NOVEL IMPULSE DETECTION TECHNIQUE FOR IMAGE DENOISING

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ABSTRACT

In this paper a simple noise (Salt and Pepper) detection technique is proposed by using 3 x 3 sub-windows in which the test pixel appears. A weight is assigned to the test pixel based on its position after sorting in each sub-window. Two thresholds are used to decide whether the test pixel is corrupted or not. If corrupted then only the standard median of the 3 x 3 vicinity is used to eliminate noise, other –wise no filtering is applied. The proposed scheme is simulated using standard images under different noisy conditions. The performance study shows the superiority of the proposed scheme over the existing standard median filters using 3 x 3 and 5 x 5 windows.

Keywords: *Salt and Pepper noise, Denoising, Fixed threshold, Standard median,*

1. INTRODUCTION

Most of the systems developed in the fields of communication, control or signal processing are made under the assumption that the interfering noise is Gaussian. Many physical environments are modeled accurately as impulsive with non-Gaussian distributions. The filtering systems developed under the assumption of Gaussian noise, perform poorly. Particularly, in image processing systems, the image contaminated with impulse noise, the linear filtering schemes performance is very poor. These short comings can be eliminated by non-linear filtering schemes such as median filter. The standard median filter performs blindly on each pixel, irrespective of whether the pixel is corrupted or not. It is always better to develop a mechanism to detect whether the pixel is corrupted or not and if found corrupted then only the filtering activity be initiated. G Panda and others developed an Artificial Neural Network based impulse noise detector and then only the filtering is applied [1]. For removing any residue of the noise the same method they have repeated again after iteration on the full image, which performed better than other schemes like Wiener, DD scheme, Fuzzy and standard medians. It is computationally highly complex. Rank Ordered Logarithmic Difference (ROLD), a new impulse noise detector was given by Dong, et all and after detection they applied the filter. For better performance they repeated the same with decreasing threshold [2]. This method is computationally not outperforming even though this is better than other methods. In almost all algorithms designed to detect and remove noise the 3 X 3 neighbor-hood is mainly considered. Different remedies of median filters have been proposed, in the literature like, adaptive median filter [3], the multi-state median filter [4], median filters based on homogeneity information [5,6]. These so called “decision-based” filters first identify possible noisy pixels and then replace them using the median filter (or) its variants.

The median filter was the most popular non-linear filter for removing impulse noise, due to its good denoising power [5] and computational efficiency, however at high noise levels some details of the original image are smeared by the filter [2].

In our proposed method we considered all the 3 X 3 neighbors in which the test pixel appears. And the position of the test pixel in each of the 3 X 3 neighbors is examined and a weight is assigned to it depending on its position in each window. Two thresholds are set to decide whether the test pixel is corrupted or not, if found corrupted then only median filter is invoked. The proposed algorithm is detailed in the next section. In this paper we propose a new method to identify pixels corrupted with salt and pepper noise. The noisy pixels are replaced with median value in their vicinity.

2. PROPOSED SCHEME

Let 'J' is an original image, 'A' is observed image, a general discrete time model for image degradation can be expressed as

$$A_{i,j} = J_{i,j} + \eta_{i,j}$$

for i,j = 1,2….N, where $J_{i,j}$ is original image , $\eta_{i,j}$ is long tail impulse noise and $A_{i,j}$ is the observed image. The objective of the restoration scheme is to recover the original image from the observed image. Here we assumed the noise is long tailed and the noisy pixel may occupy the extreme positions if it is sorted for ascending or descending order.

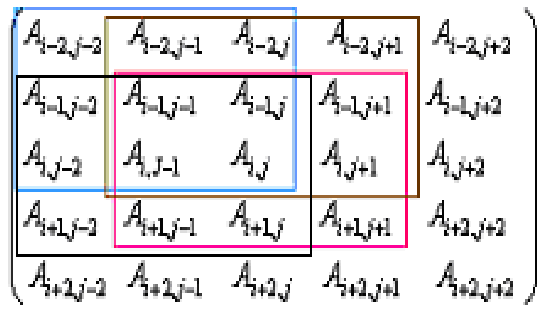
Let the noisy image is represented with A. the test pixel is located at (i,j), generally the 3 x 3 neighborhood is considered for normal filtering, whether corrupted or not. In our method we examined the 5 x 5 neighborhood of the test pixel in a different way. The 5 x 5 neighborhood is divided in to nine 3 x 3 sub-windows such that the test pixel appears in each of the sub-window. Each of the sub-windows is now sorted for ascending order. Then a weight parameter is assigned to the test pixel depending on its position. The average weight of test pixel in the sub-windows is calculated. Two thresholds, upper and lower, are defined for detecting salt (pixel valued with 255 gray level) and pepper (pixel valued with 0 gray level) noises. If the weight of test pixel below lower threshold or above upper threshold then a flag is assigned to the test pixel, which indicates that the test pixel is corrupted. The procedure is repeated for the entire noisy image and standard median is applied on those pixels which are corrupted. The step by step procedure is as follows.

2.1 Algorithm

1. Consider a 5 x 5 test window A_T from the noisy image as:

$$\mathbf{A_T} = \begin{pmatrix} A_{i-2,j-2} & A_{i-2,j-1} & A_{i-2,j} & A_{i-2,j+1} & A_{i-2,j+2} \\ A_{i-1,j-2} & A_{i-1,j-1} & A_{i-1,j} & A_{i-1,j+1} & A_{i-1,j+2} \\ A_{i,j-2} & A_{i,J-1} & A_{i,j} & A_{i,j+1} & A_{i,j+2} \\ A_{i+1,j-2} & A_{i+1,j-1} & A_{i+1,j} & A_{i+1,j+1} & A_{i+2,j+2} \\ A_{i+2,j-2} & A_{i+2,j-1} & A_{i+2,j} & A_{i+2,j+1} & A_{i+2,j+2} \end{pmatrix}$$

2. Divide this window into 3 x 3 sub-windows such that the test pixel $A_{i,j}$ should appear in each of the sub-window. Nine such sub-windows are possible and four of them are as shown below.
3. All 3 x 3 sub-windows are sorted for ascending order.
4. In each sub-window the position of the test pixel is found and weight parameter is assigned based on its position.



5. The average weight of all sub-windows is computed for the test pixel.
6. Two threshold weights are defined appropriately to decide whether the test pixel is faulty or noisy.
7. A flag is attached to each faulty test pixel.
8. The procedure is repeated for the entire image.

2.2 Denoising

The purpose of denoising is to estimate correct sample of the image from their noisy data using the neighborhood. In the second round a standard median filter is applied with 8 neighborhood of the noisy pixel.

3. TEST RESULTS AND DISCUSSIONS

Two standard images PEPPERS and LENNA are used to test the efficiency of the proposed scheme for noise detection and filtering. The MATLAB environment is used for testing the efficacy of the proposed scheme.

In the testing phase, the proposed algorithm is applied on the noisy image and noisy pixels are attached with a flag using lower and upper thresholds. If the average weight of the test pixel is below 2 (lower threshold) or above 8(upper threshold) then only a flag is attached to the test pixel. In second round standard median filter is invoked for removing salt and pepper noise using the 3 x3 neighborhood of the test pixel. The two images are contaminated with different noise levels starting from 2% to 20% and then the proposed algorithm is applied and then filtered. To compare the performance of this algorithm results are generated for standard median using 3 x 3 and standard median with 5 x 5 windows on both the images. The performance is compared for three parameters MAE (Mean Absolute Error), MSE (Mean Square Error) and PSNR (Peak Signal to Noise Ratio) by taking standard images Lena, peppers, which are shown in the table1, table 2 respectively. The corresponding graphs are generated for each parameter of both images. The formulae used are as given below.

$$MAE = \frac{1}{M * N}\left[\sum_{i=1}^{M}\sum_{j=1}^{N} | X_{ij} - Y_{ij} |\right]$$

$$MSE = \frac{1}{M * N}\left[\sum_{i=1}^{M}\sum_{j=1}^{N} | X_{ij} - Y_{ij} |^2\right]$$

$$PSNR = 10 \log_{10}\left[\frac{L^2}{MSE}\right]$$

Test results are generated for noise levels in the range 2% to 20%. The results show the proposed scheme is performing better than median operation with 3 x 3 and 5 x 5 neighbor-hood, where detection is not present. For Lena image the above three parameters are calculated using 3 x 3 median,5 x 5 median and proposed scheme. It is clear that our proposed scheme is performing excellently. For Peppers image at 20% noise level the proposed scheme starts deteriorating in MSE and PSNR but superior in MAE, than other methods. Up to 20% the proposed scheme is excellent in comparison in all respects. So the over all performance of the proposed scheme is proved better than other standard methods and the computational complexity of the proposed scheme is very much less than other schemes available in the literature.

Table:1 Comparison of parameters(MAE,MSE,PSNR) for Lena

% Noise	Median 3 x 3			Median 5 x 5			Proposed scheme		
	MAE	MSE	PSNR	MAE	MSE	PSNR	MAE	MSE	PSNR
2	2.75	41.92	31.91	4.79	100.9	28.09	1.13	22.1	34.69
4	2.87	46.46	31.46	4.87	102.65	28.01	1.16	22.83	34.54
6	3.02	51.86	30.98	4.97	107.88	27.8	1.17	23.57	34.4
8	3.16	59.26	30.4	5.01	108.17	27.71	1.22	25.26	34.1
10	3.29	63.36	30.11	5.13	115.15	27.52	1.29	29.48	33.44
12	3.49	72.13	30	5.3	124.31	27.19	1.39	35.27	32.59
15	3.82	98.73	28.18	5.5	137.09	26.76	1.58	52.7	30.91
20	4.33	135.57	26.8	5.71	154.59	26.24	2.23	132.05	26.92

Table:2 Comparison of parameters(MAE,MSE,PSNR) for peppers

% Noise	Median 3 x 3			Median 5 x 5			Proposed scheme		
	MAE	MSE	PSNR	MAE	MSE	PSNR	MAE	MSE	PSNR
2	1.75	20.99	34.91	2.9	47.13	31.39	0.59	9.83	38.2
4	1.8	21.8	34.75	2.94	47.86	31.33	0.61	10.53	37.9
6	1.92	25.81	34.01	3	49.38	31.19	0.66	12.3	37.24
8	1.98	27.05	33.81	3.05	50.79	31.07	0.7	14.66	36.47
10	2.2	34.21	32.79	3.15	55.07	30.92	0.76	19.49	35.23
12	2.22	38.2	32.31	3.3	54.68	30.75	0.83	25.95	33.99
15	2.42	46.2	31.48	3.3	61.51	30.24	0.99	40.06	32.28
20	2.84	88.23	28.67	3.45	66.89	29.88	1.62	129.47	27.16

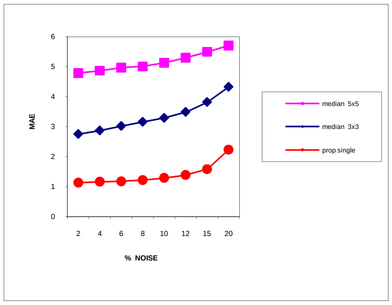


Figure: **1 Graph of MAE for Lena image**

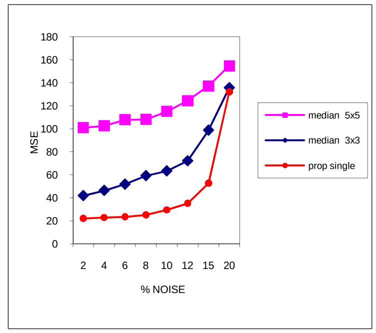


Figure: **2 Graph of MSE for Lena image**

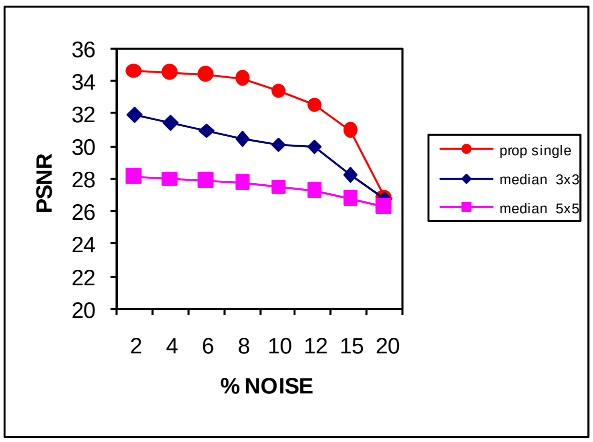


Figure: **3 Graph of PSNR for Lena image**

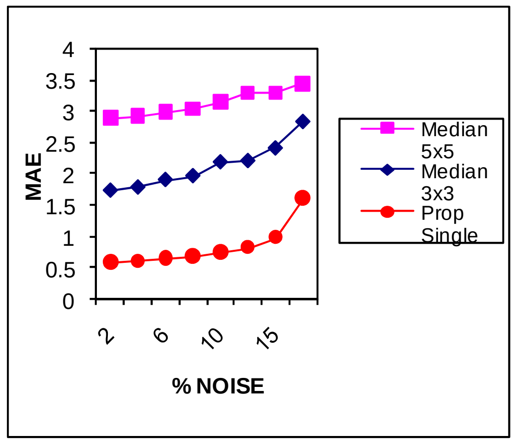


Figure: **4 Graph of MAE for peppers image**

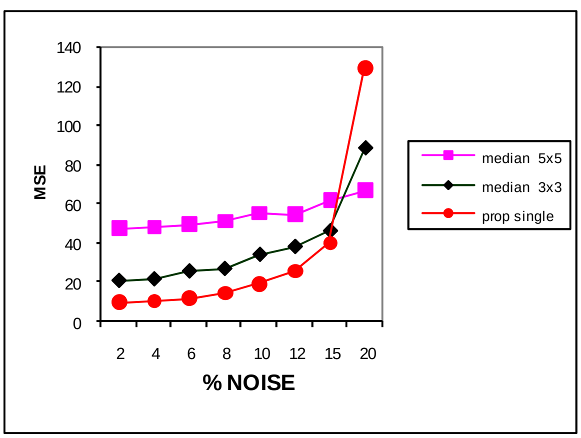


Figure: **5 Graph of MSE for peppers image**

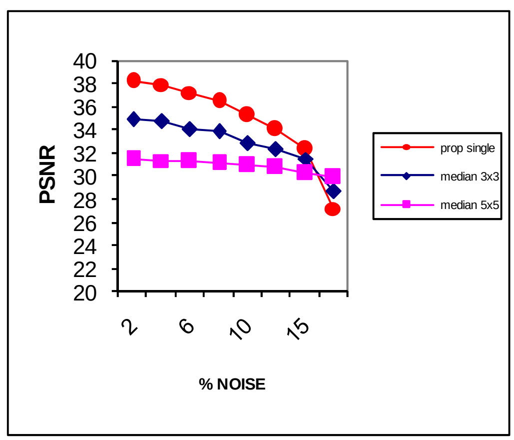
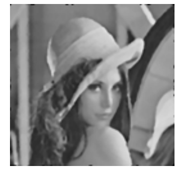


Figure: **6 Graph of PSNR for peppers image**

original

noisy

3x3 median



5x5 median

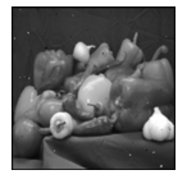
proposed

original

noisy

3x3 median

5x5 median



proposed

4. CONCLUSIONS

In this paper a novel and efficient noise detection technique with less computational complexity is proposed. Non-linear filtering is applied only if the pixel is found faulty, other wise the original pixel value is not altered, which is the unique feature of this proposed scheme, unlike the standard methods which operates on all pixels. This scheme shows very good performance with less complexity upto noise levels of 20%.

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