

A New Improved Multistage Eight Directional Median Filter

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Abstract

Background/Objectives: To propose a new improved multistage multi directional median filtering algorithm for impulse noise removal. **Methods/Statistical Analysis:** Calculate standard deviation of the 5 pixels in each direction giving extra weight to the direction in which the standard deviation is smallest, the weighted median is computed and the noisy pixel is replaced with this median value then move window throughout the image and iterate the process. **Findings:** The experimental results show that the proposed filter can provide excellent performance of suppressing impulse noise in all situations. **Improvement/Application:** The paper offers a new improved multistage eight directional median filtering algorithm for impulse noise removal from digital images.

Keywords: Impulse Noise, Median Filter, Multi Stage, Multistage Eight Directional Median Filters

1. Introduction

Noise removal techniques in digital images are a highly demanded research area. There are various types of noise that cause damage in the digital images. Among these noises impulse noise is the most important one. They are termed as salt and pepper noise and they appear black and white spots and they will adversely affect the quality of the digital images.

Two-dimensional function $f(x, y)$ can be used to define an image. Here the coordinates x and y can be used to represent spatial coordinates or plane coordinates. The intensity of the image at that point (x, y) is taken as the amplitude of the point (x, y) . For a digital image the value x, y and the amplitude values of are all finite discrete quantities.

Impulse noise can be removed without blurring sharp edges using the widely used filter known as the median filter. But, median filter may not work well when the noise level is increased within edges.

A new improved multistage eight directional median filter is proposed in this paper. In the first stage of the

algorithm the noise pixels are identified. In the second stage the edges are detected. Noise pixels are restored along the detected edges in the third stage. The algorithm is expressed in Section 4. Simulation is expressed in Section 5. The experimental results shows that the new improved multistage eight directional median filter can remove most noise preserving detail features.

2. Steps in Digital Image Processing

The major steps in digital image processing can be listed as

2.1 Image Enhancement

In this phase enhancement of the image is done by enhancing edges, filtering noise, sharpening.

2.2 Restoring Image

In this phase the degradation of the image is eliminated by deblurring of images.

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2.3 Analysing Image

In this step measurements are made on quantitative aspects for creating description of the image.

2.4 Compression of Image

Using this step the data can be stored effectively by minimizing the storage needed.

3. Impulse Noise

Impulse noise is a very general problem in image processing and this type of noise also called salt and pepper noise and here pixels appear as black and white dots which are evenly distributed on the image. Impulse noise is a type of noise which includes nonusable, instantaneous sharp sounds. This impulse noise is caused by errors during transmission of signals, errors occurred during analog to digital conversion; electromagnet interference errors occurred during electromagnet interference, unfair digital recording and communication errors and bit errors. In the case of salt and pepper noise can be removed using an impulse noise filter.

4. A New Improved Multistage Eight Directional Median Filter

The errors in data transmission are the real cause for impulse noise. The corrupted pixels are either set to the maximum value by positive impulse or set to zero value by negative impulse. This gives a salt and pepper appearance. The unaffected pixels are kept unchanged. Usually the noise is quantified by the percentage of pixels which are corrupted. If an image is corrupted by 30% then 15% of the pixels in the image are corrupted by positive impulses and 15% of the pixels corrupted by negative impulses.

Most median based filters use median value or weighted median value from the whole window as estimated value. Details and edges are not recovered satisfactorily since the noisy pixels are replaced by median value in their vicinity without taking into account local features such as the possible presence of edges.

Let D_k ($k = 1$ to 8) denotes a set of coordinates aligned with the k th direction cantered at $(0, 0)$. The entire pixel along D_1 should be similar if there is one edge along D_1 , but pixels along other directions should not be similar. Standard deviation can be used to calculate the similarity along directions since standard deviation describes how

tightly all the value are clustered around the mean in the set of pixels. Standard deviations ($Sk(i, j)$, $k = 1$ to 8) and median values ($Mk(i, j)$, $k = 1$ to 8) along eight directions need to be calculated. Smallest standard deviation along D_1 suggests that a possible diagonal edge existed in window there for median value of pixels along that direction in filter window $M_1(i, j)$ is used as the estimated value to replace the center noise pixel.

This algorithm can detect most edges but have problem for thin edges especially single pixels with edges. The center pixel is corrupted by positive impels and should be replaced by an estimated value since the estimated value should calculated only from noise free pixels within the filter window, the center pixel is excluded from calculation.

5. Simulation

In the experiment, the original test images are corrupted with the impulse noise i.e. salt-and-pepper noise.

In order to calculate the restoration performance, the Peak Signal-to-Noise Ratio (PSNR) is used and it can be represented as,

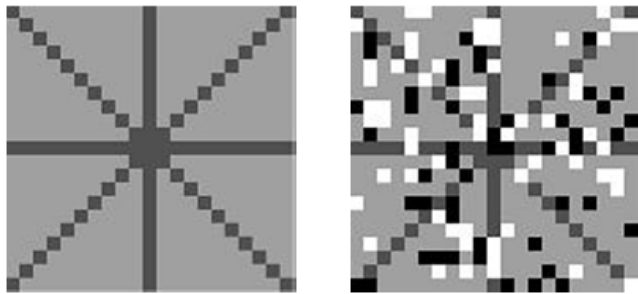
$$PSNR = 10 \log_{10} \frac{\max\{o(i, j), (i, j) \in I\}^2}{\frac{1}{MN} \sum_{(i, j) \in I} [r(i, j) - o(i, j)]^2} (dB)$$

Where r and o denote the pixel values of the restored image at (i, j) and the original image at (i, j) respectively, and the image size is $M \times N$.

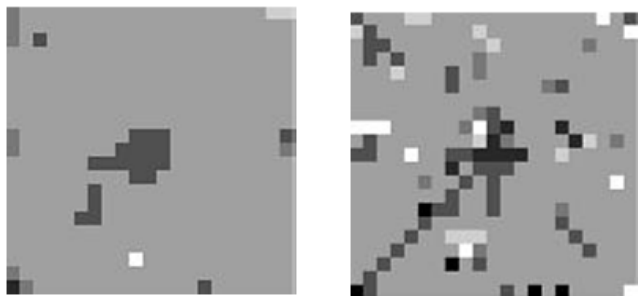
Figure 1(a) shows an original image (21×21) with single pixel width edges. Figure 1(b) is Figure 1(a) corrupted by 30% impulse noise. Figure 1(c) shows the conventional median filter result. Figure 1(d) shows the directional weighted median filter result. Figure 1(e) shows the adaptive median filter result. Figure 1(f) shows the multi-stage directional median filter result.

The PSNR value obtained for conventional median filter is 15.69 dB. The PSNR value obtained for directional weighted median filter is 15.46 dB. For adaptive median filter the PSNR value obtained is 19.78 dB. For the multi-stage directional median filter the PSNR value obtained is 22.94 dB. The result shows that the multi-stage-directional median filter is the best. Adaptive median filter is the second. Even the directional weighted median filter produces higher PSNR than conventional median filter, Figure 1(d) looks better than Figure 1(c).

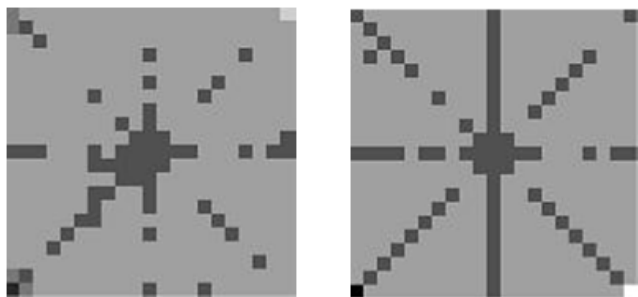
Figure 2(a) shows an original image with thin edges. The image in Figure 2(a) is corrupted by 30% impulse



(a) (b)
Original and corrupted images.



(c) (d)
Results of conventional median and directional weighted median filters



(e) (f)
Results of adaptive median and multi-stage directional median filters.

Figure 1. (a) Original image, (b) Corrupted image, (c) Conventional median, (d) Directional Weighted median, (e) Adaptive median filter and (f) Multistage directional

noise and is shown in Figure 2(b). The result of the conventional median filter is shown in Figure 2(c). The result of the directional weighted median filter is shown in Figure 2(d).

The PSNR value obtained for conventional median filter is 15.73dB. The PSNR value obtained for directional weighted median filter is 14.46 dB. For adaptive median filter the PSNR value obtained is 18.97 dB. For the multi-stage directional median filter the PSNR value obtained is



(a) (b)
Original and corrupted images.



(c) (d)
Results of conventional median and directional weighted median filters



(e) (f)
Results of adaptive median and multi-stage directional median filters.

Figure 2. (a) Original image Corrupted image, (b) Original and corrupted images, (c) Conventional median, (d) Directional Weighted median, (f) Adaptive median filter, (g) Multistage directional median filter.

20.50dB. The result shows that the multi-stage-directional median filter is the best.

6. Conclusion

A new improved multi stage eight directional median filter is proposed in this paper. Here in the first stage Impulse noise is detected. Edges are identified along eight directions after noise detection. To preserve the

edge information median filter is applied only along edge directions. The new improved multistage eight directional median filter performs better than other conventional median filter algorithms. It is very clear from the simulation results given in the experiment.

7. References

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