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Comparative Analysis of Mean and Median Filter for High Density Salt and Pepper Noise Removal

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Abstract— This paper has evaluated the performance of different median and mean based filters for removing the high density Salt and Pepper noise from color and grey scale images. Traditional filters are very effective for low density of noise but fails for high density of noises. Various filters have been proposed so far for removal the high density of noise. But the experimental results has shown among various high density noise removal algorithms DBMF and Mean filter with variable window are quite effective. Computer simulations verify extensive improvement of these methods with others in terms of PSNR, MSE, RMSE, BER, and SSIM. Experiments have been done in MATLAB using image processing toolbox.

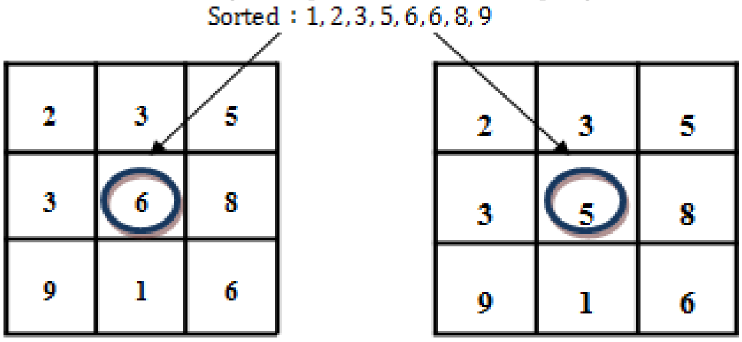
Keywords— DBMF, Median Filter, Salt & Pepper noise, Mean Filter

I. INTRODUCTION

Imaging noise is unwanted information embedded with the original image. Image noise is a variation in the brightness, illumination, contrast or intensity in images. It is usually formed by the sensors, circuitry of scanner or when an image acquired by the camera. Before any kind of subsequence processing like edge detection or object recognition, it is necessary to remove noise from original image. There are many types of image noise present such random noise and Impulse noise. In this paper, we are focusing on removal of Salt and Pepper noise. Which is one of type of Impulse noise is produced due to broken or out of order pixel in camera sensors, due to faulty memory location in hardware or due to noisy channel [9].An image that contains Salt and Pepper noise having dark pixels in the brighter regions and bright pixels in darker regions. And take only minimum and maximum values in the dynamic range [22]. Mean and Median filters generally used for impulse noise removal at low density noise as well as for high density noise.

II. MEDIAN FILTERING

Median filtering is Non - linear method is very popular for removing noise from an image, particularly for Salt and Pepper noise. It works by moving on whole image pixel by pixel and replace each value with median value of neighbouring pixels. 2D Median filtering Example used of 3 x 3 Sampling window in Figure 1.



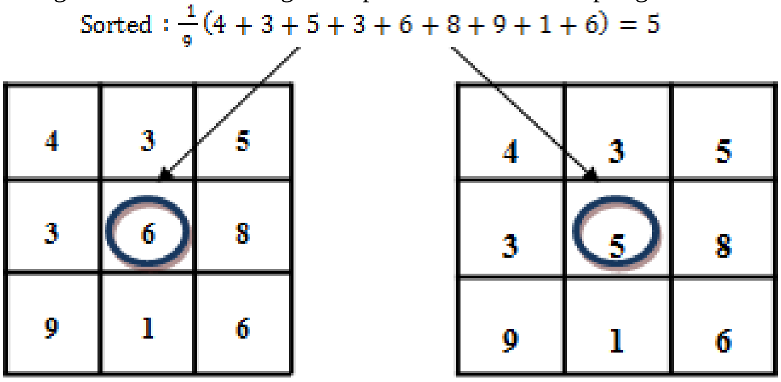
(a) (b)

Figure 1 :(a) Unfiltered window (b)Median filtered

This filter shows certain advantages such as: 1) Edge preservation 2) Efficient noise attenuation with robustness against impulsive-type noise. The main drawbacks of median filters are:1) Signal weakening 2) It affects non corrupted image pixels 3) Computational complexity is more compared to linear filtering. 5) Posterization effect introduced.

III. MEAN FILTER

Mean filter is also called Average filter in which the value of resulting signal over each point is the average of the value in the specified window. Basically in mean filtering, substitute every pixel value in an image with the mean value of its neighbors, as well as itself. Mean filtering frequently also known as convolution filter. Similar to other convolutions it is found around a kernel which characterizes the shape and size of the neighborhood and it is sampled during mean calculation. frequently a 3x3 square kernel used, even though larger kernels such as 5x5 squares, 7x7 squares may be used for further more smoothing. 2D Median filtering Example used of 3 x 3 Sampling window in Figure 2.



(a) (b)

Figure 2 :(a) Unfiltered window (b) Mean filtered

Here we are introducing Mean Filtering for the reason that it is the straightforward kind of low-pass filter. It is characterized by a kernel width, height and shape. When image variation occurs frequently only on one direction, the smoothing can be adjusted by shifting the shape of the filter for that reason. When the range of the kernel raises the smoothing effect also raises [4].

In this paper, Outline is arranged as follows: In section I, a brief introduction about the noise and types are explained. In section II, we introduced idea about median filter and in section III, mean filtering is explained. In section IV, literature review is presented regarding previous approachs. Section V depicts regarding the Algorithm used. Simulation and performance analysis along with associated graph are presented in Section VI and VII respectively. And to end with conclusions drowned in Section VIII.

IV. LITRATURE SURVEY

In This Section, We offer to the point background of many presented techniques of mean and median filters. Previous works on High Density noise removal have introduced mean filtering but at higher noise levels they used the concept of Median filtering [6]. For edge preservation, median filter is more suitable. Raymond H. Chan et al.[10] proposed a scheme for removing Salt-and-Pepper Noise Removal by adaptive Median-Type Noise Detectors and special Regularization method for detail preservation Anisha Bhatia[1] presented an algorithm for removing impulse noise by decision based median filtering technique. This methods performed better results on removing 90% salt and pepper noise with preserving visual Quality and important detail of image. Rabul et al.9] described a approach for removal of high density salt and pepper noise from colored image with variable window size. In this paper mean filter and linear filter used for improvement in an image and also preserve edges of image and lesser distortion than other proposed methods. By increasing the Window size at higher noise levels we get better results than Trimmed filter [3]. Megha et al.[7] described a independent component analysis in medical imaging used for separating out noise from original image to provide important diagnostic detail to physician. Easwara M. et al.[2]presented fast decision based weighted fuzzy mean filter for highly noise density images. In this method corrupted pixels are replaced by weighted fuzzy mean estimation and certainty degrees of each pixel are used as weight. Shaym Lal et al.[11]purposed a super mean filter to remove high density salt and pepper noise with two stages. In first stage, noisy pixel detected and in second , stage every noisy pixel substituted by the mean value of Non-noisy pixel of 2×2 matrix. Pawan Patidar et al.[8] introduces better results of median filter as compared to other mean and wiener filter. Hossein et al.[5] purposed an efficient iterative method for noise removal in both objective and subjective performance.

V. ALGORITHM

Procedure to be taken for filtering of an images by Mean filter with variable window and for Decision based median filtering is given below:

Step 1: Select image from computer memory into existing program and Read Noisy Image.

Step 2: 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.

Step 3: If $P(m,n,k)$ is an uncorrupted pixel (that is, 0< $P(m,n,k)$ <255), then its value is not changed.

Step 4: If $P(m,n,k)$ = 0 or 255, then $P(m,n,k)$ is a corrupted pixel.

Step 5: If 3/4th or more pixels in selected window are corrupted then increase window size to 5x5 or next higher order of odd dimension.

Step 6: If all pixels in the selected window are 0's and 255's, then replace $P(m,n,k)$ with the mean or median of the pixels in the window else go to

Step 7: Eliminate all 0's and 255's from the selected window and find the mean or median value of the remaining pixels. Replace $P(m,n,k)$ with the mean or median value.

Step 8: Repeat steps 2-6 until all the pixels of whole image are processed.

VI. SIMULATION AND PERFORMANCE EVALUATION

A. Simulation Results

Design and implementation of this approach is done in MATLAB by using Image Processing Toolbox. This filtering approach is tested on different 10 images of different format and size as given in table. All these images are of different Type because of this filtering evaluation also is different for each image. These images are corrupted by “salt” (with value 255) and “pepper” (with value 0) noise at various noise intensity vary from 10% to 90%.

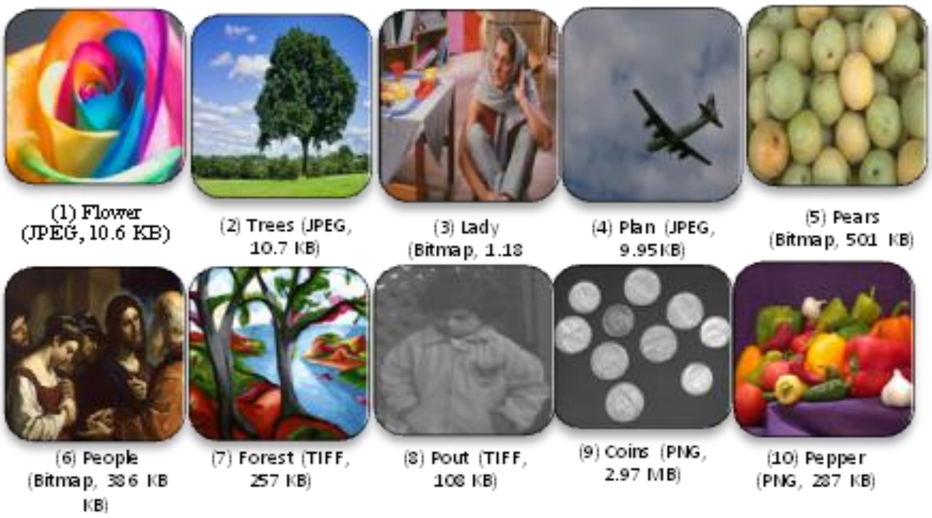


Figure 3: Different kind of Test Images along with their Format and Size

Effective Performance of available methods(such as Median , Relaxed median, Mean and DBMF filters) are measured by using the parameters such as Peak Signal-to-Noise Ratio (PSNR), Mean Square Error (MSE), Bit Error Rate, Root Mean Square Error(RMSE) and the last one is Structural similarity index mean (SSIM) for comparative analysis as well.

B. Parameters

1. Peak Signal to Noise Ratio(PSNR)

PSNR in db = $10\log_{10}(255^2/MSE)$ 1

2. Mean Squared Error(MSE)

$$MSE = \sum_t \sum_f \frac{\left(Y(i,j)-Y'(i,j)\right)^2}{M \times N}$$ 2

3. Root Mean Square Error(RMSE)

$$RMSE = \frac{1}{MSE}$$ 3

4. Bit Error Rate(BER)

$$BER = \frac{\text{Number of errors}}{\text{Total number of tarnsmitted bits}}$$ 4

5. Structural Similarity index mean (SSIM)

$$SSIM(x,y) = \frac{(2\mu_X\ \mu_Y + C_1)}{(\mu_X^2\ + \mu_Y^2 + C_1)} \frac{(2\sigma_{XY} + C_2)}{(\sigma_X^2\ +\ \sigma_Y^2 + C_2)}$$ 5

Results on “Lady” image

In Figure 4, Image “a” is original image passed to simulation and image “b” is noisy image at noise density =.9

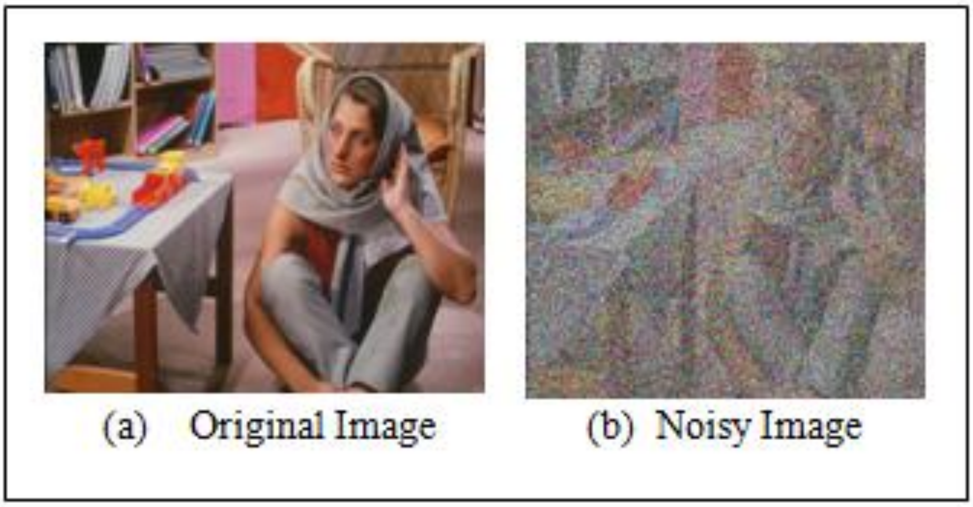


Figure 4: Original and Noisy Image

Following Figure 5 shows the simulation result of traditional Median filter (a) and which gives not better results and the Image (b) gives better result than median but not efficient result.

Figure 5: Median and Relaxed Median Filtered Image

Figure 6 shown the outcomes are fairly efficient with quite improved results than the existing methods. So this method has shown comparatively imperative improvement above presented methods.

Figure 6: Mean Filtered and DBMF Image

C. Performance Evaluation

In Table 3 and Figure 7, PSNR analyses taken on 10 images and to get maximum value of PSNR for efficient results. It is clearly shown in table and figure that for some images mean filtered PSNR is larger than DBMF and in some images DBMF give maximum value of PSNR.

TABLE 3: PEAK SIGNAL TO NOISE RATIO

Test Images	Noisy Image	Median Filter	Relaxed Median filter	Mean Filter	DBMF	Noisy Image
Flower	5.4793	8.2497	10.1685	18.4553	20.9292	5.4793
Trees	6.4638	9.2021	11.0628	18.3308	19.9419	6.4638
Lady	6.8088	9.7739	11.8510	19.5938	21.4938	6.8088
Plan	7.3188	10.388	12.5932	22.6777	30.2775	7.3188
Pears	6.9261	9.8481	11.7911	21.4376	25.0773	6.9261
People	6.2241	9.0718	10.9976	17.9814	19.9354	6.2241
Forest	5.3653	8.1657	10.0487	9.3444	16.4547	5.3653
Pout	5.6349	8.5356	10.5500	7.3166	18.5071	5.6349
Coins	5.4471	8.3063	10.2605	6.1979	17.3535	5.4471
Peppers	5.6675	8.6174	10.6832	8.3135	18.5547	5.6675

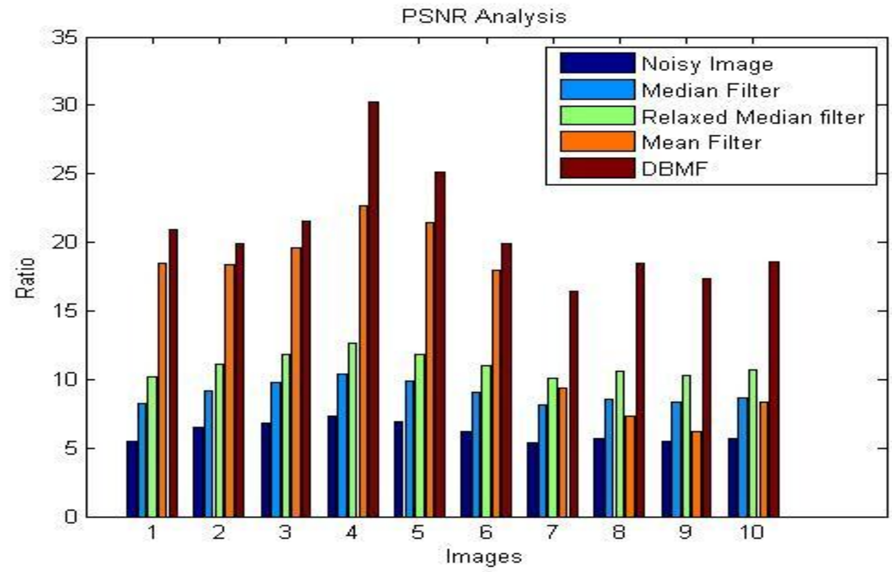


Figure 7: PSNR Analysis

In the Table 4 and Figure 8, MSE Evaluation is present. Its value should be minimum as possible to get filtered image. So in mean filtered and DBMF image, we have lesser value of MSE.

TABLE 4: MEAN SQUARE ERROR

Test Images	Noisy Image	Median Filter	Relaxed Median filter	Mean Filter	DBMF
Flower	18414	9730	6255	928	525
Trees	14679	7814	5091	955	659
Lady	13558	6850	4246	714	461
Plan	12056	5947	3579	351	61
Pears	13197	6734	4305	202	467
People	15512	8052	5168	1035	660
Forest	18904	9920	6430	7562	1471
Pout	17766	9110	5729	12062	917
Coins	18551	9604	6124	15606	1196
Peppers	17633	8940	5556	9588	907

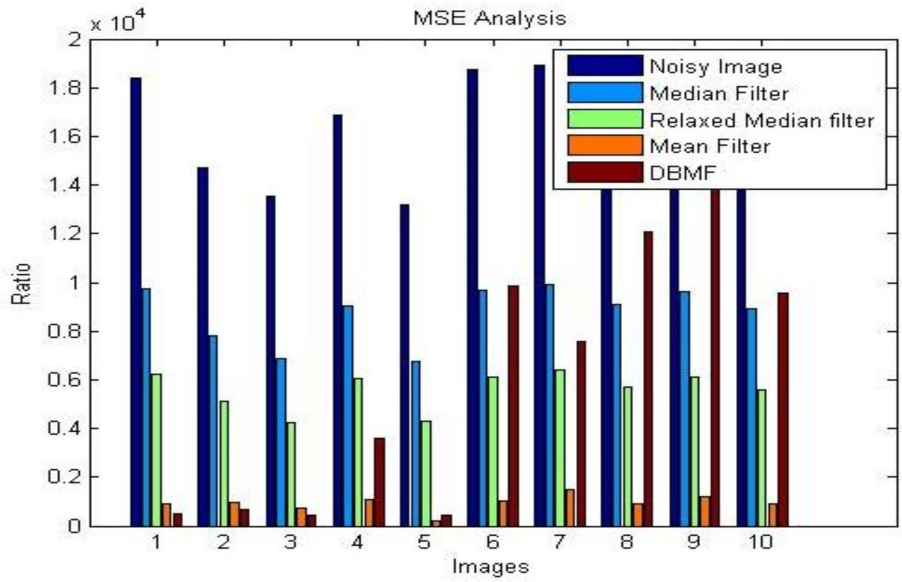


Figure 8: MSE Analysis

In Table 5 and Figure 9, RMSE Analysis performed which is reciprocal of MSE.

TABLE 5: ROOT MEAN SQUARE ERROR (RMSE)

Test Images	Noisy Image	Median Filter	Relaxed Median filter	Mean Filter	DBMF
Flower	135.6982	98.6408	79.0886	30.4631	22.9129
Trees	121.1569	88.3968	71.3512	30.9031	25.6710
Lady	116.4388	82.7647	65.1613	26.720	21.4709
Plan	109.7998	77.1168	59.8247	18.7350	7.8102
Pears	114.8782	82.0610	65.6125	21.6102	14.2127
People	124.5472	89.7329	71.8888	32.1714	25.6905
Forest	137.4918	99.5992	80.1873	86.9598	38.3536
Pout	133.2892	95.4463	75.6902	109.827	30.2820
Coins	136.2021	98.0000	78.2560	124.924	34.5832
Peppers	132.7893	94.5516	74.5386	97.9183	30.1164

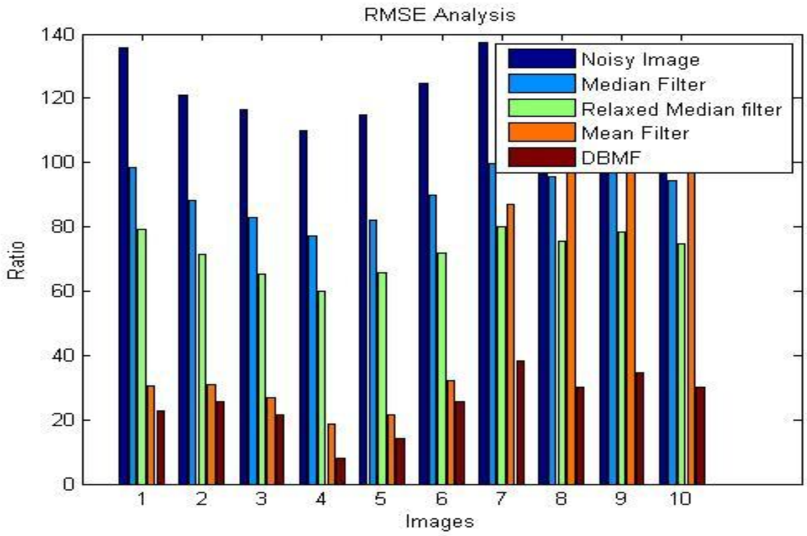


Figure 9: RMSE Analysis

In Table 6 and Figure 10, BER valuation done, lesser value of BER is required to get error free results.

TABLE 6: BIT ERROR RATE(BER)

Test Images	Noisy Image	Median Filter	Relaxed Median filter	Mean Filter	DBMF
Flower	0.1825	0.1212	0.0983	0.0542	0.0478
Trees	0.1547	0.1087	0.0904	0.0546	0.0501
Lady	0.1469	0.1023	0.0844	0.0510	0.0465
Plan	0.1366	0.0963	0.0794	0.0441	0.0330
Pears	0.1444	0.1015	0.0848	0.0466	0.0399
People	89.7329	71.8888	0.0909	0.0556	0.0502
Forest	0.1864	0.1225	0.0995	0.1070	0.0608
Pout	0.1775	0.1172	0.0948	0.1367	0.0540
Coins	0.1836	0.1204	0.0975	0.1613	0.0576
Peppers	0.1764	0.1160	0.0936	0.1203	0.0539

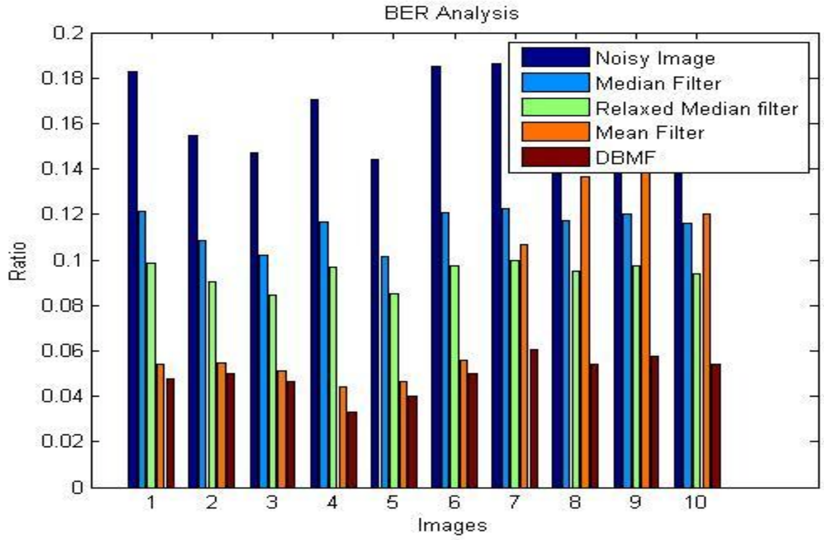


Figure 10: BER Analysis

In Table 7 and Figure 11, SSIM evaluated to acquire similarity between original image and in Obtained image after filtering. Maximum value of this factor is necessary.

TABLE 7: STRUCTURAL SIMILARITY INDEX MEAN (SSIM)

Test Images	Noisy Image	Median Filtered	Relaxed Median filter	Mean Filtered	DBMF
Flower	0.0188	0.0711	0.1995	0.5768	0.7839
Trees	0.0273	0.0763	0.1588	0.4943	0.6135
Lady	0.0879	0.1282	0.1868	0.6186	0.7875
Plan	0.0070	0.0254	0.0984	0.5403	0.9423
Pears	0.0152	0.0641	0.1718	0.6098	0.7671
People	0.0285	0.0730	0.1553	0.5106	0.6720
Forest	0.0258	0.0814	0.2133	0.4799	0.5017
Pout	0.0102	0.0405	0.1664	0.5569	0.5599
Coins	0.0172	0.0580	0.1809	0.5078	0.5598
Peppers	0.0656	0.1042	0.1638	0.6779	0.5860

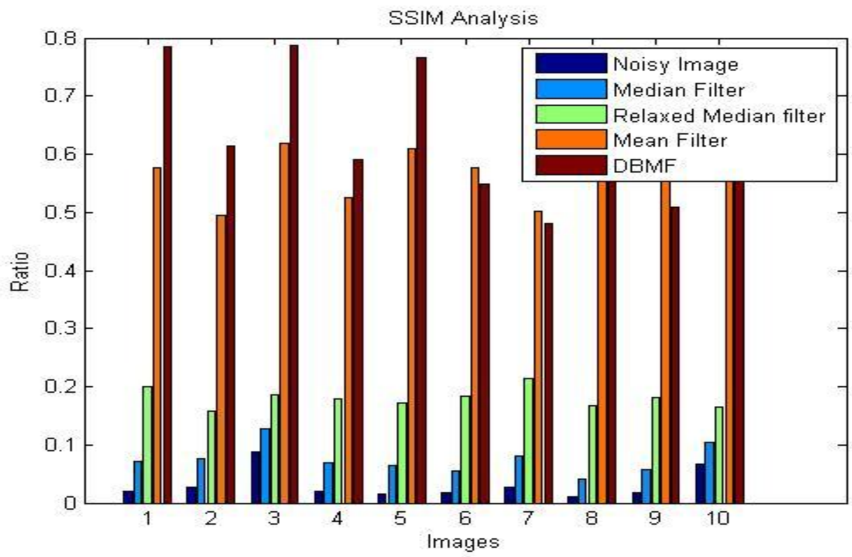


Figure 11: SSIM Analysis

VII. COMPARATIVE ANALYSIS

Following Figure 12 demonstrates the value of PSNR on different Image over different noise densities vary from 10 to 90 percentages. In comparative analysis, all existing filters have shown that the DBMF and the mean filter with variable window size are quite effective among others. But there exist strong trade-off between these two because some time DBMF performs better and also some time mean filter with variable window size.

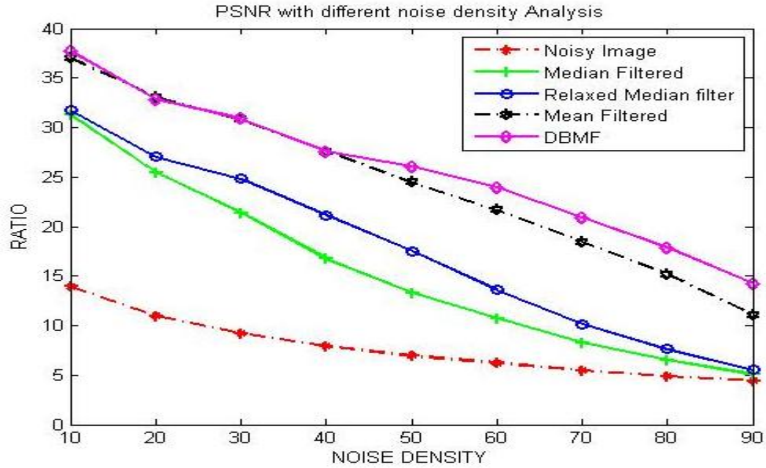


Figure 12 : PSNR at different noise levels on different image(1)

VIII. CONCLUSION

In this paper, Performance of different filters for removing high density Salt and Pepper noise for both color and grey scale images is evaluated. The analysis has shown that the long-established filters were very effective for low density of noise but fails for high density of noises. This paper has considered traditional median, relaxed median, mean filter with variable window size and also DBMF filters. Experiments have been done by designing these given filters in MATLAB using image processing toolbox. Comparitative study between the chosen filters has shown that the DBMF is effective among others. It is clear from results that DBMF performs well on different sizes and formats of images. In close proximity to future we will propose a new filter by integrating the mean filter with variable window size with DBMF to enhance the results further by adjusting the over smoothing problem of integration of two filters.

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