A Decision and Repetition Based Algorithm for Removing High Density Impulse Noise

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***Abstract*— The main objective of the project is removal of salt and pepper noise which degrades the image quality. Salt and pepper noise involves noise value that may be maximum or minimum value of dynamic gray scale range of image respectively. The idea is to filter image having noise high density noise up to 92% and restore the original image. The algorithm makes use of methods based on median filtering in which corrupted pixels are replaced by median value or else if it is not effective then by the adjacent pixels. Run time, PSNR, SSIM and IEF were noted for different observations and compared. The major advantage of the proposed algorithm is the minimum run-time requirement and high PSNR value of the filtered image. The proposed algorithm is better even at high density noise and found to produce better PSNR and SSIM values.**

Keywords*— *Pixels , salt and pepper, PSNR , SSIM , IEF.

I. INTRODUCTION

Digital image is a numeric representation of a two-dimensional image. The digital image contains a fixed number of rows and columns of pixels. Pixels are the smallest individual elements in an image, holding quantized values that represent brightness of a given pixel at a specific point [1]. Digital image is corrupted by noise during acquisition or transmission, reception or storage and retrieval process. There are two types of impulsive noise. First is fixed-valued impulse noise, also known as salt and pepper noise where noise takes either the maximum or minimum values of the dynamic gray scale range of the image, that is 255 or 0 respectively. Second is Random-valued impulse noise where the noisy pixel is bounded by the range of the dynamic gray scale of the image.

For a meaningful and useful processing, such as image segmentation and object recognition, and to have a very good visual display in application like television and photo-phone etc., the acquired image signal must be noise-free and and of good quality. This is achieved by image filtering which is an essential part of image processing. Already different methods of image filtering have been proposed. Standard Median Filter (SMF) was the most popular method in which the pixel value was replaced by the median value of all the neighboring pixels in a 3X3 matrix. The major drawback in this method was it is effective only at low noise densities [2]. The method applies median filtering for each and every pixel whether corrupted or not. As a result, even the uncorrupted pixels are filtered and this causes degradation of image quality. In order to remove this drawback adaptive Median Filter (AMF) was introduced which worked only on the corrupted pixels. In this method a 3X3 sliding window is considered to find the median value and under a specific criteria , the window size is increased by two reaching a maximum of 7X7 window. The drawback in this method is that this method is applicable only for low noise densities and needs increased window size for higher noise densities which leads to blurring of images[3]. It also has a high processing time. Other proposed method namely Decision Based Algorithm [4](DBA) was also able to remove noise at low noise densities but fails to suppress impulse noise effectively and preserve image details when the noise density is more than 70%. Modified Decision Based Algorithm (MDBA) suffered from the drawback of large processing-time.

II. BACKGROUND

For de-noising problems, linear techniques had been gaining popularity in the recent days because of availability of systematic theory design and analysis. But they fail to cope up with the non-linearities of the image and remove noise in high frequency regions such as edges in the image[5]. The processing time involved was not appreciable. To solve the problem, non-linear techniques have been introduced which helps to improve the quality of recovered image.

Many non-linear techniques have been proposed till now. Initially Standard Median Filtering was used which helped to Preserve the edges and remove the impulse noise. It uses the median value of the neighboring pixels to replace the value of the centered pixel but this removes the important information from image as it operates on every pixel without discriminating between corrupted and non-corrupted. To improve the quality of SMF , specialized techniques like Weighted Median Filter, Center weighted filter, and Recursive weighted median filter were introduced which give more weight to selected pixel[6]. But they processed the imaged uniformly during filtering without considering whether the pixel is corrupted or not. To overcome this problem noise detecting methods is needed. AMF finds the corrupted pixels and then removes the noise by standard median filter. It is found that this method is not applicable for higher noise densities. to remove this problem Decision Based Algorithm is
introduced which uses either the median value or a more reliable neighborhood pixel value to replace the corrupted pixel. It is found that the quality of recovered image degrades as noise density increases above 60%. In 2011, modified Decision Based Unsymmetric Trimmed Median was introduced in which the corrupted pixel is replaced by trimmed median value when the pixel values in the window are 0, 255 and other. But it uses the mean value of the pixels in the window when the window has only corrupted pixels[7]. The method is used to recover a noisy image corrupted by salt and pepper impulse noise. The aim is to process only the

corrupted pixels so that the image quality does not get degraded. This method involves the use of adaptive median filter followed by co-relation shifting. So the median value replaces the corrupted pixel value. Neighboring pixel having nearly same pixel value can be used for correlation shifting. So the value of the pixel becomes the value of the neighboring pixel. The method gave a better result on image metric evaluation. Vijaykumar in [9] has proposed a new switching based trimmed median filter method for removing high density impulse noise of around 95% along with edge preservation. Hidalgo in [10] has proposed a novel filter for removing high density-salt-and pepper noise based on fuzzy mathematical morphology using t-norms. The authors are able to handle noise intensity up to 90%. Ahmed in [11] has proposed a novel adaptive iterative fuzzy filter for denoising of images corrupted by impulse noise of intensity 97%.He has used two stage detection process of noisy pixels with an adptive fuzzy detector followed by denoising using weighted mean filter. Qi in [12] has proposed a pixel wise adaptive neutrosophic filter based on neutrosophic indeterminacy feature to remove high-level salt–and-pepper noise.

In this paper, an effective method to remove high density noise has been given. The effort has been made to remove noise up to maximum of 90% with a great achievement of minimum processing time for low density noise. This has been proved by various image-metrics like PSNR[8] (Peak Signal to Noise ratio), SSIM[8] (Structural Similarity Index) and IEF[7] (Image Enhancement Factor) which are used to evaluate the performance-evaluation of the image. The image metrics results show a better value as compared to other standard existing methods.

III. PROPOSED DECISION AND REPETITION BASED ALGORITHM

First the noise impulse corrupted pixel is found out by comparing it value to the value of the salt and pepper noise that adopts either the maximum or the minimum value on the dynamic gray-scale range. The corrupted and uncorrupted pixels in the image are detected by checking the pixel element value against the maximum and minimum values in the selected window.

Let B be the corrupted image matrix. A 2-D sliding window is created having size 3X3 having the pixel evaluated at the center. If the center pixel has value either 0 or 255 then the following steps are followed.

- STEP 1 - median of all the pixel in the window is found.
- STEP 2 -If the median value is other than 0 and 255, the pixel is uncorrupted and the value of pixel is kept unchanged. Otherwise we increase the window size by 2 and go back to step 1 and this process continues up to the window size 9X9.
- STEP 3 - After all pixels of the image are processed, we again check for the corrupted pixels and the following steps.
- STEP 4 - Compare the value of pixels to the next adjacent pixel right to it.
- Step5-If the value of both the pixels not same, then replace the values of pixels by the value of adjacent pixel. Otherwise replace the value with the pixel next to next adjacent pixel value

IV. SIMULATIONS AND DISCUSSIONS

The propose filter has been checked using standard images like Lena, Cameraman. In simulation the image will be corrupted with equal probability by adding salt and pepper noise . The noise levels were varied from 10% to 90% with an increment of 10% and the proposed algorithm is applied to the corrupted image and the restored image was collected. The result was evaluated using various image metrics like PSNR(Peak Signal to Noise Ratio), SSIM(Structural Similarity Index), IEF [7](Image Enhancement Factor) defined by equation (1),(3) and (4) respectively. PSNR is the ratio of maximum possible power of the signal to the power of the noise in the image that adversely affects the image quality. It is defined in logarithmic scale expressed in dB[8]. The higher the value of PSNR, better is the result. SSIM corresponds to the similarity between the recovered image and the original image. It is a quality measure of one image as compared to other which is considered to be of perfect quality. It is in the form of a fraction, thus the closer the value of SSIM [8]to one , the more similar the recovered image is to the original image. Hence the better result. IEF indicates the filter performance under different noise densities. IEF shows the relative quality improvement of the image exhibited by the processing of a filter.

$$PSNR = 10.\log_{10}\left(\frac{MAX_i^2}{MSE}\right) \quad \text{.....(1)}$$

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2 \quad \text{.....(2)}$$

$$SSIM(x,y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)} \quad \text{.....(3)}$$

$$IEF = \frac{\sum[g(i,j) - f(i,j)]^2}{\sum[f'(i,j) - f(i,j)]^2} \quad \text{.....(4)}$$

TABLE I. PSNR COMPARISON TABLE

Noise Density(%)	SMF	AMF	PA
10	37.31	37.19	35.39
20	36.39	35.50	35.27
30	35.53	35.78	35.11
40	34.61	35.09	34.86
50	33.58	34.23	34.48
60	32.38	33.10	34.17
70	31.16	32.23	33.64
80	29.75	30.92	32.96
90	28.31	29.43	31.99

TABLE II. IEF COMPARISON TABLE

Noise Density	SMF	AMF	PA
10	48.14	5.39	31.66
20	48.16	7.17	59.34
30	35.75	7.99	81.61
40	18.74	8.79	98.61
50	10.38	7.26	101.44
60	5.88	5.48	100.35
70	3.52	3.95	80.01
80	00.32	2.77	64.78
90	1.41	1.83	38.44

TABLE III. SSIM COMPARISON TABLE

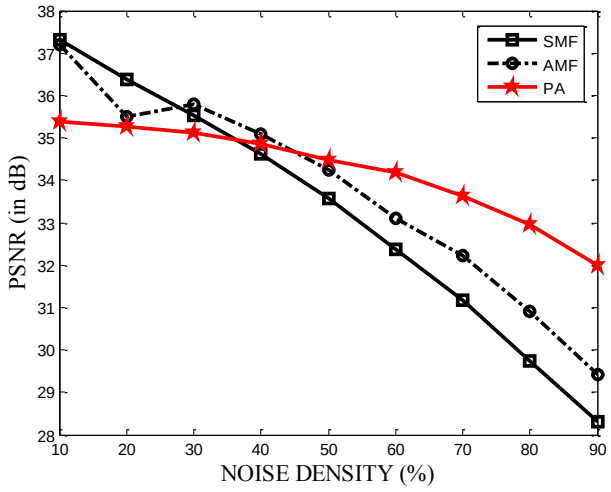
Noise Density	SMF	AMF	PA
10	0.9926	0.9530	0.9884
20	0.9851	0.9292	0.9877
30	0.9706	0.9038	0.9866
40	0.9267	0.8860	0.9851
50	0.8512	0.8318	0.9820
60	0.7154	0.7466	0.9781
70	0.5216	0.6199	0.9678
80	0.3157	0.4641	0.9544
90	0.1275	0.2541	0.9134

The restoration performance is assessed according to the noise density of the corrupted pixels of the cameraman image.The result of the images corrupted with 10% to 90% of noise intensity and corresponding recoverd image using SMF AMF and proposed method is given in 1 (a) to (e). The performance of the proposed method is compared with the other proposed methods like SMF, AMF. The performances of the proposed algorithm is given in Table I to Table IV.and the graphs of PSNR, IEF and SSIM are given in Fig 2, 3 ,4 respectively.

The method was applied to Cameraman image and the recovered image was compared to those obtained by SMF and AMF. The results show the superiority of the proposed method even at high noise density of around 90%.

The image results as well as the image metrics shows that the proposed algorithm gives a better result in recovering the original image from a noisy image.

PSNR COMPARISON TABLE



(1)

Fig.1 PSNR comparison.

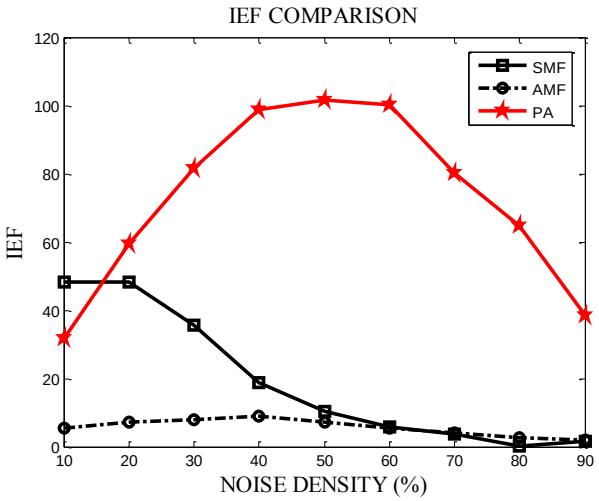


Fig.2 IEF comparison.

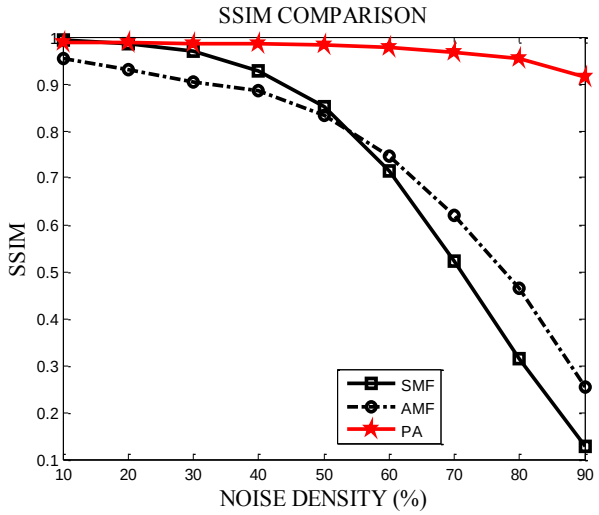


Fig.3 SSIM comparison

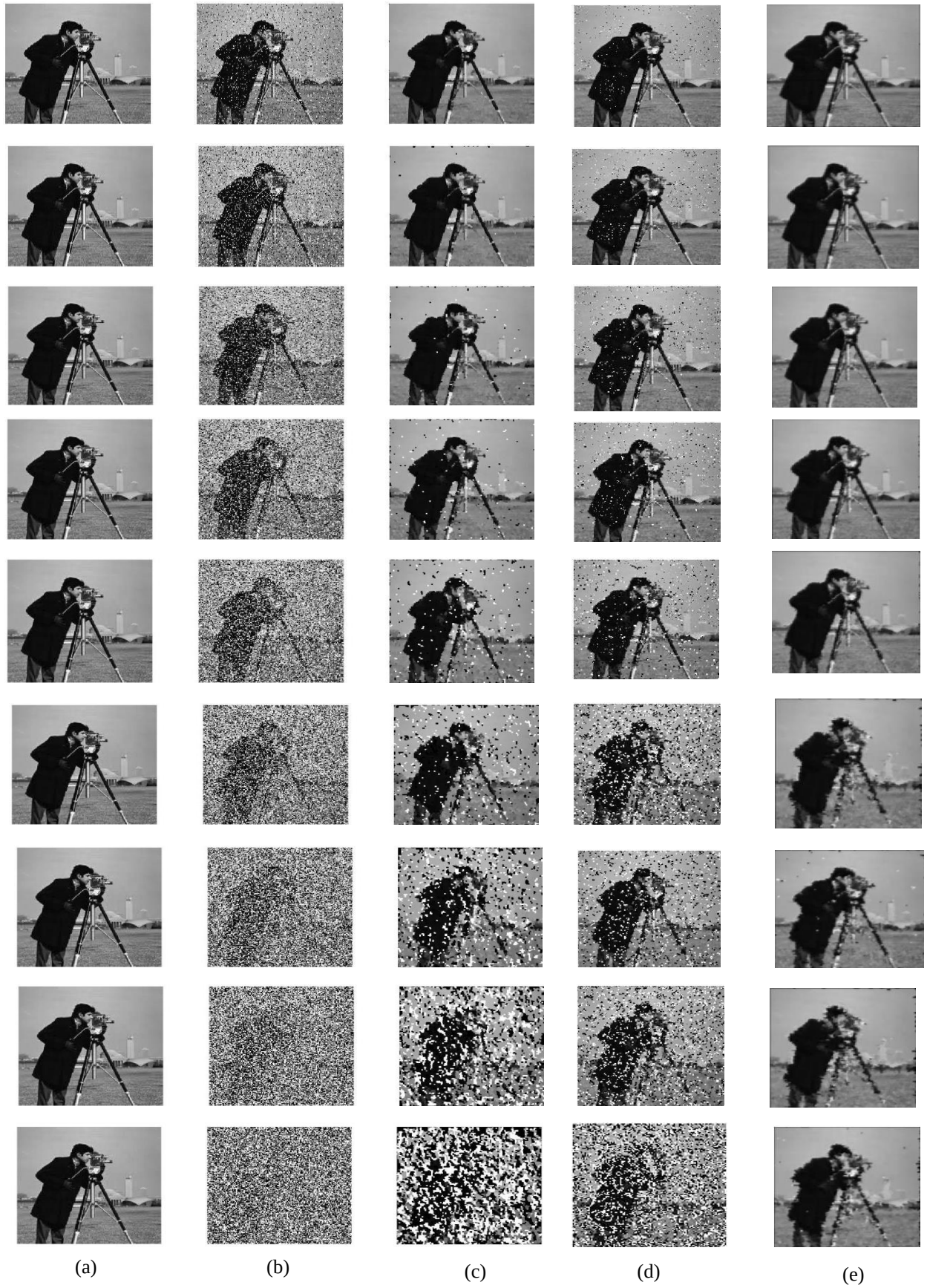


Fig.4 (a) original image (b) noisy image (10% to 90% from top to bottom) (c) recovered image by MF technique (d) recovered image by AMF technique (e) recovered image by Proposed algorithm.

V. CONCLUSIONS

In this paper, a new method is proposed to recover the noisy image corrupted by salt and pepper impulse noise. The proposed algorithm gives a better performance as compared to few standard noise removing methods like SMF and AMF. The performance was analyzed using different image metrics and the recovered image was compared to those for SMF, AMF at different noise intensities ranging from 10% to 90%. The proposed method shows a better result even at high noise densities. The processing time is found to be less for low density noise but time complexity increases as the noise density increases.

Our future work will focus on reducing time complexity for removing still higher intensity noise with edge preservation.

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