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Performance analysis of Impulse Noise Reduction Algorithms: Survey

P.Thirumurugan[1*] and S.Sasi Kumar[2]

[1]Department of Electronics and Communication Engg, PSNA College of Engineering and Technology, Tamil Nadu 624622, India

[2]Department of Computer and Science Engg, RMD Engineering College

***Corresponding author**

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Impulse noise detector, noise reduction, Power consumption, Edges details and Image quality

A B S T R A C T

Impulse noise is corrupted in the field of DIP applications of transmission and reception due to unwanted disturbance. So, the original image will corrupted at the acquiring end. The various denoising filter algorithm of impulse noise reduction in this survey were studied. So the impulse noise detection and removal technique, they have several drawbacks also discussed for various image with various denoising filter methods and also comparative results study with psnr values and reconstructed image in this survey

Introduction

The basic idea to behind in this research is the restoration of original image from the distorted image corrupted by impulse noise. It is also referred to as image "denoising". Denoising is the process of removing unwanted noise from an image. A denoised image is an approximation to the underlying true image, before it was contaminated. Image denoising finds applications in fields such as astronomy, medical imaging and forensic science. Different types of noise frequently contaminate images. Impulse noise is one such noise, which is frequently introduced into images while transmitting and acquiring them due to channel errors or in storage media due to faulty hardware. According to the distribution of noisy pixel values, impulse noise can be classified into two categories: Fixed-Valued impulse noise and Random-Valued impulse noise.

The Fixed Values impulse noise is also known as "Salt and Pepper Noise" since the pixel value of a noisy pixel is either minimum or maximum value in grayscale images. The values of noisy pixels corrupted by random valued impulse noise are uniformly distributed in the range of [0, 255] for gray-scale images. Removal of Random valued impulse noise is more complicated due to the random distribution of the noise pixels.

In this paper, the main focus is on the detection and correction of the random-valued impulse noise from the corrupted image. Recently many methods have been proposed for the removal of Impulse noise from the image. Many methods recently have been proposed for the removal of Impulse noise from the image. Some of them employ the standard median filter or its modifications. However, these approaches might blur the image since both noisy and noise-free pixels are modified. To avoid the damage on noise-free pixels, an efficient switching strategy has been proposed in the related works. In general, the switching median filter (Non-linear technique) consists of two steps: 1) impulse detection and 2) noise filtering. It locates the noisy pixels with an impulse detector, and then filters them rather than the whole pixels of an image to avoid causing the damage on noise-free pixels. These filter work with low noise ratios, and are very poor when the noise ratio reaches above 40%.

In this survey, a various denoising algorithm performs preserves the image details effectively than other older technique. The design uses two steps for easy computation—impulse detection and mean filtering. The mean filtering does not affect the edges or other small structures in the image. This method is more important for the restoring of corrupted images. After the impulse noise is detected, only those pixels are processed by the filter algorithm and reconstructed the corrupted image in good manner as shown in Fig.1.

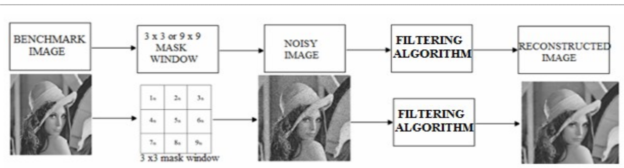

Fig.1: Block Diagram of Noise Removal Technique

Al -Araji et al. [1] presented an auto selection technique to reduce impulse noise presented an auto selection technique to reduce impulse noise in wireless communication systems. The selection of the appropriate reduction technique was based on an estimation of the rate of impulse noise present in the system. The impulse noise can be detected by comparing it with a fixed reference. Their system used subtraction-gating for low occurrence rate, conventional limiting for high occurrence rate and directly sends the incoming signal to the output if impulse noise is absent. The simulation results for QAM and FSK and real-time implementation on an FPGA were presented and the bit error rate was estimated.

Chen et al. [2] proposed an adaptive pixel-correlation filter (APCF) to remove impulse noise, with an adaptive threshold which was designed based on the correlations between a pixel and its neighbors. The filter was designed with a novel adaptive working window and weighted function for impulse noise detection and preserving noise-free pixels based on the fact that both horizontal and vertical correlations for a pixel are more significant than other orientations. Numerous simulations show that APCF is more robust and effective than other well-known median filtering algorithms.

Chen et al. [3] proposed an adaptive working window to remove impulse noise. All pixels are correlated with its neighboring pixels, i.e. they have pixel-correlation. The intensity of impulse noise was estimated with the value of pixel-correlation. They introduced a simple rule for impulse noise reduction for various median-based filters with adaptive working window. The switching median (SM) filter and multi-state median (MSM) filter were designed with this simple rule and the simulations showed that this method improves the reliability of MSM and SM filters in reducing impulse noise.

Divya Jothi et al. [4] proposed a new integrated fuzzy filter for the reduction of additive noise and impulse noise from digital color images. They used an impulse noise detector in the filter to detect the presence of impulse noise. The detector divides the set of pixels into impulse noise affected points and cleans points. A filter selection module was employed to select the appropriate filter to match the type of noise. The output of integrated filter contains the enhanced image after noise removal. Their method combined the advantages of both additive noise and impulse noise filters. Their results showed that the approach effectively removed the integrated noise even at high noise levels.

In [5], Rezvanian et al. presented an efficient method to reduce impulse noise in two passes. At the first pass impulse noise detection using ANFIS, and at the second pass the impulse noise estimation, that corrupted noise pixel replaced with new value based on neural networks. The method was experimented on popular grayscale test images and compared with other methods using subjective and objective measures. Their results showed that the method works efficiently in reducing impulse noise than other compared methods.

In [6], Tao Chen, Kai-Kuang Ma and Li-Hui Chen (1999) proposed a Tri-State Median Filter for Image Denoising. A novel nonlinear filter, called tri-state median (TSM) filter, is proposed for preserving image details while effectively suppressing impulse noise. The simulation result of the proposed filter consistently outperforms other median filters by balancing the tradeoff between noise reduction and detail preservation. To achieve better results, a camera calibration procedure may be placed before our system. For different values of noise density, optimum threshold range for yielding smallest MSE values and good visual quality can be obtained through similar simulation experiments.

In [7], Zhou wang and David zhang (1999) proposed a new median based filter, i.e., Progressive switching median (PSM) filter to restore images corrupted by salt & pepper noise. This algorithm was developed by two main concepts 1) switching scheme based image filters 2) progressive methods –impulse detection and noise filtering procedures are progressively through several iterations. The Simulation results demonstrate that the proposed algorithm is better than traditional median-based filters and is particularly effective for the cases where the images are very highly corrupted ratios ranging from 5% to 70% and MSE also better than other median based methods, especially when noise ratios are high. It can remove almost all of the noise pixels while preserve image details very well.

In [8], Tao Chen and Hong Ren Wu (2001) proposed a novel adaptive median filter that employs the switching scheme based on the impulse detection mechanism. i.e., Adaptive Impulse Detection Using Center-Weighted Median (ACWM) Filters. The Extensive simulations that the proposed filter consistently works well in suppressing both types of impulses (fixed & random valued impulse) with different noise ratios. While still possessing a simple computational structure.

In [9], Tao Chen and Hong Ren Wu (2001) proposed a generalized framework of median based switching schemes, called multi-state median (MSM) filter. By using simple thresholding logic, the output of the MSM filter is adaptively switched among those of a group of center weighted median (CWM) filters that have different center weights. This proposed MSM filter is equivalent to an adaptive CWM filter with a space varying center weight which is dependent on local signal statistics. The proposed extensive simulations MSM filter produces better performance than the other median based filters, being consistently effective in noise suppression and detail preservation for various images corrupted at different noise ratios.

In [10], Crnojevic, Senk and Trpovski (2004) proposed a robust estimator of the variance, MAD (median of the absolute deviation from the median), is modified and used to efficiently separate noisy pixels from the image details and therefore has no sensitivity to image contents. The proposed algorithm complexity is equivalent to that of the median filter and the pixel-wise MAD concept is straight forward, low in complexity, and achieves high filtering performance.

In [11], Raymond H. Chan, Chen Hu and Mila Nikolova (2004) proposed a consists of two-stage iterative method for removing random-valued impulse noise. In the first phase, we use the adaptive center-weighted median filter (ACWM) to identify pixels which are likely to be corrupted by noise (noise candidates). In the second phase, these noise candidates are restored using a detail-preserving regularization method which allows edges and noise-free pixels to be preserved. These two phases are applied alternatively. This Simulation results indicate that the proposed method is significantly better than those using just nonlinear filters or regularization only. Like other medium-type filters, ACWMF can be done very fast. The application of DPVM is the most time-consuming part as it requires the minimization of the functional in robust statistics with applications to early vision. For example, for 30% noise, our method takes 30 times more CPU time than ACWMF. The timing can be improved by better implementations of minimization routines for solving the robust statistics with applications to early vision.

In [12], Hancheng Yu, Li Zhao and Haixian Wang (2008) proposed an efficient algorithm method uses a statistic of Rank-ordered relative differences to identify pixels which are likely to be corrupted by impulse noise. Its consists of two methods 1.RORD impulse detector into many existing filtering techniques, allowing them to detect and properly handle impulse-like pixels in a noisy image. 2. A simple weighted mean filter (SWMF) by using the RORD detector and the reference image to suppress impulse noise, while preserving image details. The time required for our denoising process is less compared with ACWM-EPR, ROAD-TRIF, and ROLD-EPR. Although our algorithm is applied iteratively also much faster, especially when the noise level is high., the simple weighted mean filter offers good filtering performance while its implementation complexity is lower than other filters.

In [13], Francisco Estrada, David Fleet and Allan Jepson (2009) proposed a novel, probabilistic algorithm for image noise removal. i.e., Stochastic Image Denoising. These proposed algorithm for image denoising based on simulated random walks on image space and also it very simple, yields excellent results on heavily corrupted images. The random walks produce stable estimates even for few trials, and that the overall behaviour of the random walks approximates that of more computationally expensive blur kernels. Stochastic denoising will become a useful tool in image processing applications for which noise removal is important.

In [14], Jian-Feng Cai, Raymond H. Chan and Mila Nikolova (2010) proposed a Fast Two-Phase Image Deblurring under Impulse Noise. This proposed algorithm consists a two-phase approach to restore images corrupted by blur and impulse noise, which is much simpler. In First phases, Accurate detection of the location of outliers (the noise candidates) using a median-type filter and Second phase, Edge-preserving restoration that deblur using only those data samples that are not noise candidates. The PSNR of the restoration by our method is about 1 to 3 dB higher than that by the variational method. Even for blurred images corrupted by 55% random-valued noise, proposed method can give a very good restoration result. Comparing the two-phase methods Image Deblurring under Impulse Noise with the Two-phase methods for deblurring images corrupted by impulse plus Gaussian noise. The proposed method produces more computationally efficient and takes only about 1/8 CPU.

In [15], P. E. Trahanias and A. N. Venetsanopoulos (1993) proposed a Vector Directional Filter-A New Class of Multichannel Image Processing Filters. These proposed filters separate the processing of vector-valued signals into directional processing and magnitude processing. This provides a link between single-channel image processing, where only magnitude processing is essentially performed, and multichannel image processing where both the direction and the magnitude of the image vectors play an important role in the resulting (processed) image. VDF perform at least as good and in most cases and also better chrominance estimate than VMF and this justifies their employment in color image processing. VDF can achieve very good filtering results for various noise source models.

In [16], Yiqiu Dong, Raymond H. Chan, and Shufang Xu (2007) proposed a Detection Statistic for Random-Valued Impulse Noise. This proposed technique for detecting random-valued impulse noise based on image statistic. By this statistic, we can identify most of the noisy pixels in the corrupted images. Combining it with an edge-preserving regularization, we obtain a powerful two-stage method for denoising random-valued impulse noise even for noise level as high as 60%. These propose a new local image statistic ROLD, by which we can identify more noisy pixels with less false-hits. We combine it with the edge-preserving regularization in the two-stage method iterative method to get a powerful method for removing random-valued impulse noise. Simulation results that proposed method outperforms a number of existing methods both visually and quantitatively.

In [17], Yiqiu Dong and Shufang Xu (2007) proposed a New Directional Weighted Median Filter for Removal of Random-Valued Impulse Noise. This proposed a new impulse detector, which is based on the differences between the current pixel and its neighbors aligned with four main directions. Then, we combine it with the weighted median filter to get a new directional weighted median (DWM) filter. These Extensive simulations that the proposed filter not only can provide better performance of suppressing impulse with high noise level but can preserve more detail features, even thin lines. As extended to restoring corrupted color images, this filter also performs very well. Simulation results show that the DWM filter performs much better than many existing median-based filters in both subjective and objective (PSNR) evaluations. Especially, it can preserve edges very well, even thin lines, as removing noise. In addition, it can be extended to restore the color images corrupted by random-valued impulse noise and also perform well.

In [18], Roman Garnett, Timothy Huegerich and Charles Chui proposed a Universal Noise Removal Algorithm with an Impulse Detector. This proposed a local image statistic for identifying noise pixels in images corrupted with impulse noise of random values. The simulation result of new filter is capable of reducing both Gaussian and impulse noises from noisy images effectively, which performs remarkably well, both in terms of quantitative measures of signal restoration and qualitative judgments of image quality. This approach is extended to automatically remove any mix of Gaussian and impulse noise. For high levels of noise ratio > 25%, applying two to five iterations provides better results than the median filter for mixed noise.

In [19], Vector directional filters (VDF) for multichannel image processing were introduced. VDF separates the processing of vector-valued signals into directional processing and magnitude processing. This provides a link between single-channel image processing, where only magnitude processing is essentially performed and multi-channel image processing where both the direction and the magnitude of the image vectors play an important role in the processed image. The experimental result shows that for the case of colour images, VDF achieved very good filtering results for various noise source models. A survey of various denoising filters with 50% corrupted of various images on PSNR values as shown in Table I.

TABLE.I Compare various denoising filter with 50% corrupted on Psnr values

IMAGE\ FILTERS	NOISY	MEDIAN	ACWM	AMF
LENA	14.47	21.22	21.23	22.56
COUPLE	14.56	21.14	21.16	22.52
BARBARA	14.33	20.73	20.64	21.99
BOAT	14.52	21.15	21.20	22.44
GOLDHILL	14.42	21.22	21.20	22.54
HOUSE	8.44	14.81	15.31	16.43

In various denoising filter are compared and restored of various images for LENA, BARBARA, BOAT, COUPLE, GOLDHILL and HOUSE as shown in Fig 2, 3 and 4 respectively and A comparison of different median-based filters for the restoration of corrupted various image under a large range of impulse noise ratio as shown in Fig 5, 6, 7, 8, 9 and 10 respectively.

The various denoising filter algorithm of impulse noise reduction in this survey were studied. So, in this survey, Median Filter has restored the image with blurring the image details. ACWM Filter has restored the good image only at low noise ratio and poor in high noisy ratio. Robust for a wide variety of images due to the selection of the threshold. AMF Filter has restored the good image only at high noise ratio and poor in low noisy ratio compare to ACWM Filter in suppressing both types of impulses (fixed & random valued impulse) with different noise ratios. It possessed a simple computational structure.

Fig 2. Restoration results of Median filters with 50% corrupted ratio.

Fig 3. Restoration results of ACWM filters with 50% corrupted ratio

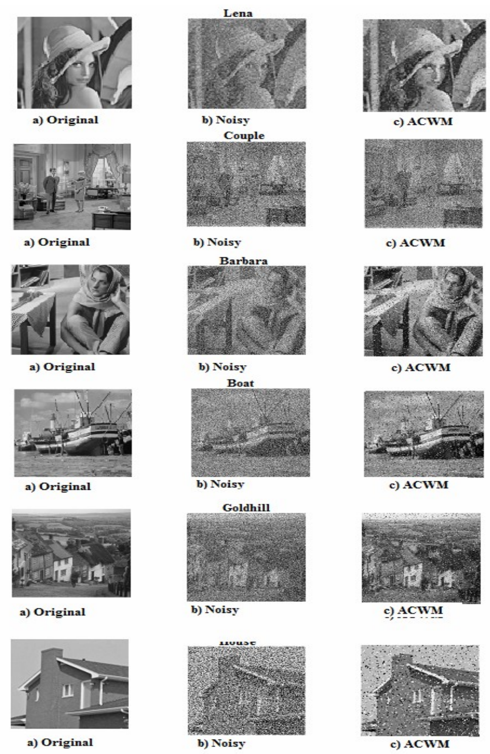

Fig 4. Restoration results of AMF filters with 50% corrupted ratio.

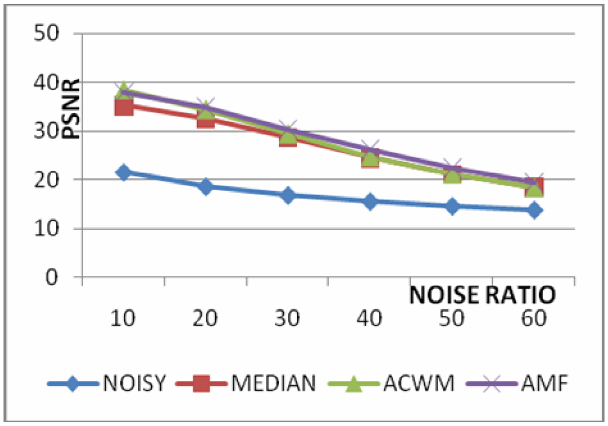

Fig.5 A comparison of different median-based filters for the restoration of corrupted image "LENA" under a large range of impulse noise ratio.

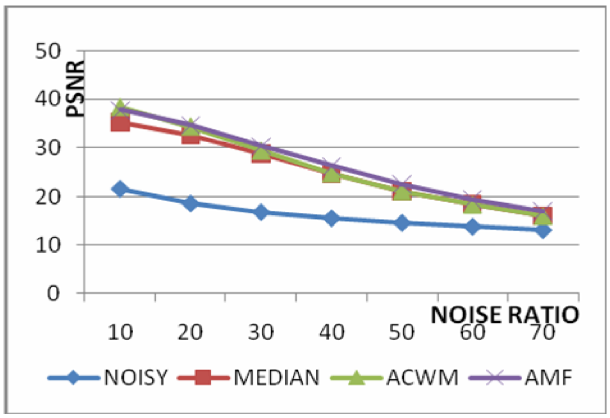

Fig.6 A comparison of different median-based filters for the restoration of corrupted image "COUPLE" under a large range of impulse noise ratio.

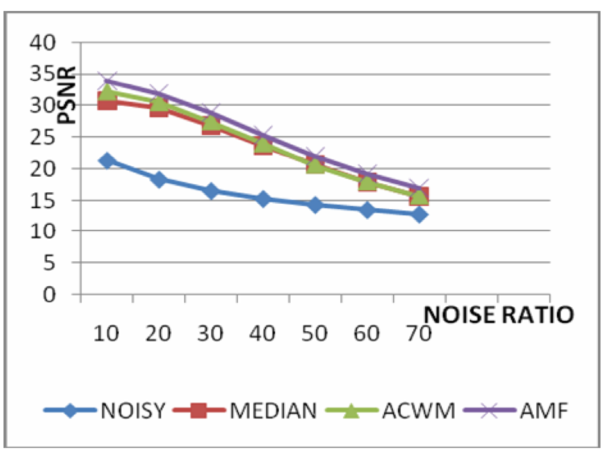

Fig.7 A comparison of different median-based filters for the restoration of corrupted image "BARBARA" under a large range of impulse noise ratio.

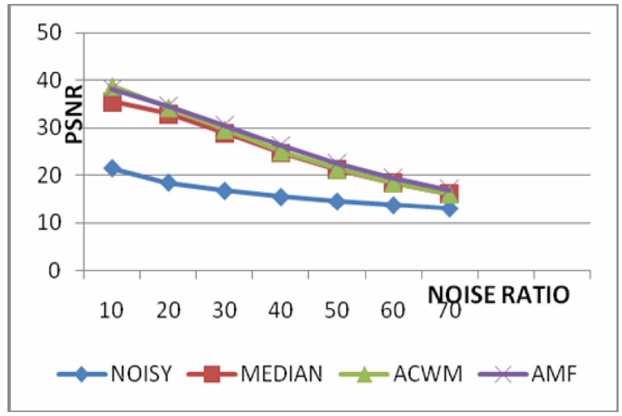

Fig.8 A comparison of different median-based filters for the restoration of corrupted image "BOAT" under a large range of impulse noise ratio.

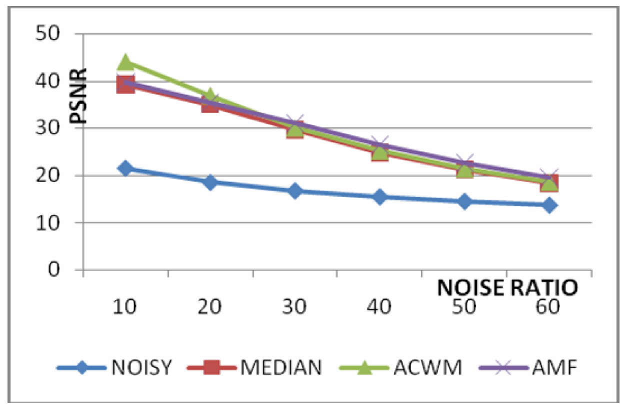

Fig.9 A comparison of different median-based filters for the restoration of corrupted image "GOLD HILL" under a large range of impulse noise ratio.

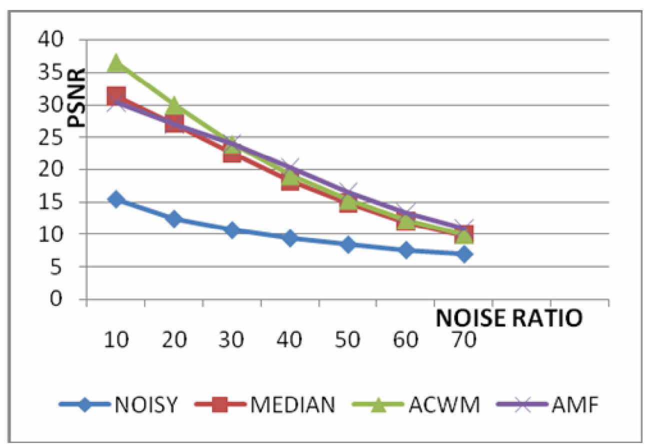

Fig.10 A comparison of different median-based filters for the restoration of corrupted image "HOUSE" under a large range of impulse noise ratio.

Conclusion

From the above discussion, conclude the impulse noise reduction is more valuable in tradition in digital image processing applications like Medical Application and we presented a survey of impulse noise reduction algorithm for restored of corrupted various images for MRI BRAIN, MAMMOGRAM, LENA, BARBARA, BOAT, COUPLE, GOLDHILL and HOUSE, even though they have several drawbacks for restoration of corrupted image processing. So, a new impulse detection and removal algorithm and FPGA Implementation of impulse noise reduction algorithm is proposing in my future work.

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