Anisha Bhatia, Prof. Ramesh K Kulkarni / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 3, Issue 2, March -April 2013, pp.1023-1026

HIGH DENSITY SALT-AND-PEPPER NOISE REMOVAL THROUGH IMPROVED ADAPTIVE MEDIAN FILTER

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Abstract

In this paper, a new image-denoising filter that is based on the standard median (SM) filter is proposed. In our method, the adaptive standard median is used to detect noise and change the original pixel value to a newer that is closer to or the same as the standard median. With our experimental results, we have made a comparison among our method, the standard median (SM) filter, the median filter with mask of 3-by-3, 5-by-5, 7-by-7, the center weighted median (CWM) filter, the adaptive center weighted median (ACWM) filter, the progressive switching median (PSM) filter, the decision based median (DBM) filter, and the untrimmed (UT) median filter, in which our method proves to be superior.

Keywords— Salt-and-pepper noise, the standard median (SM) filter, the median filter with mask of 3-by-3, 5-by-5, 7-by-7, the center weighted median (CWM) filter, the adaptive center weighted median (ACWM) filter , the progressive switching median (PSM) filter, the decision based median (DBM) filter, the untrimmed (UT) median filter.

I. INTRODUCTION

Digital images get corrupted by impulse noise when acquired by a defective sensor or when transmitted through a faulty channel. Impulse noise removal image processing is an important pre-processing step which involves the removal of salt and pepper noise from digital images so that the restored images can be applied to subsequent phases of segmentation [1]. Impulsive noises can be commonly found in the sensor or transmission channel during the acquisition and transfer procedure for the digital signals images. Salt-and-pepper noise is a typical kind of impulsive noise. The nonlinear filter algorithms are often adopted for the salt-and-pepper noise removal as it possesses many advantages [2].

It is well known that linear filtering techniques fail when the noise is non-additive and are not effective in removing impulse noise. This has led the researchers to use nonlinear signal processing techniques. Classes of widely used nonlinear digital filters are median filters. Median filters are known for their capability to remove impulse noise as well as preserve the edges. The main drawback of a standard median filter (SMF) is that it is effective only for low noise densities. At high noise densities, SMFs often exhibit blurring for large window sizes and insufficient noise suppression for small window sizes [3].

When the noise level is over 50% the edge details of the original image will not be preserved by standard median filter, hence this poses as a major drawback for noise to be removed at higher density.
In the low-density noise cases, SM filter has better and enhanced performance for noise removal and detail preservation. Since SM filter is implemented uniformly across the image, thus it modifies both noisy and noise-free pixels, so the denoising performance greatly degrades in the high noise density cases.

Hence to solve the above problem the adaptive median filter method has been proposed which eradicates the noise even at very high noise density levels.

The results obtained are then compared with the standard median (SM) filter, the median filter with mask of 3-by-3, 5-by-5, 7-by-7, the center weighted median (CWM) filter, the adaptive center weighted median (ACWM) filter, the progressive switching median (PSM) filter, the decision based median (DBM) filter, and the untrimmed median filter, in which our method proves to be superior.
Our method gives better Peak Signal-to-Noise Ratio (PSNR) and Mean square error (MSE), Correlation ratio (COR), universal quality index (UQI), Structural similarity index mean (SSIM) values than the existing algorithm.

II. METHODOLOGY

REVIEW OF FILTERS

The weighted median (WM) filter is an extension of the median filter, which gives more weight to some values within the window. This WM filter allows a degree of control of the smoothing behaviour through the weights that can be set, and therefore, it is a promising image enhancement technique. In this paper, we focus our attention on a special case of WM filters called the center weighted median (CWM) filter. This filter gives more weight only to the central value of a window, and thus it is easier to design and implement than general WM filters. We shall analyze the properties of CWM filters and observe that CWM filters preserve more details at the expense of less noise suppression like the other non-adaptive detail preserving filters. In an attempt to improve CWM filters further, an adaptive CWM (ACWM) filter having a variable central weight has been proposed [4].

Next a median-based filter, progressive switching median (PSM) filter, is proposed to restore images corrupted by salt–pepper impulse noise.

The algorithm is developed by switching scheme in which an impulse detection algorithm is used before filtering, thus only a proportion of all the pixels will be filtered and progressive methods in which both the impulse detection and the noise filtering procedures are progressively applied through several iterations [5].

THE PROPOSED METHOD

The adaptive median filter is based on the following steps:

1. It checks for pixels that are noisy in the image, i.e. pixels with values 0 or 255 are considered.
2. For each such pixel P, a window of size 3×3 around the pixel P is taken.
3. Find the absolute differences between the pixel P and the surrounding pixels.
4. The arithmetic mean (AM) of the differences for a given pixel p is computed.
5. The AM is then compared with the “threshold” to detect whether the pixel p is informative or corruptive.

a) If AM is greater than or equal to the threshold the pixel is considered noisy.

b) Otherwise the pixel is considered as information.

Median filters produce the best result for a mask of size 3×3 at low noise density levels though the image is considerably blurred. The filter fails to perform well at higher noise densities and hence an alternative that works well at low as well as higher noise densities is required. This lies in the fact that when noise density is high it is highly unlikely that there might be more informative pixels than corruptive pixels.

The proposed method overcomes the shortcomings faced by the normal median filter at high noise densities by considering only those pixels that are informative in the neighbourhood.

The algorithm for the improved adaptive median filtering is as follows

1. Noise is detected by the noise detection algorithm as mentioned above.
2. Filtering is done only at those pixels that were detected as noisy.
3. Once a given pixel p is found to be noisy the following steps are followed.

a) A 3×3 mask is centred at the pixel p and finds if there exists at least one informative pixel around the pixel P.

b) If found so, the pixel p is replaced by the median of the informative pixels found in the 3×3 neighbourhood of P.

4. The above steps are repeated if noise still persists in the output image for betterment.

Peak Signal-to-Noise Ratio (PSNR) and Mean square error (MSE), universal quality index (UQI), Structural similarity index mean (SSIM) of the output image are computed to analyse the performance of the proposed filter as a denoising technique.

III. EXPERIMENTAL RESULTS

The performance of the proposed improved adaptive median filter, a comparison among our method, the standard median (SM) filter, the median filter with mask of 3-by-3, 5-by-5, 7-by-7, the center weighted median (CWM) filter, the adaptive center weighted median (ACWM) filter , the progressive switching median (PSM) filter, the decision based median (DBM) filter, and the untrimmed median filter, were analyzed for high noise density (ND) of salt-and-pepper noise added to gray level Lena image shown in Fig.1

Fig. 1 Original Lena image

RESULT FOR PROPOSED FILTER

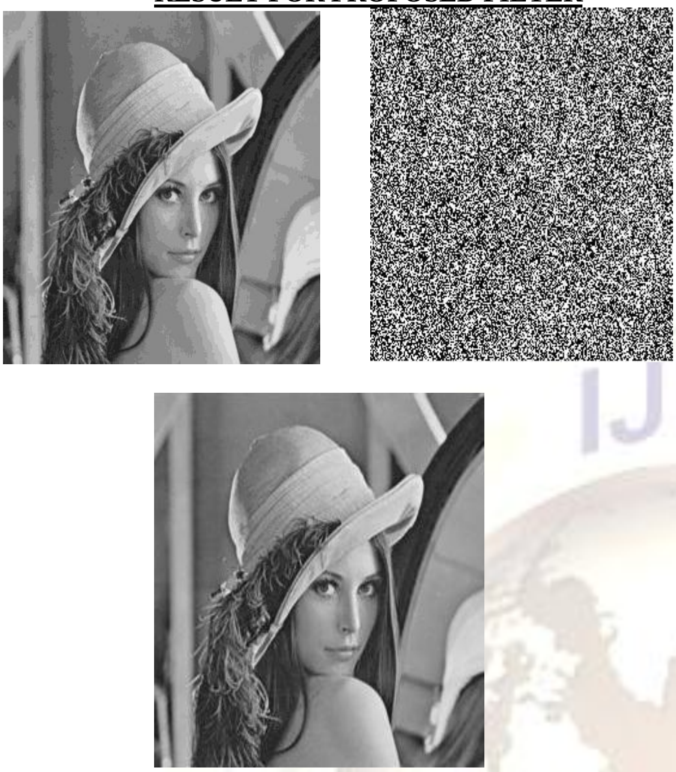

Fig. 2 Original image, image corrupted with 90% noise, output of proposed filter

The parameters used to define the performance of
The parameters used to define the performance are:

Peak Signal-to-Noise Ratio (PSNR):

$$PSNR = 20 \log_{10} (255 / RMSE)$$

where Root Mean square error (MSE):

$$RMSE = \sqrt{1/MN \sum_{i,j} (Y_{ij}-X_{ij})^2}$$

Correlation ratio (COR):

$$COR = \sum_{i,j} (Y_{ij} - \mu_y)(X_{ij} - \mu_x) / \sqrt{\sum_{i,j} (Y_{ij} - \mu_y)^2 \sum (X_{ij} - \mu_x)^2}$$

Structural similarity index mean (SSIM):

SSIM is designed to improve on traditional methods like peak signal-to-noise ratio (PSNR) and mean squared error (MSE), which have proved to be inconsistent with human eye perception [7].

The Structural Similarity (SSIM) index is a method for measuring the similarity between two images. The SSIM index can be viewed as a quality measure of one of the images being compared provided the other image is regarded as of perfect quality. It is an improved version of the universal image quality index [6].

The structural similarity index correlates with human visual system. Thus SSIM is used as a perceptual image quality evaluation metric. The SSIM is defined as function of luminance, contrast and structural components(s) [7].

Universal image quality index (UQI):

The universal quality index is given by

$$Q = 1/M \sum Q_j$$

MF 3X3	MF 5X5	MF 7X7	CWM	ACWM	DBMF	PSMF	UT	PF
-.03	-.042	-.047	0.016	0.99	0.995	0.77	0.9	1

Where M is the steps and Q_j is the local universal quality index [8].

COMPARISON TABLE OF VARIOUS FILTERS WITH PROPOSED FILTER (PF)

(A) PSNR TABLE

MF 3X3	MF 5X5	MF 7X7	CW M	ACW M	DBM F	PSMF	UT	P F
6.42	6.46	6.18	3.35	25.005	8.82	2.913	8.8	∞

(B) MSE TABLE

MF 3X3	MF 5X5	MF 7X7	CWM	ACW M	DB MF	PSM F	UT	PF
4.24	4.4	5.3	1.4	13.9	0.1	1.7	15.8	0

(C) COR TABLE

MF 3X3	MF 5X5	MF 7X7	CWM	AC WM	DB MF	PS MF	UT	PF
-.03	-.04	-.05	0.10	0.99	0.9 5	0.8 3	0.99	1

(D) SSIM TABLE

MF 3X3	MF 5X5	MF 7X7	CWM	ACW M	DB MF	PSMF	UT	PF
0.23	0.33	0.34	0.67	0.98	0.996 4	0.2236	0.99	1

(E) UQI TABLE

IV. CONCLUSION

In this paper, our algorithm is proposed which gives better performance in comparison with the median filter with mask of 3-by-3, 5-by-5, 7-by-7, the center weighted median (CWM) filter, the adaptive center weighted median (ACWM) filter, the progressive switching median (PSM) filter, the decision based median (DBM) filter, and the untrimmed (UT) median filter.At high noise density levels this algorithm gives better results in comparison with other existing algorithms. Also the quantitive parameters like Peak Signal-to-Noise Ratio (PSNR) and Mean square error (MSE), Correlation ratio (COR), universal quality index (UQI), Structural similarity index mean (SSIM) prove to be superior. Hence the proposed algorithm is effective for salt and pepper noise removal in images even at high noise densities.

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