© 2018 IJSRST | Volume 4 | Issue 3 | Print ISSN : 2395-6011 | Online ISSN: 2395-602X

National Conference on Advances in Engineering and Applied Science (NCAEAS)
29th January 2018
Organized by : Anjuman College of Engineering and Technology (ACET) Nagpur, Maharashtra, India, In association with
International Journal of Scientific Research in Science and Technology

"A Review on Noise Removal Using Modified Global-Local Filters"

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ABSTRACT

This review summarizes the current research works made in the field of removing salt and pepper noise or impulse noise using filters. In this work, we can reduce Salt and Pepper noise using median filter and Improved Progressive Switching Median Filter (IPSMF). It also highlights the comparable results between mean and median filter. It gives a review on current research works, considerable prospects for the future, and discusses the issues most important for further enhancement in the filters for removing noise and applications.

This paper is a survey of various novel algorithms to get better Peak Signal-to-Noise Ratio (PSNR), Mean Square Error (MSE) and Structural similarity (SSIM). This survey mainly focuses on removing noise using filters.

Keywords: Impulse noise, Peak Signal-to-Noise Ratio (PSNR), Mean Square Error (MSE), mean filter, median filter, Improved progressive switching median filter (IPSMF).

I. INTRODUCTION

Background: The available literature shows many methods based on mean and median filters employed for removal of impulse noise. There are many variants in median filter such as Standard Median Filter (MF), Adaptive Median Filter (AMF), Switching Median Filter (SMF), Progressive switching median filter (PSMF). So this concept was then actually introduced and was called Improved progressive switching median filter (IPSMF).

Introduction to noise: Noise is basically an undesired information that affects the quality of signals and data. Noise is always present in digital images during image acquisition, coding, transmission, and processing steps. The most common type of noise is salt and pepper noise which is a subtype of impulse noise. In case of salt and pepper noise, the corrupted pixels will take either gray value 255(Salt) or gray value 0(Pepper). In order to remove noise from the noisy images, different filters have been proposed.

Among different filtering techniques proposed to remove impulse noise in digital images, the most common filter used in removing impulse noise is median filter. The main idea of the median filter is to run the filter window pixel by pixel, replacing each pixel with the median of pixels in the window.

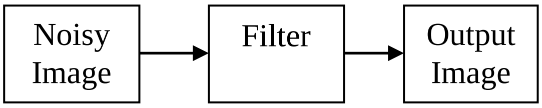

Figure 1. Noise removal workflow

Applications: This improved progressive switching median filter (IPSM) can enhance progressive median filter in terms of its noise filtering ability. The main aim of the filtering is to eliminate outliers with maximum signal distortion to the recovered noise free image. The algorithm sets a limit on the number of good pixels used in determine median and mean values, and substitute impulse pixel with half of the value of the summation of median and mean value.

II. NOISE REMOVAL USING DIFFERENT FILTERS

A noise removal technique can be done by using mean filter, median filter, progressive switching median filter (PSMF) and improved progressive switching median filter (IPSMF) depending upon the analysing parameters Mean Squared Error (MSE), Peak Signal-to-Noise Ratio (PSNR), Structural Similarity (SSIM) and Impulse noise.

Analysing Parameters:

1. Impulse Noise:-

Impulse noise is random variation of brightness or colour information in images, and is usually an aspect of electronic noise. Impulse noise corruption is very common in digital images. Impulse noise is always independent and uncorrelated to the image pixels and is randomly distributed over the image. For an impulse noise corrupted image all the image pixels are not noisy, a number of image pixels will be noisy and the rest of pixels will be noise free.

2. Mean square error (MSE):-

The MSE symbolizes your cumulative squared mistake relating to the compacted along with the unique image.

Where, f represents the matrix data of our original image, g represents the matrix data of our degraded image, m represents the numbers of rows of pixels of the image and i represent the index of that row, n represents the number of columns of the pixels of the image and j represents the index of that column.

3. Peak-Signal-to-Noise-Ratio (PSNR):-

PSNR is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. It is expressed in terms of the logarithmic decibel (db). PSNR is most commonly used to measure the quality of reconstruction of lossy compression codecs (e.g., for image compression). PSNR is most easily defined via the mean squared error (MSE).

$$\begin{aligned} PSNR &= 10 \cdot \log_{10}\left(\frac{MAX_I^2}{MSE}\right) \\ &= 20 \cdot \log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right) \\ &= 20 \cdot \log_{10}(MAX_I) - 10 \cdot \log_{10}(MSE) \end{aligned}$$

4.Structural Similarity (SSIM):-

It is a method for predicting the perceived quality of digital television and cinematic pictures, as well as other kinds of digital images and videos. It is used for measuring the similarity between two images. SSIM is designed to improve on traditional methods such as peak signal-to-noise ratio (PSNR) and mean squared error (MSE).

$$\mathrm{SSIM}(X,Y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)}$$

Where μx is the average of x,
μy is the average of y,
σ_x^2 the variance of x
σ_y^2 the variance of y
σ_{xy} the covariance of x and y,
c1= (k1 L)² and c2= (k2 L)² two variables to stabilize the division with weak denominator,
L the dynamic range of the pixel-value

In the paper [1], Jayanta Das, Bhaswati Das, Jesmine Saikia and S.R.Nirmala proposed a method for the restoration of gray scale images that are highly corrupted by salt and pepper noise. In this filter at first the noisy pixel is identified and then it is replaced by a suitable value. Here the size of the window automatically increases until it gets its suitable median value to replace the noisy pixel. This proposed algorithm shows better results than the standard median filter (MF), weighted median filter (WMF), switching mean median filter (SMMF) and bilateral filter.

The result demonstrated selective adaptive median filter performs better than median based filters. Even at a very high noise density (80%) the texture, details and edges are preserved to an acceptable level. The combination of bilateral filter and adaptive median filter may also be considered.

Raghuram Kunsoth and Mantosh Biswas [2], proposed method that follows Decision Based Median Filter (DBMF) that considers only the noisy pixels and replaces the pixel value with median value of the pixels present in the processing window and increase the window size as per the requirement.

Evaluation is done based on the PSNR and SSIM values and the method works extremely well even with high noise density and deals with poor quality images even when all the pixels are corrupted in small window preserving as much image details as possible.

Paper [3], Pei-Eng Ng and Kai-Kuang Ma proposed a switching median filter incorporating with a powerful impulse noise detection method, called the boundary discriminative noise detection (BDND) for effectively de-noising extremely corrupted images.

The result demonstrated that the performance delivery is mainly due to highly accurate noise detection accomplished by the BDND algorithm—achieving zero miss-detection rate up to 70% noise density corruption while maintaining a fairly low false-alarm rate. Together with additional improvements contributed from the post-detection filtering stage, the entire switching median filtering performance has yielded a very close performance to that of the ideal-switching case consistently.

In the novel framework [4], Mr.N.Krishna Chaitanya and Mr.P.Sreenivasulu proposed a Advanced Modified Decision Based Unsymmetric Trimmed Median Filter (AMDBUTMF) for removing salt & pepper noise from high density salt & pepper noisy images. The performance of AMDBUTMF is analysed by using various metrics such as Mean Square Error (MSE) and Peak Signal-to-Noise Ratio (PSNR).

The result demonstrated that the proposed method is much better in removing the noise with high density compared with the existing methods in terms of PSNR and MSE. This method is also applicable for another type of noises like speckle, Gaussian, random etc.

This paper [5], Archana Singh, Sanjana Yadav and Neeraj Singh proposed a concept of contrast enhancement using the global mean of entire image and local mean of 3x3 sub images. Local mean filter is used to smooth the image by taking the mean value of the pixels surrounding the center pixel within the image.

The proposed method combines global information as well as local information of the input gray images in order to enhance them. In this method, mean filter is also used that removes artifacts existing within the images. The result is demonstrated by applying this concept on number of real time images.

Research work in paper [6], Zhou Wang and David Zhang proposed a new median-based filter which is a progressive switching median (PSM) filter, which is used to restore images corrupted by salt–pepper impulse noise.

The algorithm is developed by the following two main points:

1) switching scheme—an impulse detection algorithm is used before filtering, thus only a proportion of all the pixels will be filtered

2) progressive methods—both the impulse detection and the noise filtering procedures are progressively applied through several iterations.

In the novel research paper [7], Soon Ting Boo, Haidi Ibrahim and Kenny Kal Vin Toh proposed a method to improve the PSM filter, an improved progressive switching median filter (IPSM) is proposed to enhance progressive median filter in term of its noise filtering ability. The algorithm sets a limit on the number of good pixels used in determine median and mean values, and substitute impulse pixel with half of the value of the summation of median and mean value.

The result illustrated that Improved Progressive Switching Median (IPSM) filter performs better restoration compared to Progressive Switching Median (PSM) filter, particularly for highly corrupted images. The performance of IPSM is almost equal to PSM when the image is corrupted with low level of impulse noise. This is because of the redundancy of good pixels in images corrupted with low-level of impulse noise.

In novel work [8], S. Esakkirajan, T. Veerakumar, Adabala N. Subramanyam, and C. H. PremChand proposed an algorithm which replaces the noisy pixel by trimmed median value when other pixel values, 0's and 255's are present in the selected window and when all the pixel values are 0's and 255's then the noise pixel is replaced by mean value of all the elements present in the selected window.
This proposed algorithm shows better results than the Standard Median Filter (MF), Decision Based Algorithm (DBA), Modified Decision Based Algorithm (MDBA), and Progressive Switched Median Filter (PSMF).

The result illustrated that MDBUTMF is better in terms of its performance when it is compared with MF, AMF and other existing noise removal algorithms in terms of PSNR and IEF. Even at high noise density levels the MDBUTMF gives better results in comparison with other existing algorithms.

In this novel research paper [9] Thomas A. Nodes and Neal C. Gallagher proposed some modifications in median filter. It is also shown that for non-median nth ranked-order operations, repeated application of the operation will reduce any signal to a constant. Also it is proved that the output of a recursive median filter is invariant to subsequent passes by the same filter.

It is examined for several variants of the median filter and have proven many of their properties. All of the properties are based on finite length signals with constant appended endpoints of values equal to the values of the respective endpoints of the signal. It was also found that the set of nth ranked-order operations is a generalization of the median filter, and that they all have many similar characteristics.

T. Loupas, W. N. Mcdicken, and P. L. Allan in paper [10] proposed a method for reducing speckle noise in medical ultrasonic image and the method used for such noise reduction is called as AWMF (Adaptive Weighted Median Filter). It is based on the weighted median, which originates from the well-known median filter through the introduction of weight coefficients. By adjusting the weight coefficients and consequently the smoothing characteristics of the filter according to the local statistics around each point of the image, it is possible to suppress noise while edges and other important features are preserved.

The result demonstrated that the filter combines the edge-preserving properties of the WMs with the space-varying implementation based on the local image characteristics to reduce significantly the speckle with negligible loss of genuine image detail.

The centre weighted median (CWM) filter 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. In this paper [11], it is an attempt to improve the performance of CWM filters, so a new improved adaptive CWM (ACWM) filter having a space varying central weight is proposed.

The CWM and ACWM filters are useful detail preserving smoothers, were proposed and their properties were analyzed. ACWM filters can suppress multiplicative noise as well as additive white and impulsive noise.

In this framework [12], a new impulse noise detection technique is presented for switching median filters. This technique is based on the minimum absolute value of four convolutions obtained using one-dimensional Laplacian operators. This filter provides better performance than many of the existing switching median filters.

From the result it is illustrated that this filter prevents removal of fine details such as lines from images and thus it provides improved impulse detection ability. The proposed method is better than many of the existing filters in terms of their simulation and computational complexity analysis.

K. S. Srinivasan and D. Ebenezer proposed a new decision based algorithm in paper [13], for restoration of images that are highly corrupted by noise. Unlike other non-linear filter, the proposed method removes only corrupted pixel by the median value or by its neighbouring pixel value.

From result it is demonstrated that the proposed filter exhibits better in comparison with SMF, AMF, and TD filters in terms of higher PSNR and IEF. This performance of this filter is consistent and stable across a wide range of noise densities varying from 10%–90%. Effective noise removal can be observed even up to 90% noise density level, while edges are preserved up to 80%.

A method for removing salt-and-pepper impulse noise in two phase scheme is discussed in the paper [14]. In the first phase, an adaptive median filter is used to identify pixels which are likely to be contaminated by noise. In the second phase, the image is restored using a specialized regularization method that applies only to those selected noisy pixels.

Experimental results show that this method performs much better than median-based filters or the edge preserving regularization methods. The texture, details, and edges are preserved accurately even at very high noise.

III. APPLICATIONS AND FUTURE SCOPE

Median filters are known for their capability to remove impulse noise as well as preserve the edges, so in future we can use advanced median filter which can be called as progressive switching median filter which will works in two stages. This filter implements a noise detection algorithm before filtering. But the disadvantage to use PSM is that it removes both the noise and the fine detail since it cannot tell the difference between the two. So it is an attempt to improve the PSM filter, and an Improved PSM filter can be proposed.

IV. CONCLUSION

In this paper we have given an introductory survey for removal of noise from images using different filters. Among all filters, progressive switching median filter is advantageous to be used because of its ability that it can restore images that are corrupted by salt-pepper impulse noise.

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