preserving smoother that can suppress signal-dependent noise as well as signal-independent noise.

B. Jeong et al. [3] observed that the design of optimal weighted order statistic (WOS) filters under the mean absolute error criterion could be thought of as a two-class linear classification problem. Based on this observation, the perceptron algorithm was applied to designing WOS filters. It was shown experimentally that the perceptron algorithm could find optimal or near-optimal WOS filters in practical situations. A 2-D 3 x 3 WOS filter was applied to noisy images corrupted by additive impulses. The results showed that for perceptron value equal to zero, the WOS is the identity filter. When this value increases, the WOS is the median filter. It was shown that for perceptron value less than 0.025 the WOS filter is the optimal one and also minimizes the mean absolute error and is equivalent to the stack filter.

T. Chen et al. [11] suggested that previous median-based impulse detection strategies tend to work well for fixed-valued impulses but poorly for random-valued impulse noise, or vice versa. This letter devises a novel adaptive

operator, which forms estimates based on the differences between the current pixel and the outputs of center-weighted median (CWM) filters with varied center weights. Extensive simulations show that the proposed scheme consistently works well in suppressing both types of impulses with different noise ratios. The performance of the proposed impulse rejecting filter has been evaluated and compared with those of some existing detection based filters. In our simulations, a group of 512 X 512 grayscale images corrupted by fixed-valued and random-valued impulses with various noise ratios are used. The noise intensity of fixed-valued impulses corresponds to 0 or 255 with equal probability, while for the random-valued impulses, the noise values are uniformly distributed in the range of [0, 255]. The peak SNR (PSNR) is used to measure the image quality. Compared to other detection-based filtering schemes, the proposed technique consistently yields satisfactory results in suppressing both of the random-valued and fixed-valued impulse noises while still possessing a simple computational structure.

S. Zhang et al. [15] presented a new impulse noise detection technique for switching median filters, which is based on the minimum absolute value of four convolutions obtained using one-dimensional laplacian operators. Extensive simulations showed that the proposed filter provide better performance than many of the existing switching median filters with comparable computational complexity. In particular, the proposed filter was directed toward improved line preservation. It was shown that the number of compare/swap operations in the proposed filter was much smaller than other filters. Although some additions or subtractions were required, they were faster than compare/swap operations. This was because an addition or a subtraction was just an operation, while a comparison must be implemented by at least two operations in assembly language: a subtraction followed by a conditional jump operation, and if swap was needed, three additional assignment operations are required. Accordingly, the proposed filter had the lowest computational complexity in comparison to median filter, switching median filter and non switching filter.

R. Oten et al. [16] showed that alpha-trimmed mean filters are widely used for the restoration of signals and images corrupted by additive non-Gaussian noise. They are especially preferred if the underlying noise deviates from Gaussian with the impulsive noise components. The key design issue of these filters is to select its only parameter, , optimally for a given noise type. In image restoration, adaptive filters utilize the flexibility of selecting according to some local noise statistics. First review the existing adaptive alpha-trimmed mean filter schemes. We then analyze the performance of these filters when the underlying noise distribution deviates from the Gaussian and does not satisfy the assumptions such as symmetry. Specifically, the clipping effect and the mixed noise cases are analyzed. We also present a new adaptive alpha-trimmed filter implementation that detects the non-symmetry points locally and applies alpha-trimmed mean filter that trims out the outlier pixels such as edges or impulsive noise according to this local decision. Comparisons of the speed and filtering performances under deviations from symmetry and Gaussian

assumptions show that the proposed filter is a very good alternative to the existing schemes.

B. Ghandeharian et al. [18] presented a new switch median filter for suppression of impulsive noise in image. The proposed filter is Modified Adaptive Center Weighted Median (MACWM) filter with an adjustable central weight obtained by partitioning the observation vector space. Dominant points of the proposed approach are partitioning of observation vector space using clustering method, training procedure using LMS algorithm then freezing weights in each block are applied to test image. The proposed method includes fuzzy clustering part for clustering the observed vector of each pixel into one of M mutually exclusive blocks. In the training phase, Least Mean Square (LMS) algorithm used to train center weight in each block then obtained weights used in testing phase. Final results shows better performance in the impulse noise reduction over standard images relative the median (MED) filter, the switching scheme I (SWM-I) filter, the signal dependent rank order mean (SD-ROM) filter, the tristate median (TSM) filter, the fast peer group filter (FPGF), the fuzzy median (FM) filter, the PFM filter and the adaptive center weighted median (ACWM) filter.

A. M. Harale et al. [19] proposed a methodology based on median filters for the removal of Salt and Pepper noise by its detection followed by filtering in both binary and gray level images. Linear and nonlinear filters have been proposed earlier for the removal of impulse noise; however the removal of impulse noise often brings about blurring which results in edges being distorted and poor quality. Therefore the necessity to preserve the edges and fine details during filtering is the challenge faced by researchers today. The proposed method consists of noise detection followed by the removal of detected noise by median filter using selective pixels that are not noise themselves. The noise detection is based on simple thresholding of pixels. Computer simulations were carried out to analyze the performance of the proposed method and the results obtained were compared to that of conventional median filter and center weighted median (CWM) filter.

3. Filters for Impulse Noise Removal

3.1 Median Filter

In general, the median filter allows a great deal of high spatial frequency detail to pass while remaining very effective at removing noise on images where less than half of the pixels in a smoothing neighborhood have been effected.

3.2 Adaptive Median Filter

The Adaptive Median Filter performs spatial processing to determine which pixels in an image have been affected by impulse noise. The Adaptive Median Filter classifies pixels as noise by comparing each pixel in the image to its surrounding neighbor pixels. The size of the neighborhood is adjustable, as well as the threshold for the comparison. A pixel that is different from a majority of its neighbors, as

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well as being not structurally aligned with those pixels to which it is similar, is labeled as impulse noise. These noise pixels are then replaced by the median pixel value of the pixels in the neighborhood that have passed the noise labeling test.

3.3 Proposed Filter

In our proposed method, first of all adaptive median filtered is applied and then linear contrast stretching is done and after then contrast limited adaptive histogram equalization is applied. The results of proposed methodology are better than median and adaptive median filter.

4. Parameters Used for Evaluation

Mean square error is the average difference between the input and final image.

$$MSE = \frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} \left(f_1(i,j) - f_2(i,j) \right)^2 \quad (1)$$

Peak Signal to Noise Ratio is the logarithmic magnitude of division of maximum value of pixel value and mean square error.

$$PSNR = 10 LOG \left(255^2 / MSE \right) \quad (2)$$

The MSE should be minimum and PSNR should be maximum for satisfactory results.
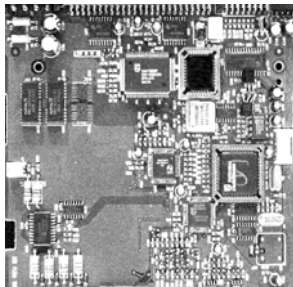
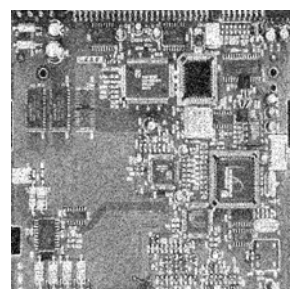## 5. Results and Conclusion

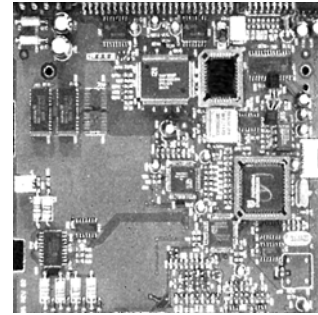**Figure 1(a):** Original Image

Figure 1(b): Impulse Noise
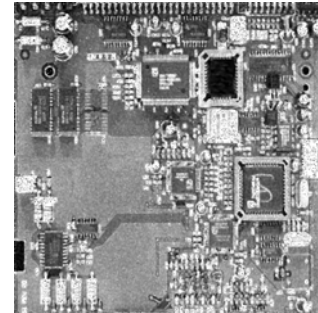

Figure 1(c): Median Filtered

Figure 1(d): Adaptive Median Filtered

Figure 1(e): Proposed Filter

Table 1: Parameters result for circuit image

Parameters	Fig 1(c)	Fig 1(d)	Fig 1(e)
MSE	4.1313e+003	3.6025e+003	3.5934e+003
PSNR	11.9699	12.5648	12.5757
NAE	0.2125	0.1897	0.1852

Figure 2(a): Original Image

Figure 2(b): Impulse Noise

Figure 2(c): Median Filtered
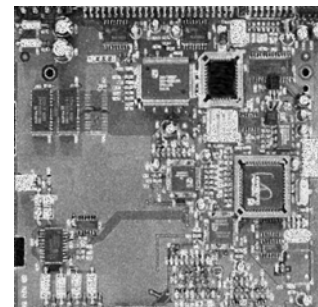

Figure 2(d): Adaptive Median Filtered

Figure 2(e): Proposed Filter

Table 2: Parameters result for chest image

Parameters	Fig 2(c)	Fig 2(d)	Fig 2(e)
MSE	4.6931e+003	3.3179e+003	3.2377e+003
PSNR	11.4162	12.9222	13.0284
NAE	0.1919	0.1896	0.1573

The results shown in table shows that PSNR value is maximum for the proposed methodology and MSE is minimum for the same. The proposed methodology is better than median and adaptive median filter to remove impulse noise at some extent.

Future Scope

The algorithm can be further improved in accuracy and in time consumption. The psnr value can be improved and mse value can be decreased further.

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