ORSMF: Optimistic Replacement Based Switching Median Filter for Highly Corrupted Images

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***ABSTRACT*:- Noise in the digital images has become a major area of research due to increasing the role of visual sensors in embedded applications. This paper has proposed a new approach which that has improved the sorted switching median filter by using the optimistic replacement of noisy pixel. The Optimistic Replacement Based Switching Median Filter (ORSMF) also called Multiple selection policy (MSP) has used the optimistic noise replacement instead of local median. It has also preserved the edges using image gradients and border exchanging used to preserve the borders. The proposed technique seems to be effective as it has replaced the noisy pixel with its best suitable alternative by taking more than one replacements for the noisy pixel. The optimistic replacement includes the median of medians (also called hybrid median), min of medians, max of medians, mean of medians etc. Experiments have been done in MATLAB using image processing toolbox in order to evaluate the effectiveness of the proposed technique. The comparative analysis has shown the effectiveness of the proposed technique over the available techniques.**

KEYWORDS:- Denoising, SSMF, Median Filter, ORSMF.

1. INTRODUCTION

Digital images processing area deals with digital images which mean computer images. A digital image is 2-D array of real numbers. 2-D images are divided into N-rows and M-columns, interaction of these rows and columns is known as pixels [1]. The purpose of image de-noising is to restore the detail of original image as much as possible. Digital image tending to a variety of noise which affects the quality of image. The criteria of the noise removal problem depend on the noise type by which the image is corrupting. In the field of reducing the image noise several type of linear and non linear filtering techniques used. Noise in image is any degradation in an image signal, caused by external distribution while an image sent from one place to another place via. Satellite, wireless and network cable. Filtering in an image processing is a basis function that is used to achieve many tasks such as noise reduction, interpolation, and re-sampling. Filtering image data is a standard process used in almost all image processing systems. The choice of filter is determined by the nature of the task performed by filter and behavior and type of the data. Filters are used to remove noise from digital image while keeping the details of image preserved is necessary part of image processing.

 Digital images inclined a variety of noise which affects quality of image. Type of noise is Uniform noise, Gaussian noise, Gamma noise, Rayleigh distribution and Impulse noise

1.1 Salt and Pepper Noise(Impulse noise)

Salt and pepper noise is also called a shot noise or spike noise. An image containing salt and pepper noise will have dark pixels in bright regions and bright pixels in dark regions. This type of noise is caused by sudden and sharp disturbance in image signal. The typical value used for salt-noise is 255 and for pepper noise is 0[2]. Source of image noise: Sensor heat while clicking an image, Size of sensor, By memory cell failure, Error occurs in image while an image is being sent electronically from one place to another.

1.2 Impulse noise in gray scale images

 A grayscale image represented by a two dimensional array where a location (i,j) is a position in image and called pixel[3].In grayscale image each pixel is shade of gray, which have value normally 0(black) to 255(white). This means each pixel in this image can be shown by 8 bits, that is exactly of one byte.

1.3 Impulse noise in color images

Color in the image is described by the quantity of red, green and blue value in image. Each color component contains value in [0-255] integer interval that means this give a total of 2563 different possible colors values. Every pixel in color image contains three values such as red, green and blue.

This paper is structured as follows: Section 2 Related work. Section 3 show simulation result and discussion. Section 4 presents the conclusion of this paper.

2. RELATED WORK

Ping, Wei, et al. [4] Have presented a fast and reliable impulse noise filter for highly corrupted images. The median filter is the nonlinear filter for removing impulse noise because of its good denoising power and computational efficiency, but this filter not work well when noise ratio is high. R. Vijaykumar et al.[5] have studied a new nonlinear filter called detail preserving median based filter for removing salt and pepper noise and random valued impulse noise. It works well upto a noise density as high as 70% with less computation time compared to the other techniques. This filter does not preserve the edges and borders of an image very well when noise density is high. V. Jayaraj et al. [6] have described a Switching Bilateral Filter for universal noise removal. This algorithm contains two stages: detection followed by filtering. This filter

removes both Gaussian and impulse noise without using additional weighting function. A.K.Tripathi et al. [7] have provided an impulse noise detector for switching median filter which is simple and efficient. This new technique can remove the impulsive noise from corrupted images (gray scale and color) efficiently. A.Fabijanska et al. [8] provide a new switching filter which identifies the noisy pixels and then corrects them by using median filter. An analysis of local intensity extrema is applied, In order to identify pixels corrupted by noise or not.

S.Esakkirajan et al. [9] have studied a modified decision based unsymmetrical trimmed median filter algorithm for the restoration of gray scale, and color images that are highly corrupted by salt and pepper noise. This algorithm 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. Xuechen Li at al. [10] have provide the impulse noise removal technique in the image of the welded joint, they provide improved switching median (ISM) filter. This filter only used for welded joint images to remove salt and pepper noise.

S.Liu [11] they discuss the filtering algorithm based on noise estimation as well as adaptive scalar (SMF) and vector median filter (VMF). The problem of removing impulsive noise with different density from colour images is solved by this algorithm. Zhe Zhou [12] has discussed Uncertainties are the major inherent feature of impulse noise. This makes image denoising a difficult task. The author presents adaptive detail-preserving filter based on the cloud model (CM) to remove impulse noise. Then, a weighted fuzzy mean filter is applied to remove the noise candidates.

Md Tabish Raza et al. [13] describe a denoising algorithm which eliminates salt and pepper noise from digital images that are highly corrupted by salt and pepper noise. This algorithm (PA) shows better results than existing filtering methods. Lyad F. Jafar et al. [14] have described the Switching median filters. This filter show better results than standard median filters in the removal of impulse noise due to their capability of filtering candidate noisy pixels and leaving other pixels intact.

Madhu S.Nair et al. [15] have provide an efficient direction based adaptive weighted switching median filter for restoration of images corrupted by high density impulse noise. Lu Ching-Ta [16] has described that Musical residual noise is a major problem for a speech enhancement system. This noise is very irritating to the human ear and can significantly weaken the perception quality of enhanced speech. They aim at reducing the quantity of musical residual noise by a two-stage speech enhancement approach.

Shi-Jinn Horng et al. [17] a novel Sorted Switching Median Filter (i.e. SSMF) is proposed by these authors for successfully denoising extremely corrupted images while preserving the image details. Three stages used by these authors i.e. detection, sorting and filtering stage. The center pixel is considered as ''uncorrupted'' or ''corrupted'' pixel in the detecting stage. The corrupted pixels that hold more

noise-free surroundings will have higher processing priority in the SSMF sorting and filtering stages to rescue the heavily noisy neighbors. Five noise models are used to assess the performance of the proposed SSMF algorithm. Simulation results conducted on both grayscale and color images with a wide range (from 10% to 90%) of noise corruption.

3. PROPOSED METHOD

A sorted switching median filter (SSMF) was proposed, which has been ignored the efficient alternative for noisy pixel removal and used only local evaluated median. SSMF has not done much work to preserve the edges and borders of the images in more efficient way. To overcome these problems stated with SSMF methods, We purposed a Modified SSMF, i.e. gradient based switching median filter for high density impulse noise using optimistic replacement selection algorithm. Steps for proposed algorithm are shown below:

Step 1. Read an Input Image: Select image from computer memory into existing program. An image passed to the proposed algorithm. Image must be either 2-D or 3-D plane i.e. gray scale or color image. Create noise in input image using noise models. The salt & pepper noise is a special type of impulse noise in which some portion of image pixel values are replaced by either minimum or maximum pixel values.

Step 2. Apply mask of 3×3 on an image: Set initial window of size 3x3. Take centre pixel $P(m, n, k)$ of window as kernal. Where m=row, n=column, k=channel (k=1 for R, 2 for G, 3 for B) and P is the pixel. If $P(m, n, k)$ is an uncorrupted pixel (that is, $0 < P(m, n, k) < 255$), then its value is not changed. Then without any change in image pixel value, window switched further.

If $P(m, n, k) = 0$ or 255, then $P(m, n, k)$ is a corrupted pixel. If all pixels in the selected window are 0's and 255's, then replace $P(m, n, k)$ with the optimistic noise free alternate using optimistic replacement selection algorithm. Repeat until all the pixels of whole image pixels are processed.

Step 3. Evaluate value of noisy pixels Each and every pixel of the image is checked for the presence of salt and pepper noise. Different cases are illustrated in this Section. If the processing pixel is noisy and all other pixel values are either 0's or 255's is given in Case i). If the processing pixel is noisy pixel that is 0 or 255 is given in Case ii). If the processing pixel is not noisy pixel and its value lies between 0 and 255 is given in Case iii).

Case i): If the selected window contains salt/pepper noise as processing pixel (i.e., 255/0 pixel value) and neighboring pixel values contains all pixels that adds salt and pepper noise to the image:

255	255	0
0	**<255>**	255
255	0	0

Figure 1: 3×3 Mask have all noisy pixels

Where "255" is processing pixel, i.e., P_{mn} Since all the elements neighbouring are 0's and 255's. If one takes the median value it will be either 0 or 255 which is again noisy. To solve this problem, optimistic median evaluation algorithm will come in action to find the best alternative. The proposed technique finds the optimistic pixel replacement by using the median of various alternatives. The alter native median are the global median of medians, global mean of medians, global min of medians, global max of median and the recently evaluated mean.

Case ii): If the selected window contains salt or pepper noise as processing pixel (i.e., 255/0 pixel value) and neighboring pixel values contains some pixels that adds salt (i.e., 255 pixel value) and pepper noise to the image:

78	90	0
255	<0>	120
97	255	73

Figure 2: 3×3 Mask have some noisy pixel

Where "0" is processing pixel, i.e., .P_{mn}
Now eliminate the salt and pepper noise from the selected window. That is, elimination of 0's and 255's. The 1-D array of the above matrix is [78 90 0 255 0 120 97 255 73]. After elimination of 0's and 255's the pixel values in the selected window will be [78 90 120 97 73]. Here the median value is 90. Hence replace the processing pixel by 90.

Case iii): If the selected window contains a noise free pixel as a processing pixel, it does not require further processing. For example, if the processing pixel is 90 then it is noise free pixel:

43	67	70
70	<90>	23
76	87	60

Figure 3 : 3×3 Mask with all pixels are noise free

Where "90" is processing pixel, i.e., since "90" is a noise free pixel it does not require further processing

Step 4. Output Image: The Final denoising image, which is noise free and also preserve edges and border detail.

4. SIMULATION RESULTS AND DISCUSSIONS

Design and implementation of this approach is done in MATLAB by using Image Processing Toolbox. Simulations are carried out on the well known gray scale and colored images(Goldhill and Barbara).These images are corrupted by "salt" (with value 255) and "pepper" (with value 0) noise at various noise intensity vary from 10% to 90%. Comparison of performance of ORSMF with standard median filter and SSMF based on various performance parameters like: Mean square error (MSE), Peak signal to noise ratio (PSNR), Mean difference and Bit error rate.

1. Peak Signal to Noise Ratio: Peak signal to noise ratio measure the degree of image distortion. PSNR is used to measure the quality between the original image and compressed image.

PSNR is defined as:

$$PSNR = 10.\log_{10}\left(\frac{MAX_I^2}{MSE}\right)$$

$$= 20.\log_{10}\left(\frac{MAX_I}{MSE}\right)$$

$$= 20\log_{10}(MAX_I) - 10.\log_{10}(MSE) \quad ...Eq(1).$$

2. Mean Square Error: In image processing mean square error is the most general measure for performance measurement of the existing method and the coded images. It is computed by using equation

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(f(i,j) - f'(i,j))^2 \quad ...Eq(2).$$

3. Mean Difference: The mean difference is defined as the "average" or "mean", formally the expected value, of the absolute difference of two random variables X and Y independently and identically distributed with the same (unknown) distribution henceforth called Q.

$$MD = E[|X - Y|] \quad ...Eq(3).$$

4. **Bit Error Rate (BER):** The rate at which errors occur in the transmission of digital data.

$$BER = \frac{Number\ of\ errors}{Total\ number\ of\ tarnsmitted\ bits} \quad ...Eq(4).$$

4.1 Results for Gray Scale Image

This subsection shows the results for the gray scale image at different noise intensity levels. Results on "Goldhill" image.
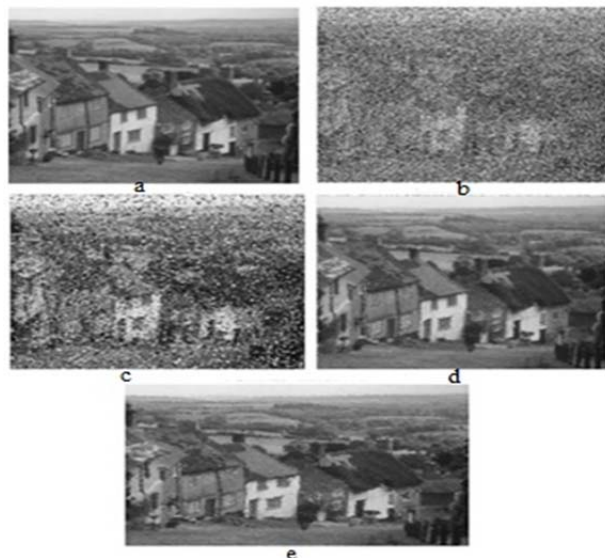

Figure 4: Simulation result of different filters. a) Input Image b) 60% Noisy Image c) Median Filtered Image d) SSMF result e) MSP result

Figure 4. Show the result of different filters on 60% noisy image. In Figure 4, Image a) is original image passed to

simulation and image b) is noisy image at noise density = 0.6. Figure c) shows the simulation result of traditional Median filter and which gives not better results and the Image d) shows the results of the switching median filter Image e) show result of MSP which gives better result than others.
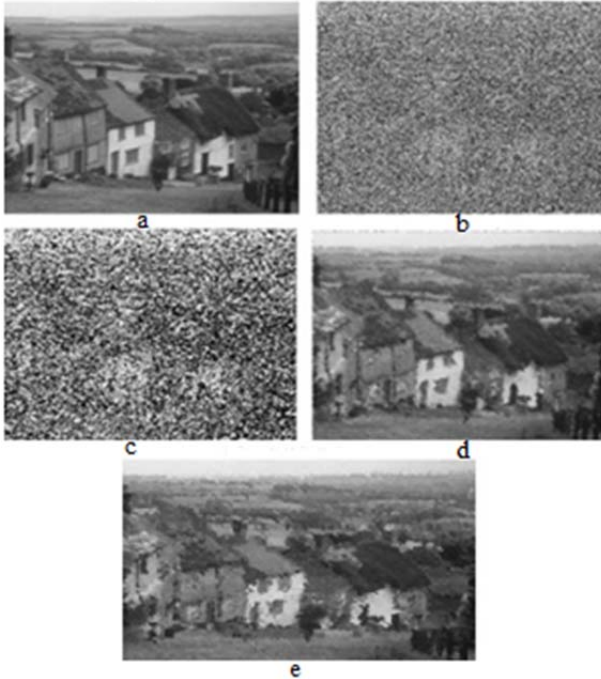

Figure 5: a) Input Image b) 80% Noisy Image c) Median Filtered Image d) SSMF Result e) MSP result

In Figure 5, "Goldhill" image is corrupted at noise density =0.8. Image a) is the original image and Image b) is noisy image with noise density 80%, Image c) show the result of SMF, Image d) show the result of SSMF, Image e) show the result of MSP. As shown in these images results MSP show better result than others filters and also preserves the edges and borders of an image very well as compared to SSMF and SMF. MSP policy also removes the noise density more as compared to others.

4.1.1 Parameter Values for Gray Image
a) Mean Square Error
Table 1 shows the values for Mean Square Error for gray image at various levels of noise intensity ranging from 10% to 90%.

Table 1: MSE Evaluation

Noise Intensity	Results for Noisy Image	Results for Median Filter	Results for SSMF	Results for MSP
0.1	1903	62	23	7
0.2	3785	115	54	16
0.3	5670	316	78	31
0.4	7585	852	117	51
0.5	9451	2006	163	82
0.6	11372	3923	216	125
0.7	13252	6661	401	208
0.8	15131	10214	645	345
0.9	17028	14356	952	667

Figure 6 has shown the quantized analysis of the mean square error of gray scale image at various levels of noise intensity. It is especially clear from the plot that there is decrease in MSE value of image in proposed method.
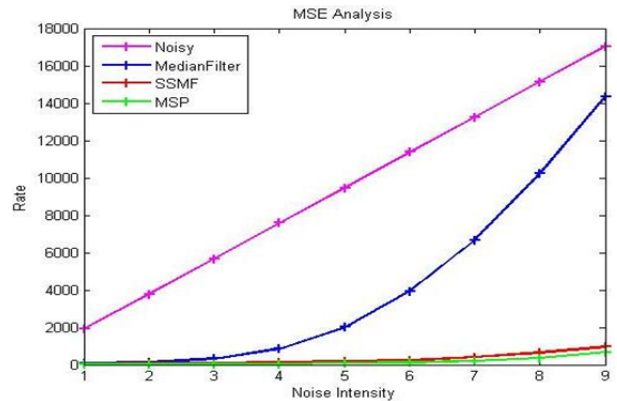

Figure 6: comparison graph of MSE at different noise densities of gray image.

b) Peak Signal to Noise Ratio
Table 2 shows the values for Peak Signal to noise ratio for gray image at various levels of noise intensity ranging from 10% to 90%

Table 2: PSNR Evaluation

Noise Intensity	Results for Noisy Image	Results for Median Filter	Results for SSMF	Results for MSP
0.1	15.3364	30.2069	34.5135	39.6798
0.2	12.3501	27.5238	30.8069	36.0896
0.3	10.5950	23.1339	29.2099	33.2172
0.4	9.3312	18.8264	27.4489	31.0551
0.5	8.3760	15.1075	26.0089	28.9927
0.6	7.5724	12.1946	24.7863	27.1616
0.7	6.9080	9.8954	23.3451	24.9502
0.8	6.3321	8.0388	21.6472	22.7526
0.9	5.8192	6.5605	19.3686	19.8895

Figure 7 has shown the quantized analysis of the peak signal to noise ratio of gray scale Goldhill image at various levels of noise intensity. It is especially clear from the plot that there is increase in PSNR value of image.
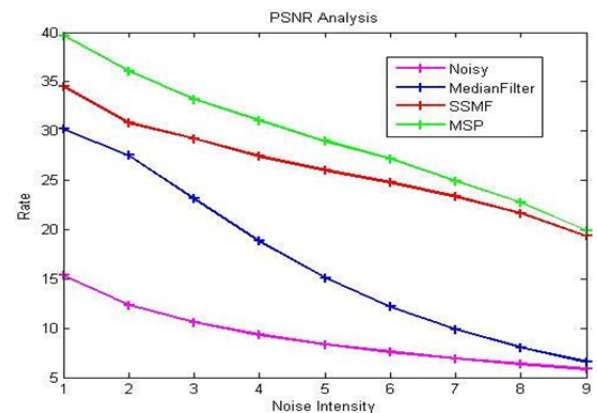

Figure 7: comparison graph of PSNR at different densities of gray image.

c) Bit Error Rate

Table 3 shows the values for BER ratio for gray image at various levels of noise intensity ranging from 10% to 90%.

Table 3: BER Evaluation

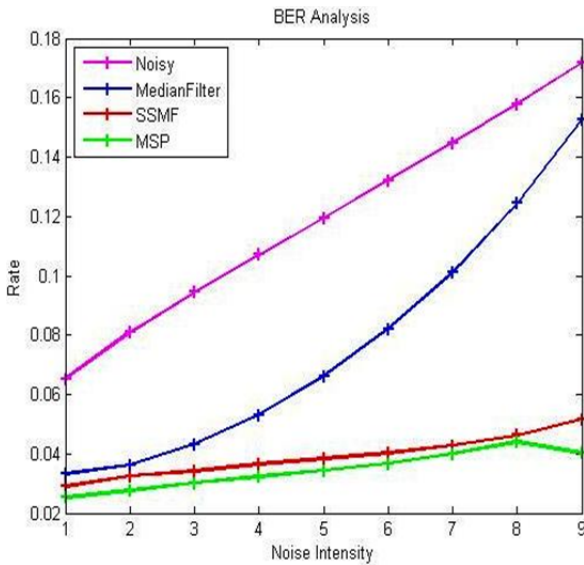| Noise Intensity	Results for Noisy Image	Results for Median Filter	Results for SSMF	Results for MSP
0.1	0.0652	0.0331	0.0290	0.0252
0.2	0.0810	0.0363	0.0325	0.0277
0.3	0.0944	0.0432	0.0342	0.0301
0.4	0.1072	0.0531	0.0364	0.0322
0.5	0.1194	0.0662	0.0384	0.0345
0.6	0.1321	0.0820	0.0403	0.0368
0.7	0.1448	0.1011	0.0428	0.0401
0.8	0.1579	0.1244	0.0462	0.0440
0.9	0.1718	0.1524	0.0516	0.0403

Figure 8: comparison graph of BER at different densities of gray image.

d) Mean Difference

Table 4 shows the values for Mean Difference for gray image at various levels of noise intensity ranging from 10% to 90%.

Table 4: Mean Difference Evaluation

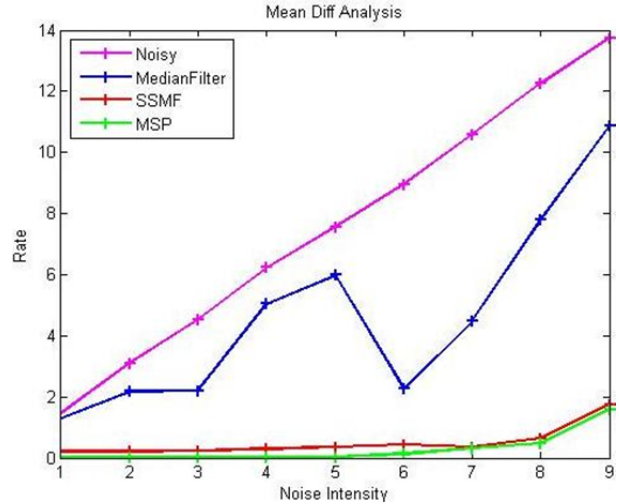| Noise Intensity	Results for Noisy Image	Results for Median Filter	Results for SSMF	Results for MSP
0.1	1.4699	1.2834	0.2208	0.0175
0.2	3.1086	2.1747	0.2089	0.0187
0.3	4.5293	2.1979	0.2263	0.0118
0.4	6.2243	5.0381	0.3023	0.0386
0.5	7.5566	5.9946	0.3660	0.0320
0.6	8.9582	2.2531	0.4367	0.1256
0.7	10.5842	4.4704	0.3609	0.3233
0.8	12.2568	7.7822	0.6545	0.4736
0.9	13.7320	10.8636	1.7425	1.5842

Figure 9: comparison graph of Mean difference at different noise densities of gray image.

Figure 9 has shown the quantized analysis of the Mean Difference of gray scale image at various levels of noise intensity. It is especially clear from the plot that there is decrease in Mean Difference value of image by using MSP technique.

4.2 Results for Color Image

This subsection shows the results for the color image at different noise intensity levels. In Figure 10, Image a) is original image passed to simulation and Image b) is noisy image at noise density = 0.6. Image c) shows the simulation result of traditional Median filter and which gives not better results and the Image d) shows the results of the switching median filter which gives better result than median Image e) shows the MSP result.

Figure 10: a) Input Image b) 60% Noisy Image c) Median Filtered Image d) SSMF Result e) MSP result
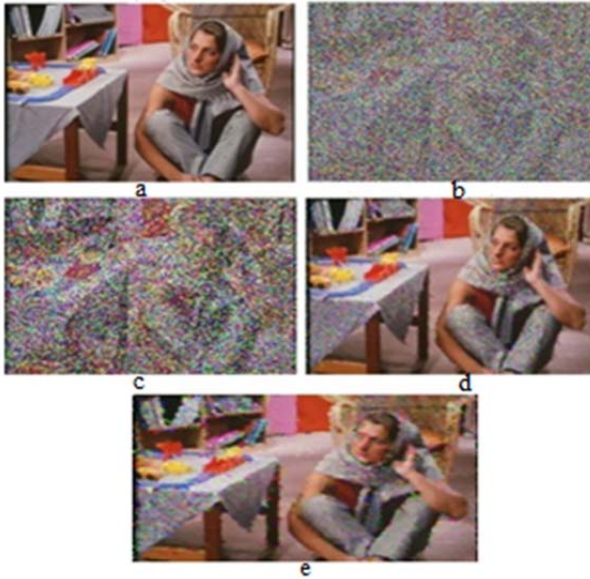
Figure 11: a) Input Image b) 80% Noisy Image c) Median Filtered Image d) SSMF Result e) MSP result

In Figure 11, "Barbara" image is corrupted at noise density 0.8 and result are shown by different filters.

4.2.1 Parameter Values for color Image
a) Mean Square Error
Table 5 shows the values for Mean Square Error for color image at various levels of noise intensity ranging from 10% to 90%.

Table 5: MSE Evaluation

Noise Intensity	Results for Noisy Image	Results for Median Filter	Results for SSMF	Results for MSP
0.1	1919	167	110	110
0.2	3878	236	121	121
0.3	5802	460	173	138
0.4	7755	1044	229	163
0.5	9686	2187	280	205
0.6	11622	4091	386	297
0.7	13569	6883	536	403
0.8	15458	10411	756	663
0.9	17415	14643	1340	1236

Figure 12. has shown the quantized analysis of the mean square error of colored "Barbara" image at various levels of noise intensity. MSE value of image decrease in case of MSP method as compared to others as shown in plot.
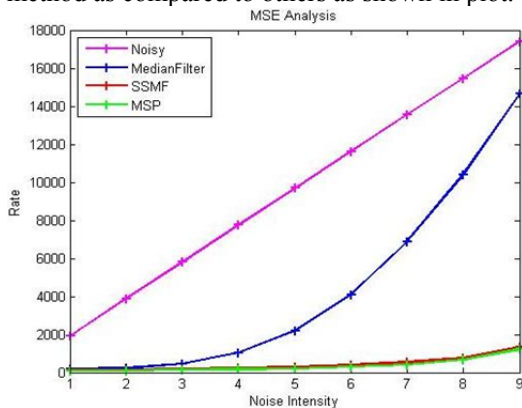

Figure 12: comparison graph of MSE at different noise densities of color image.

b) Peak Signal to Noise Ratio
Peak signal to noise ratio measure the degree of image distortion. PSNR is used to measure the quality between the original image and compressed image. If the value of PSNR is higher, then the quality of reconstructed image is better PSNR represent the peak error.

Table 6 shows the values for Peak Signal to noise ratio for color image at various levels of noise intensity ranging from 10% to 90%.

Table 6: PSNR Evaluation

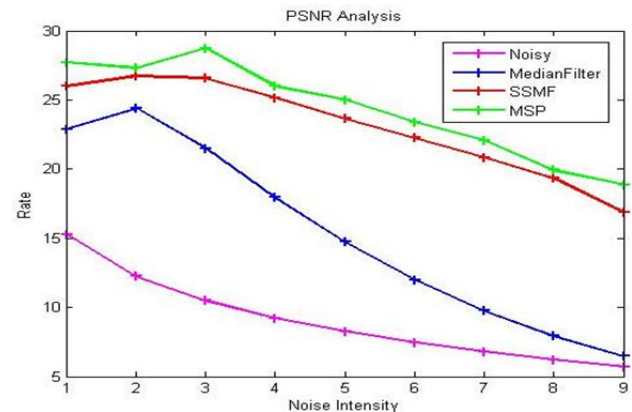| Noise Intensity	Results for Noisy Image	Results for Median Filter	Results for SSMF	Results for MSP
0.1	15.3001	25.9036	32.0030	27.7169
0.2	12.2447	24.4017	28.7356	27.3029
0.3	10.4950	21.5032	26.5774	28.7320
0.4	9.2350	17.9438	25.1423	26.0089
0.5	8.2694	14.7323	23.6592	25.0133
0.6	7.4780	12.0125	22.2649	23.4032
0.7	6.8053	9.7530	20.8392	22.0778
0.8	6.2393	7.9559	19.3456	19.9157
0.9	5.7216	6.4745	16.8598	18.8727

Figure 13: comparison graph of PSNR at different densities of color image.

Figure 13. has shown the quantized analysis of the peak signal to noise ratio of color "Barbara" image at various levels of noise intensity. As shown in plot, PSNR value of image is increased in case of MSP method.

c) Bit Error Rate
BER need to be minimized; so the main goal is to decrease the BER as much as possible. Table 7 shows the values for BER ratio for color image at various levels of noise intensity ranging from 10% to 90%.

Table 7: BER Evaluation

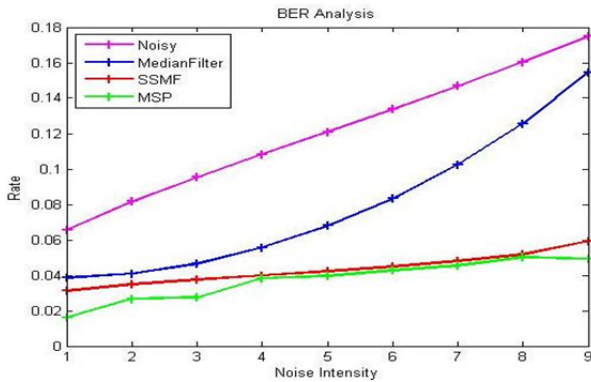| Noise Intensity	Results for Noisy Image	Results for Median Filter	Results for SSMF	Results for MSP
0.1	0.0654	0.0386	0.0312	0.0161
0.2	0.0817	0.0410	0.0348	0.0266
0.3	0.0953	0.0465	0.0376	0.0274
0.4	0.1083	0.0557	0.0398	0.0384
0.5	0.1209	0.0679	0.0423	0.0396
0.6	0.1337	0.0832	0.0449	0.0427
0.7	0.1469	0.1025	0.0480	0.0453
0.8	0.1603	0.1257	0.0517	0.0502
0.9	0.1748	0.1545	0.0593	0.0493

Figure 14: comparison graph of BER at different noise densities of color image.

Figure 14. has shown the quantized analysis of the bit error rate of color image at various levels of noise intensity. It is especially clear from the plot that there is decrease in BER value of image in case of MSP as compared to others.

d) Mean Difference
The mean difference is defined as the "average" or "mean", formally the expected value, of the absolute difference of two random variables X and Y independently and identically distributed with the same (unknown) distribution henceforth called Q.
Table 8 shows the values for Mean Difference for color image at various levels of noise intensity ranging from 10% to 90%.

Table 8: Mean Difference Evaluation

Noise Intensity	Results for Noisy Image	Results for Median Filter	Results for SSMF	Results for MSP
0.1	0.3836	0.1008	0.0383	0.0182
0.2	0.6916	0.1142	0.0915	0.0287
0.3	0.8743	0.0770	0.1837	0.0415
0.4	1.1969	0.1214	0.1662	0.0054
0.5	1.7965	0.6749	0.2260	0.0400
0.6	2.2682	1.3286	0.2540	0.0580
0.7	2.2598	1.3727	0.4828	0.2936
0.8	2.6415	2.2331	0.5780	0.0475
0.9	2.9699	2.9372	0.4043	0.0881

Figure 15 has shown the quantized analysis of the Mean Difference of color image at various levels of noise intensity. It is clear from the plot that there is decrease in Mean Difference value of image.
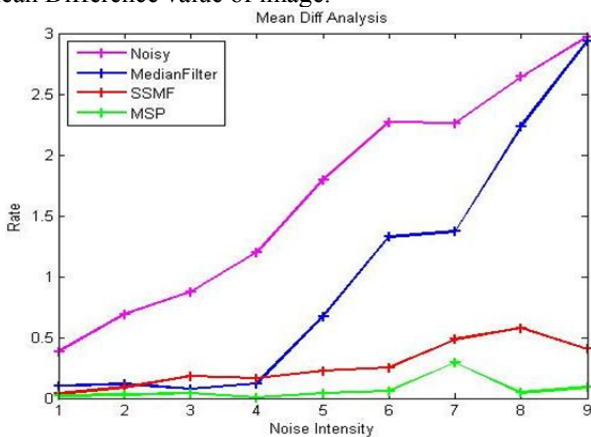

Figure 15: comparison graph of Mean difference at different noise densities of color image.

5. CONCLUSION AND FUTURE SCOPE
This paper has proposed a new approach which has improved the sorted switching median filter by using the optimistic replacement of noisy pixel. The Optimistic Replacement Based Switching Median Filter (ORSMF) also called multiple selection policy (MSP) has used the optimistic noise replacement instead of local median. It has also preserved the edges using image gradients and border exchanging has also used in order to preserve the borders. The proposed technique seems to be effective as it has replaced the noisy pixel with its best suitable alternative by taking more than one replacements for the noisy pixel. The optimistic replacement includes the median of medians (also called hybrid median), min of medians, max of medians, mean of medians etc. Experiments have been done in MATLAB using image processing toolbox in order to evaluate the effectiveness of the proposed technique. The comparative analysis has shown the effectiveness of the proposed technique over the available techniques.
This paper has not considered any other kind of the noise in so in near future the proposed technique can be tested for other kind of noises. Also the fuzzy set theory based rules can also be used to enhance the results further.

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