Available Online at www.ijcsmc.com

International Journal of Computer Science and Mobile Computing

A Monthly Journal of Computer Science and Information Technology

ISSN 2320–088X

IJCSMC, Vol. 4, Issue. 4, April 2015, pg.710 – 716

RESEARCH ARTICLE

AN IMPROVED APPROACH FOR REMOVAL OF HIGH DENSITY SALT AND PEPPER NOISE THROUGH MODIFIED DECISION BASED UNSYMMETRIC TRIMMED MEDIAN FILTER

Ashwin Thakur[1], Vipul Agrawal[2], Yogeshwar Khandagre[3], Alok Duby[4]

[1]P.G.Student, Trinity Institute of Technology & Research-India
[2,3,4]Faculty of Engineering, Trinity Institute of Technology & Research-India
ashwin.thakur09@gmail.com [1], vipul.agar@gmail.com [2],
yogesh.khandagare@gmail.com [3], dubeyalok2002@gmail.com [4]

Abstract — Noise is an unwanted parameter i.e. dot, line present in an image. There is several type of noise out of this impulse noise i.e. salt and pepper noise can corrupt image. Salt and pepper noise can corrupt pixel by taking either maximum or minimum gray level. Ideally, the filtering should be applied only to corrupted pixels while leaving uncorrupted pixels intact. The main function of filtering is to remove the impulses so that the noise free image is fully recovered with minimum signal distortion.. Median filters are known for their capability to remove impulse noise without damaging the edges. . The effective removal of impulse often leads to images with blurred and distorted features. Many denoising algorithms have been proposed to recover a noise corrupted image. However, most of them cannot well recover a heavy noise corrupted image with noise density above 70%. To remove the noise from image median filter are used. The nonlinear mean filter cannot mitigate such positive and negative impulses simultaneously only when occurrence of noise is high & hence median filter are used. The proposed method can efficiently remove background noise by detecting and modifying noisy pixels in an image. Here, a modified decision based unsymmetrical trimmed median filter algorithm for the restoration of gray scale, and colour images that are highly corrupted by salt and pepper noise is proposed. It produced better results than the Standard Median Filter (MF), Mean Filter and Spatial Median Filter (SMF). The different gray scale and colour image have been tested against different grayscale and colour images and it gives better Peak Signal-to-Noise Ratio (PSNR).

Keywords Median filter, salt and pepper noise, unsymmetrical trimmed median filter, AMF, SMF, DBUTM.

1. INTRODUCTION

Image processing is widely used in many fields, such as medical imaging, scanning techniques, printing skills, license plate recognition, face recognition, and so on. The noise may seriously affect the performance of image processing techniques. Hence, an efficient denoising technique becomes a very important issue in image processing. 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 former is also known as salt-and-pepper noise because the pixel value of a noisy pixel is either minimum or maximum value in gray-scale images. Due to the faulty communications, images are corrupted by salt and pepper noise, in the transmission of images over channels.

Images are frequently corrupted by impulse noise, which is owing to transmission errors, faulty memory locations or timing errors in analog to digital conversion. Salt and Pepper noise is also known as impulse noise. Salt and pepper noise can corrupt the images where the corrupted pixel takes either maximum or minimum gray level. The noise which sprinkles on the images like white and black dots significantly reduces the visual effects of images [1]. By using filtering technique can remove the impulse noise so that noise free image is fully recovered with minimum signal distortion. Some nonlinear filters have been proposed for removal of salt and pepper noise which is presented in the image.
Some pepper and salt noise filtering algorithm includes: Adaptive Median (AM) filter algorithm [2][3], Traditional Median (TM) filter algorithm; Extreme Median (EM) filter algorithm etc. This entire standard median filter has been established as reliable method to remove the salt and pepper noise without damaging the edge details. But the major drawback of standard Median Filter (MF) is that the filter is effective only at low noise densities [4]. When the noise level is over 50% the edge details of the original image will not be preserved by standard median filter. Adaptive Median Filter (AMF) [5] performs well at low noise densities. But at high noise densities the window size has to be increased which may lead to blurring the image. In switching median filter (SMF) [6,7] the decision is based on a pre-defined threshold value. The major drawback of this method is that defining a robust decision is difficult. To overcome the above drawback, Decision Based Algorithm (DBA) is proposed[8].But this Algorithm produces sticking effect during replacement of pixel. To avoid drawback of this Algorithm Decision Based
Unsymmetrical Trimmed Median Filter (DBUTMF) is proposed [9].But this algorithm does not give better results at very high noise density that is at 80% to 90%. The Modified Decision Based Unsymmetrical Trimmed Median Filter (MDBUTMF) algorithm removes this drawback at high noise density and gives better Peak Signal-to-Noise Ratio (PSNR) values than the existing algorithm.

It is observed that the main drawback of the median filter is that it also modifies non noisy pixels thus removing some fine details of the image. Therefore it is only suitable for very low level noise density. At high noise density it shows the blurring for the larger template sizes and not able to suppress the noise completely for smaller template sizes. Therefore, contemporary switching filters split the denoising process in two steps. First one is detection of noise and second one is the replacement of the noisy pixel value with estimated median value. These are weighted median filter [10-11], adaptive impulse detection using centre weighted median [12], rank order filtering algorithm [13-14]. The performance of the centre weighted median filter (CWMF), standard adaptive median filter (AMF) and progressive switching median filter (PSMF) algorithms are good at the lower noise density due to less numbers of the noisy pixels which are replaced with the median values [15-16]. But at high noise density, there are a large number of the noisy pixels which are need to be replaced, therefore the size of the template will be larger to provide the better performance; however, the values of the noisy pixel and its replacement as median values are less correlated which results in information loss. The main disadvantage of the switching median filter [17] and decision based filter is that it is based on the predefined threshold, due to this some details and edges are also removed particularly in case of high noise density. Ideally the filtering should be applied only to the values of the noisy pixel while keeping the values of the noise free pixels. In order to overcome the disadvantages of these mentioned filtering techniques a two stage algorithm has been proposed [18]. In this algorithm an adaptive median filter is used in first stage to classify the values of the noisy and noise free pixels and detail preserving regularization technique is used in second stage to preserve the details and edges as much as possible. Due to large template size, processing time is too large and more complexity is involved in its implementation. In order to avoid this drawback, open-close sequence filter (OCSF) has been proposed [19]. This algorithm is based on mathematical morphology, which is suitable only for high density impulse noise (noise density ranging from 50% to 80%). The main drawback of this algorithm is that its performance is not good in very low noise density as well as in very high noise density. To overcome this drawback, decision based algorithm (DBA) is proposed [20]. In this algorithm, image is denoised by using a 3X3 window. The image is denoised for pixel value '0' or '255' else it is left unchanged. At high noise density the median value will be '0' or '255' which is noisy. In such case, neighboring pixel is used for replacement. This repeated replacement of neighboring pixel produces streaking effect [21]. In order to avoid this drawback, decision based unsymmetrical trimmed median filter (DBUTMF) is proposed [22].

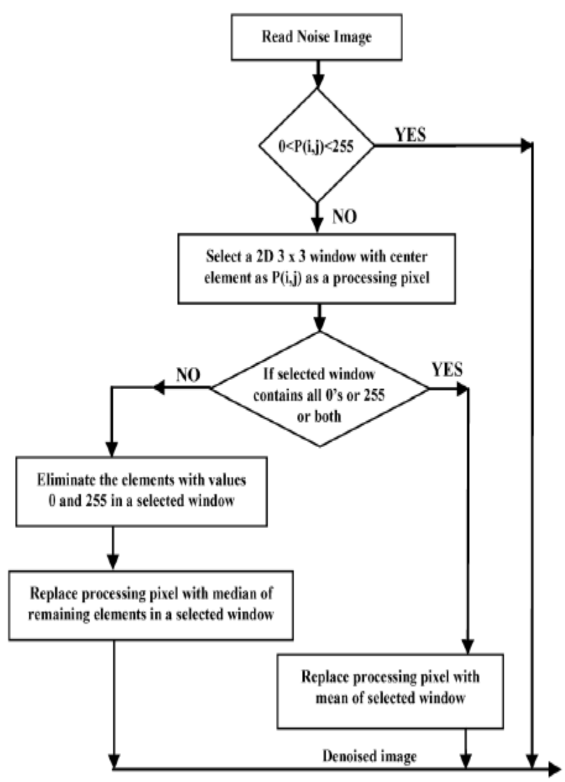
At high noise densities, if the selected window contains all '0's or '255's or both then, trimmed median value cannot be obtained. Modified non-linear filter (MNF) [23] replaces the noisy pixel by trimmed median value when other pixel values, 0's and 255's are present in the selected window and when all the pixel values are 0's and 255's then the noise pixel is replaced by increasing window size and finding trimmed mean based on algorithm. Different grayscale and color images are tested by using the MNF and found to produce better Peak Signal to Noise Ratio (PSNR) and Image Enhancement Factor (IEF). A MNF proposed to address the problems, namely, poor noise removal at high noise density, which are commonly encountered in SMFs. Results reveal that the proposed filter exhibits better performance in comparison with SMF, DBA, MDBA, MDBUTMF, filters in terms of higher PSNR and IEF. In contrast to AMF and other existing algorithms, the new algorithm uses a small 3x 3 window having only neighbors of the corrupted pixel that have higher correlation; this provides more edge details, leading to better edge preservation. The New algorithm filter also shows consistent and stable performance across a wide range of noise densities varying from 10%-90%. Effective noise removal can be observed even up to 90%.

2. PROPOSED ALGORITHM

The proposed Modified Decision Based Unsymmetric Trimmed Median Filter (MDBUTMF) algorithm first detecting the Impulse noise and then process on the corrupted pixel. The processing pixel is checked whether it is noisy or noisy free. That is, if the processing pixel lies between maximum and minimum gray level values then it is noise free pixel, it is left unchanged. If the processing pixel takes the maximum or minimum gray level then it is noisy pixel which is processed by MDBUTMF

ALGORITHM

The steps of the MDBUTMF are as follows:-
Step 1: Select 2-D window of size 3 by 3. Assume that the pixel being processed is Pij.
Step 2: If 0< Pij < 255 then Pij is an uncorrupted pixel and its value is left unchanged. This is illustrated in Case iii. in next section
Step 3: If Pij = 255 or Pij = 0 then Pij is a corrupted pixel then two cases are possible as given in Case i) and ii).
Case i): If the selected window contain all the elements as 0’s and 255’s. Then replace Pij with the mean of the element of window.
Case ii): If the selected window contains not all elements as 0’s and 255’s. Then eliminate 255’s and 0’s and find the median value of the remaining elements. Replace Pij with the median value.
Step 4: Repeat steps 1 to 3 until all the pixels in the entire image are processed.



The pictorial representation of each step of the proposed algorithm is shown in Fig. 1.

3. SIMULATION RESULTS

The proposed noise suppression algorithm is tested with various standard gray level images including Lena, Mandril and Peppers etc. the image is corrupted by Salt and Pepper noise at different density. The performance comparison is made with some standard filters like Mean Filter,Median Filter,Adaptive Median Filter and Dicision Based Algorithm. The performance of the noise suppression filter which is used in the proposed method is measured by the parameter peak signal-to-noise ratio, Mean Squared Error and Image Enhancement Factor. The Performance factor for measuring Image Noise are as follows

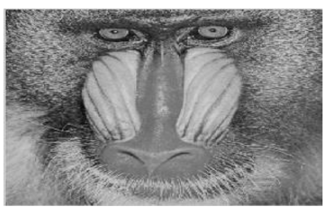
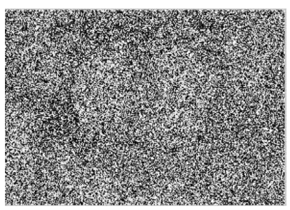
In statistics, the mean squared error or MSE of an estimator is one of many ways to quantify the amount by which an estimator differs from the true value of the quantity being estimated. MSE is defined as,

$$\text{MSE} = \frac{1}{MN}\sum_{i}^{M}\sum_{j}^{N} (Rij - Iij)^2$$

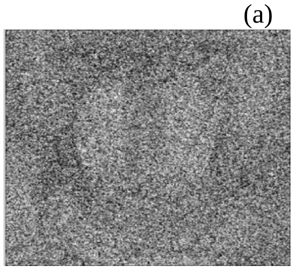
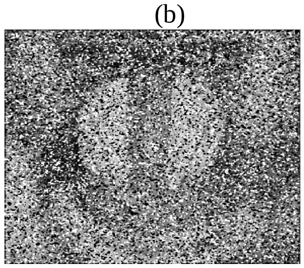
where *Ri;j and Ii;j* represents the pixel values of the restored image and the original image respectively and M multiply N is the size of the image.

PSNR uses a standard mathematical model to measure an objective difference between two images. It estimates the quality of a reconstructed image with respect to an original image. The basic idea is to compute a single number that reflects the quality of the reconstructed image. Reconstructed images with higher PSNR values are judged better. The parameter peak signal-to-noise ratio (PSNR) is defined as,

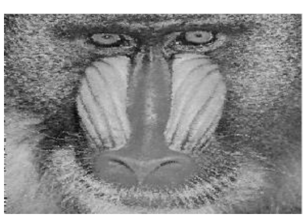
$$\text{PSNR(dB)} = 10\log10\left(\frac{255^2}{MSE}\right)$$

(a) (b)

(c) (d)

(f) (g)

Figure 1.1:Screen Shots (a) Original gray mandril image, (b) Noisy image with 70% of SAP Noise, (c) Restored image with Mean Filter (d) Restored image with Median Filter (e) Restored image with AMF (f) Restored image with DBA (g) Restored image with proposed MDBUTMF

TABLE 1.1

COMPARISON OF PSNR VALUES OF DIFFERENT ALGORITHMS FOR MANDRIL IMAGE AT DIFFERENT NOISE DENSITIES

Noise in %	Mean F.	MF	AMF	DBA	MDBU-TMF
10	5.5873	28.579	33.513	36.499	**37.972**
20	5.5869	26.096	31.527	32.731	**34.401**
30	5.5867	22.278	29.499	30.147	**32.225**
40	5.5864	18.547	27.295	27.948	**30.451**
50	5.586	15.13	24.368	26.213	**28.572**
60	5.5857	12.345	20.363	24.478	**26.462**
70	5.5854	10.113	15.778	22.853	**23.623**
80	5.5851	8.2785	11.733	20.985	**20.118**
90	5.5848	6.7783	8.4135	18.603	**16.483**

TABLE 1.2

COMPARISON OF MSE VALUES OF DIFFERENT ALGORITHMS FOR MANDRIL IMAGE AT DIFFERENT NOISE DENSITIES

Noise in %	Mean F.	MF	AMF	DBA	MDBU-TMF
10	1.7962e+4	90.1875	28.960	14.562	**10.370**
20	1.7963e+4	159.749	45.754	34.67	**23.605**
30	1.7964e+4	384.882	72.968	62.867	**38.956**
40	1.7966e+4	908.620	121.221	104.305	**58.603**
50	1.7967e+4	1.995e+3	237.865	155.501	**90.375**
60	1.7968e+4	3.789e+3	598.084	231.870	**146.839**
70	1.7970e+4	6.335e+3	1.799e+3	337.126	**282.301**
80	1.7971e+4	9.665e+3	4.363e+3	518.314	**637.718**
90	1.7972e+14	1.365e+4	9.369e+3	897.050	**1.477e+3**

Figures (1.1) show the reconstructed images for the mandril image degraded 70% Salt and Pepper noise respectively. The performance comparisons of the same images for various PSNR, MSE and IEF levels are shown in Table (1.1),and (1.2) respectively. It is observed that in these experiments, when the noise level is relatively high, i.e. above 50%, then Mean, Median and ,Adaptive Median leads to overly Noisy results whereas the proposed method provides relatively satisfactory results in effective noise suppression with preserving detailed information's. But when the noise level is nearly about 80% to 90% then the proposed method gives nearly similar results as DBA in all performance factor.

4. CONCLUSION

In this paper, a new algorithm (MDBUTMF) is proposed which gives better performance in comparison with MF, AMF and other existing noise removal algorithms in terms of PSNR and MSE. The performance of the algorithm has been tested at low and medium noise densities on both gray-scale and color images. Even at high noise density levels the MDBUTMF gives better results in comparison with other existing algorithms. Both visual and quantitative results are demonstrated. The proposed algorithm is effective for salt and pepper noise removal in images at high noise densities.

The performance of the proposed method: MDBUTMF is found to be the best in terms of PSNR. Its performance in terms of visual quality is also found to be very nice for noise density upto 70 %. it is finally concluded that this filtering scheme be recommended for removal of low and medium density salt and pepper noise from digital images.

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