Volume 4, Issue 8, August 2014 ISSN: 2277 128X

International Journal of Advanced Research in Computer Science and Software Engineering

Research Paper

Available online at: www.ijarcsse.com

Enhanced Image Denoising by Using Minimum Patch Difference Based Technique and Image Gradients

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Abstract—Images are often corrupted with noise during acquisition, transmission and retrieval from storage media So efficient Image denoising algorithm is required for removal of noise from the noisy image .image denoising is one of the most vital challenges in the ground of image processing. In image denoising original image is estimated by removing noise from a noisy version of the image Images plays vital role in our daily life. Many algorithms have been proposed for removal of noise from the digital the image denoising methods are divided into two types: local and non-local. The methods that only use the spatial redundancy in local neighbourhoods are known as Local methods. The method that estimate pixel intensity from the complete image and shows the occurrence of similar patterns and features in an image are referred as Non-Local. This technique [3] estimates a noise-free pixel value as a weighted average of all other neighbourhood pixels in the image with similar neighbourhood. non-local means perform better at low level noise and second method is named as Non local euclidean median that improves the performance of NLM at high noise level. This paper propose a minimum patch difference based technique in which we use image gradients as a post processing operation to preserve the edges in an efficient manner. this technique is capable of removing noise at both levels i.e high level noise and low level noise. The simulated results preserve edges than available method. The proposed algorithm implemented over the MATLAB shows that noise removals can be done which is higher as compared to the existing algorithms.

Keywords— Denoising, NLM, NLEM

I. INTRODUCTION

Many image denoising algorithms have been proposed for the purpose of removal of noise from the noisy image. Main goal of these algorithms is to recover the original image from the noisy image. Image denoising plays very important job in a various applications such as image restoration and in image segmentation, where obtaining the original image is important for better performance. The basic idea behind this paper[1] is the evaluation of the uncorrupted image from the distorted or noisy image, and is also referred to as image "de-noising". There are various methods [2][3] that assist to reinstate an image from noisy image. But choosing the suitable technique plays a key role in receiving the desired image.. Here a study is made on the different filters for de-noising and each is implemented in Matlab . Each method is compared and classified in terms of its effectiveness. In order to compute the performance of these de-noising algorithms, a high class image is in use and some noise is added to it. This would be known as input to the filter, which produces an image close up to the original high quality image. The performance of each filter is compared by evaluating its Noise Ratio .a good image denoising techniques is one that will remove noise at the same time preserving edges .Different kind of the images has been taken for experimental purpose. This study shows the improvement of the NLEM[8] algorithm over the NLM[7] .the non-local means algorithm is a denoising technique based on the fact that image contains an wide amount of redundancy. These redundancies can then be oppressed to remove the noise in the image. Non local median is also a denoising technique that is proven to be better than previous technique.

The rest of the letter is organized as follows. In section ii, we discuss related work. in section iii, we discuss problem formulation. in section iv, proposed algorithm is discussed .in section v shows the experimental set-up and in section vi we evaluate the performance of proposed technique with existing ones.

II. RELATED WORK

Related work that is done in this field is as follow. Gaussian filtering, bilateral filtering and median filtering are filtering techniques that remove noise from the image but these techniques also remove some fine details from the image.NLM [4][6](non-local means) is a denoising technique that is used for the preservation of structure in digital image and it perform well only at low noise level and it does not work for vicinity of edges or preservation of edges. NLEM (non-local euclidean means) is also a denoising technique that is used for the removal of noise from a noisy image and it improves the performance of NLEM[5] in the vicinity of edges by using the concept of euclidean median. Main limitation of NLM and NLEM is that NLM work only for low noise level and NLEM works only for large noise level so we conclude that both of these techniques are not suitable for every kind of noise level i.e one can work for low density noise and other work for high density noise. Both of these techniques not work for the preservation of edges.

III. PROBLEM FORMULATION

Filtering is fundamentally done in order to remove noise from an image noise effects the quality of an image. noise may be define as the unwanted signal in an image. NLM (non-local means) is a denoising technique that is used for the preservation of structure in digital image and it perform well only at low noise level and it does not work for vicinity of edges or preservation of edges .NLEM[9] (non-local Euclidean means) is also a denoising technique that is used for the removal of noise from a noisy image and it improves the performance of NLEM[10] in the vicinity of edges by using the concept of Euclidean median.main limitation of NLM and NLEM is that NLM work only for low noise level [11]and NLEM works only for large noise level therefore both are not suitable for every kind of noise level The improved Modified Decision Based Median Filter algorithm removes impulse noise at high noise density and gives better Peak Signal-to-Noise Ratio (PSNR) and root mean square(RMSE). .

Also both techniques[13][14] does not focus on preserving the edges. However the NLEM less effects the edges than NLM but not as found in edge preservation techniques. So we will propose a new technique which will use minimum patch based technique than the Euclidean median and non-local means. To achieve so we will select such a patch from noisy image that has minimum patch difference. Thus will have accurate results as not much modification is done in the input patch space i.e. image. However image gradients will be used as a post processing operation to preserve the edges in an efficient manner.

IV. PROPOSED ALGORITHM

This section shows proposed algorithm. Following different steps are required to implement the proposed algorithm.this proposed algorithm remove noise from image in efficient manner than existing techniques. following are the different steps required to successfully remove the noise from images using the proposed algorithm.

Step 1: first of all a noisy image will be taken as input image. If image is not noisy then for experimental purpose we will add some noise in the input image.

Step 2: it is not possible for us to apply this filter on 3 dimension images directly. So to overcome this issue image will be divided into the three color channels i.e. r, g and b and proposed algorithm will remove the noise separately for each color channel.

Step3: at this stage the proposed minimum patch based algorithm will come in action by taking the patch of n*n to remove the noise. The n will be odd in nature reason behind is to locate the center value.

Step4: based on similarity criteria appropriate alteration will be done in the input image to get the noise free image.

Step5: image gradients is used as a post processing operation to preserve the edges in an efficient manner

Step6: now in order to evaluate the performance the error between the ground truth image and output image will be evaluated. This error will be used to compute the different performance parameters for images.

V. EXPERIMENTAL RESULTS

This section contains the experimental results. The overall section contains the original image, noisy image with noise level 20 and 80 and these noisy images are denoised by using NLM, NLEM and proposed algorithm**.** Fig 1 to Fig 5 shows the performance of NLM ,NLEM and proposed algorithm at noise level 20 and Fig 6 to Fig 9 shows the performance of NLM and NLEM at noise level 80

Fig 1: Original Image

Fig 2: Noisy Image (20)

Fig 1 shows the original image in which noise is added in order to compute the performance of algorithms. Fig 2 shows the noisy image with noise level 20

Fig 3: Non Local Means (20%)

Fig 4: Non Local Euclidean Median (20%)

Fig 3 shows the performance of NLM denoising technique at noise level 20. Fig 4 shows the performance of NLEM at noise level 20.

Fig 5: Proposed Method (20%)

Fig 6 Noisy Image (80%)

Fig 7: Non Local Means (80%)

Fig 6 shows the noisy image with noise level 80. Fig 7 shows the performance of NLM denoising technique at noise level 80

Fig 8 Non Local Euclidean Median (80%)

Fig 9: Proposed Method (80%)

Fig 8 shows the performance of NLEM at noise level 80.Fig 9 shows the performance of proposed method

VI. PERFORMANCE ANALYSIS

In this section we evaluate the performance of NLM and NLEM by using some well-known image performance parameters.

1. MEAN SQUARE ERROR:

Mean square error is a parameter used to calculate an error signal by subtracting the test signal from the reference, and then computing the average energy of the error signal. The mean-squared-error (MSE) is the simplest, and the most widely used image quality measurement.

Table 1: Analysis of Mean Square Error

Image		**20%**	**80%**
1.	NLM	128	852
	NLEM	224	546
	PROPOSED	104	502
2.	NLM	126	1066
	NLEM	215	690
	PROPOSED	87	666

3.	NLM NLEM PROPOSED	161 212 149	1005 612 546
4.	NLM NLEM PROPOSED	164 263 142	882 605 565
5.	NLM NLEM PROPOSED	120 179 97	942 455 422
6.	NLM NLEM PROPOSED	213 336 185	1076 809 763
7.	NLM NLEM PROPOSED	186 243 149	1004 696 604
8.	NLM NLEM PROPOSED	210 469 170	1388 1128 113
9.	NLM NLEM PROPOSED	155 248 120	1018 754 698
10.	NLM NLEM PROPOSED	188 422 151	1100 921 771

This table shows the results of applying denoising algorithms NLM , NLEM and proposed algorithm, over noisy images. from these results we conclude that NLM perform better at low level noise ,NLEM perform better at high level noise and proposed algorithm perform better at both noise levels(low noise level and high noise level)

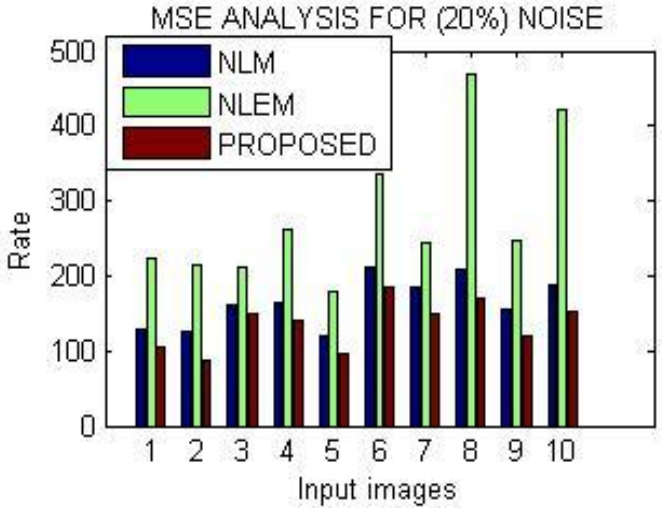

Fig 10: Analysis of MSE (20%)

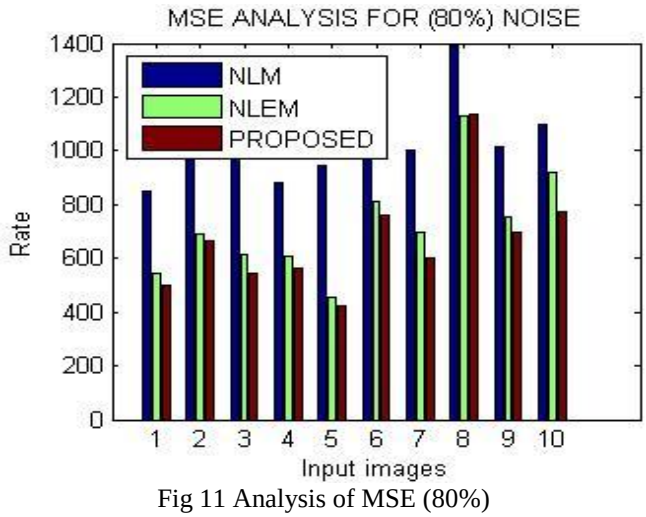

Fig 11 Analysis of MSE (80%)

Fig 10 And Fig 11 Shows The Graphical Results Of MSE At Noise Level 20% And 80%.From These Results We Conclude That NLEM Perform Better Then NLM At High Level Noise and proposed algorithm perform better then existing denoising techniques at both noise levels In Order To Obtain A Noise Free Image.

2. PEAK SIGNAL TO NOISE RATIO:

PSNR is used to specify the ratio between maximum power of signal to the power of corrupting noise. Larger PSNR indicate a smaller difference between the original (without noise) and reconstructed image.

Table 2: Peak Signal to Noise Ratio

Image		**20%**	**80%**
1.	NLM	27.0587	18.8264
	NLEM	24.6283	20.7589
	PROPOSED	27.9605	21.1238
2.	NLM	27.1271	17.8532
	NLEM	24.8064	19.7423
	PROPOSED	28.7356	19.8961
3.	NLM	26.0625	18.1091
	NLEM	24.8674	20.2633
	PROPOSED	26.3989	20.7589
4.	NLM	25.9824	18.6761
	NLEM	23.9312	20.3132
	PROPOSED	26.6079	20.6103
5.	NLM	27.3390	18.3903
	NLEM	25.6023	21.5507
	PROPOSED	28.2631	21.8777
6.	NLM	24.8470	17.8127
	NLEM	22.8674	19.0513
	PROPOSED	25.4591	19.3056
7.	NLM	25.4357	18.1135
	NLEM	24.2747	19.7047
	PROPOSED	26.3989	20.3204
8.	NLM	24.9086	16.7069
	NLEM	21.4191	17.5732
	PROPOSED	25.8263	17.6077
9.	NLM	26.2275	18.0533
	NLEM	24.1863	19.3571
	PROPOSED	27.3390	19.6922
10.	NLM	25.3892	17.7169
	NLEM	21.8777	18.4882
	PROPOSED	26.3410	19.2603

This table shows the results of applying denoising algorithm NLM and NLEM over noisy images. from these results we conclude that NLM shows large PSNR value(better results)at low level noise(20%) and NLEM shows large PSNR values (better result) over high level noise(80%) and proposed algorithm perform better at both noise levels(low noise level and high noise level)it means proposed algorithm have high PSNR value as compare to existing denoising techniques.

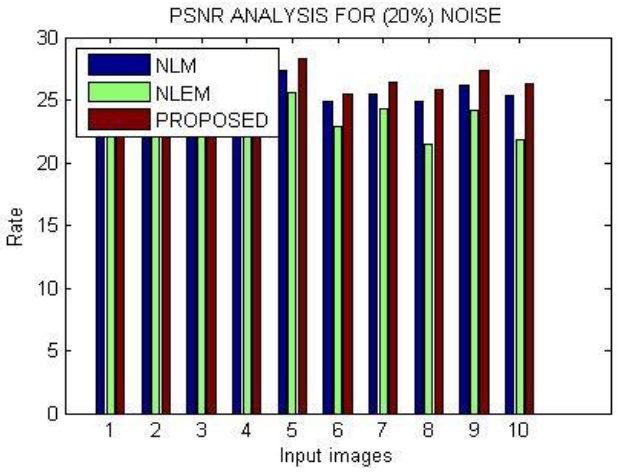

Fig 12 Analysis of PSNR (20%)

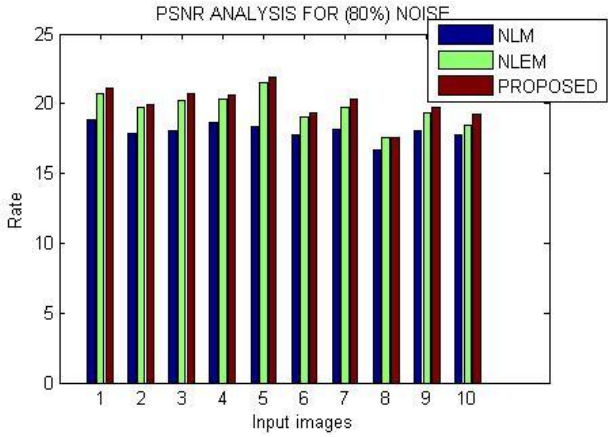

Fig 13 Analysis of PSNR (80%)

Fig 12 and fig 13 shows the graphical results of PSNR at noise level 20% and 80%.from these results we conclude that NLEM perform better then NLM at high level noise in order to obtain a noise free image. and proposed algorithm perform better at both noise levels(low noise level and high noise level) it means proposed algorithm have high PSNR value as compare to existing denoising techniques.

3. ROOT MEAN SQUARE ERROR

The root mean square error is a normally used to calculate of the difference between values predicted by a model and values observed from the environment that is being modelled.

Table 3: Root Mean Square Error

Image		20%	80%
1.	NLM	11.3137	29.1890
	NLEM	14.9666	23.3666
	PROPOSED	10.1980	22.4054
2.	NLM	11.2250	32.6497
	NLEM	14.6629 9.3274	26.2679
	PROPOSED		25.8070
3.	NLM	12.6886	31.7017
	NLEM	14.5602	24.7386
	PROPOSED	12.2066	23.3666
4.	NLM	12.8062	29.6985
	NLEM	16.2173	24.5967
	PROPOSED	11.9164	23.7697
5.	NLM	10.9545	30.6920
	NLEM	13.3791	21.3307
	PROPOSED	9.8489	20.5426
6.	NLM	14.5945	32.8024
	NLEM	18.3303	28.4429
	PROPOSED	13.6015	27.6225
7.	NLM	13.6382	31.6860
	NLEM	15.5885	26.3818
	PROPOSED	12.2066	24.5764
8.	NLM	14.4914	37.2559
	NLEM	21.6564	33.7194
	PROPOSED	13.0384	33.5857
9.	NLM	12.4499	31.9061
	NLEM	15.7480	27.4591
	PROPOSED	10.9545	26.4197
10.	NLM	13.7113	33.1662
	NLEM	20.5426	30.3480
	PROPOSED	12.2882	27.7669

This table shows the results of applying denoising algorithm NLM and NLEM over noisy images. from these results we conclude that NLM shows better results at low level noise(20%) ,NLEM shows better result at high level noise(80%) and proposed algorithm perform better at both noise levels. Less value of RMSE shows better result. These results shows that less value of RMSE is obtained by using proposed algorithm .

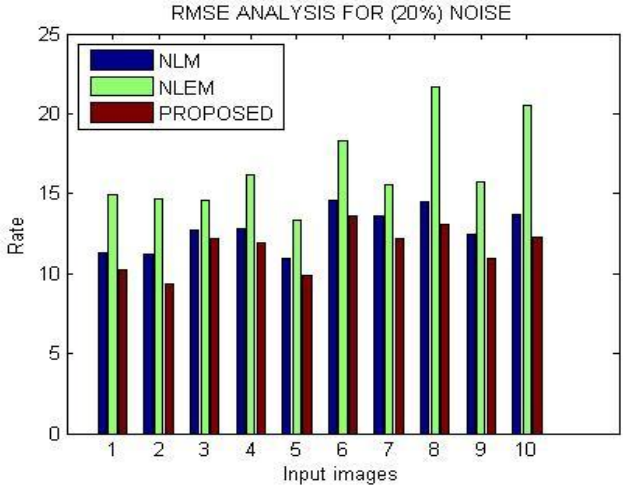

Fig 14 Analysis of RMSE (20%)

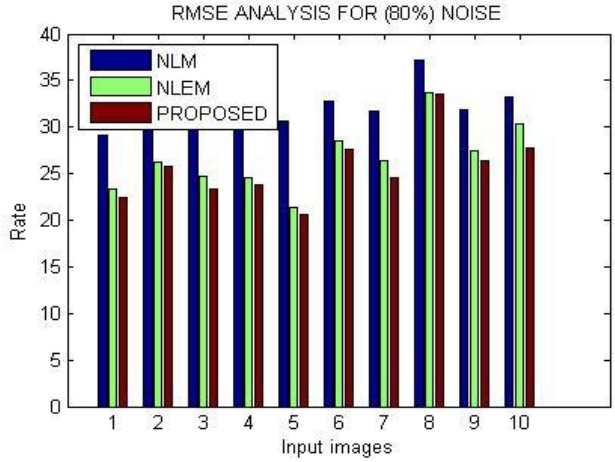

Fig 15 Analysis of RMSE (80%)

Fig 14 and fig 15 shows the graphical results of RMSE at noise level 20% and 80%.from these results we conclude that NLEM perform better then NLM at high level noise in order to obtain a noise free image and proposed algorithm perform better at both noise levels. Less value of RMSE shows better result. These results shows that less value of RMSE is obtained by using proposed algorithm .

4. MEAN DIFFERENCE

This parameter is used to compute the mean difference between original image and denoised image. Less value of mean difference implies better result.

Table 4: Mean Difference

Image		20%	80%
1.	NLM	2.5191	11.4483
	NLEM	2.5958	2.7239
	PROPOSED	0.3074	0.3399
2.	NLM	3.2763	13.3265
	NLEM	3.3257	4.2569
	PROPOSED	0.5158	0.6597
3.	NLM	1.5211	11.5351
	NLEM	1.6608	1.6496
	PROPOSED	1.0104	1.1410
4.	NLM	1.8426	9.1728
	NLEM	2.5117	1.0621
	PROPOSED	0.0371	0.0696
5.	NLM	2.3217	13.4913
	NLEM	3.0968	1.2795
	PROPOSED	0.1299	0.4082

6.	NLM NLEM PROPOSED	1.5617 2.3480 0.4283	11.0319 1.6538 0.2607
7.	NLM NLEM PROPOSED	1.3848 1.1195 0.9643	9.5881 0.4212 0.1754
8.	NLM NLEM PROPOSED	3.3075 3.9725 0.5609	13.2486 3.3584 0.7106
9.	NLM NLEM PROPOSED	1.9426 2.6392 0.3862	10.3737 0.2166 0.0617
10.	NLM NLEM PROPOSED	2.1223 2.5364 0.1033	11.1419 1.7635 1.3457

This table shows the results of applying denoising algorithm NLM and NLEM over noisy images. from these results we conclude that NLM shows better results at low level noise(20%) and NLEM shows better result over high level noise(80%) and proposed algorithm shows better result then existing techniques at both noise levels Less difference shows better results. from these results we conclude that less difference is obtained by using proposed algorithm

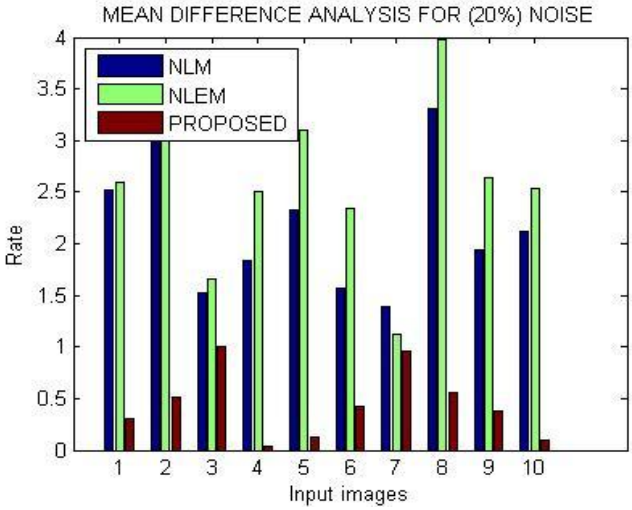

Fig 16 Analysis of MEAN DIFF (20%)

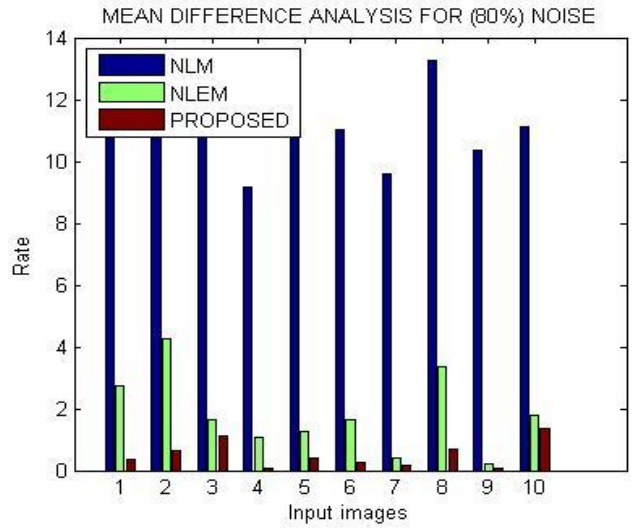

Fig 17 Analysis of MEAN DIFF (80%)

Fig 16 and fig 17 shows the graphical results of MEAN DIFFERENCE at noise level 20% and 80%.from these results we conclude that NLEM perform better then NLM at high level noise in order to obtain a noise free image and proposed algorithm shows better result then existing techniques at both noise levels Less difference shows better results. from these results we conclude that less difference is obtained by using proposed algorithm

5. BIT ERROR RATE

In order to achieve better result Bit error rate need to be minimized. NLM have low bit error rate at low level noise and NLEM have low bit error rate at high level noise and proposed algorithm have low bit level at both noise levels.

Table 5: Bit Error Rate

Image		20%	80%
1.	NLM	0.0370	0.0531
	NLEM	0.0406	0.0482 0.0473
	PROPOSED	0.0358	
2.	NLM	0.0369	0.0560 0.0507
	NLEM	0.0403	0.0503
	PROPOSED	0.0348	
3.	NLM	0.0384	0.0552
	NLEM	0.0402	0.0494
	PROPOSED	0.0379	0.0482
4.	NLM	0.0385	0.0535
	NLEM	0.0418	0.0492 0.0485
	PROPOSED	0.0376	
5.	NLM	0.0366	0.0544
	NLEM	0.0391	0.0464 0.0457
	PROPOSED	0.0354	
6.	NLM	0.0402	0.0561
	NLEM	0.0437	0.0523 0.0518
	PROPOSED	0.0393	
7.	NLM	0.0393	0.0552
	NLEM	0.0412	0.0507
	PROPOSED	0.0379	0.0492
8.	NLM	0.0401	0.0599
	NLEM	0.0467	0.0569
	PROPOSED	0.0387	0.0568
9.	NLM	0.0381	0.0554 0.0517
	NLEM	0.0413	0.0508
	PROPOSED	0.0366	
10.	NLM	0.0394	0.0564 0.0541
	NLEM	0.0457	0.0519
	PROPOSED	0.0380	

This table shows the results of applying denoising algorithm NLM and NLEM over noisy images. from these results we conclude that NLM shows better results at low level noise(20%) and NLEM shows better result over high level noise(80%).and proposed method shows better result over both noise levels.

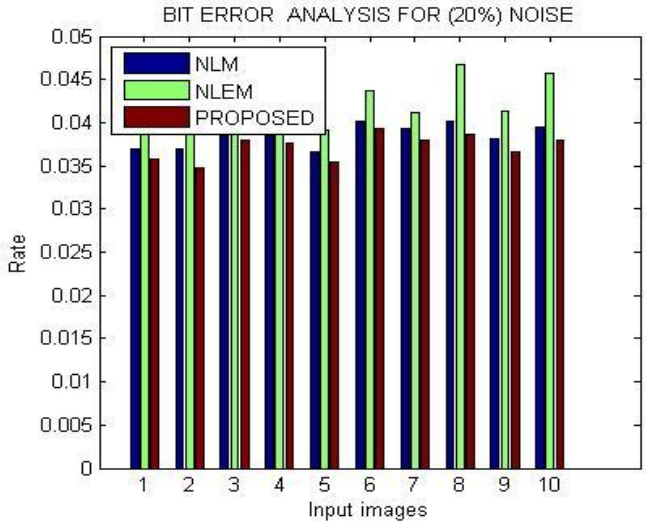

Fig 18 Analysis of Bit Error Rate (20%)

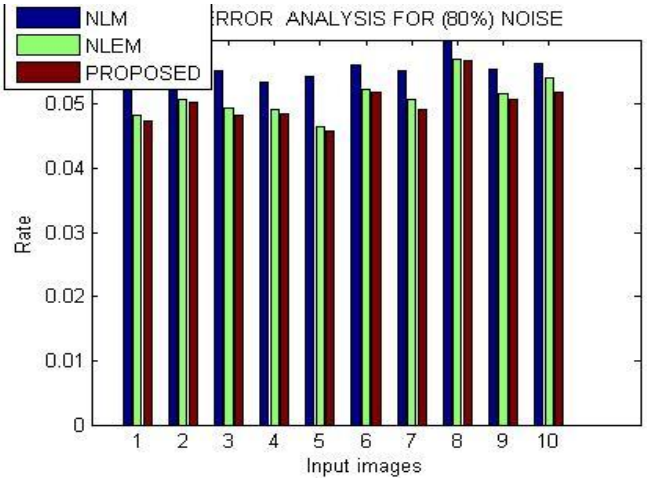

Fig 19 Analysis of Bit Error Rate (80%)

Fig 18 and fig 19 shows the graphical results of BIT ERROR RATE at noise level 20% and 80%.from these results we conclude that NLEM perform better then NLM at high level noise in order to obtain a noise free image. and proposed algorithm shows better result then existing techniques at both noise levels Less error shows better results. from these results we conclude that less error is obtained by using proposed algorithm

VII. CONCLUSION AND FUTURE WORK

In this paper different denoising techniques are discussed. These techniques have been designed and implemented in MATLAB using image processing toolbox. Different kind of the images has been taken for experimental purpose. This study shows that NLEM perform better at high noise level (80) and NLM perform better result at low level noise(20). From this we conclude that out of these denoising techniques NLM perform well for low level noise and NLEM perform well for high level noise. But the main limitation of NLM and NLEM is that NLM work only for low noise level and NLEM works only for large noise level [15][16]therefore both are not suitable for every kind of noise level.. Also both techniques does not focus on preserving the edges so to overcome this issue a method is proposed that work at both noise levels and after analysing the performance of these algorithms we conclude that proposed technique perform better at all noise levels. we use the concept of image gradients as a post processing operation to preserve the edges in an efficient manner. In near future proposed method will be extended by using fuzzy set theory to find the best alternative for the noisy pixels.

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