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GRAY SCALE IMAGE NOISE DETECTION AND CORRECTION USING LINEAR REGRESSION ANALYSIS

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ABSTRACT

Noise is major limiting factor in digital images, due to noise quality of image is degrade. According to the effect of noise and pattern of noise the noises are categorized in different types. For improving quality of image filtering techniques are used. There are various filtering technique are reported in last few years. In this presented work the impulse noise and their effect in image is measured. In addition of that the recent contributions on the image filters for impulse noise detection and correction is also investigated. After evaluation of de-noising techniques an improved impulse noise filter is proposed. The proposed image filtering technique detects and removes impulse noise from digital grey-scale images. During impulse noise the image pixels are corrupted therefore to distinguish between corrupted and uncorrupted pixels the proposed technique incorporates regression analysis. After differentiation of corrupted pixel, these pixels are processed by calculating average value of itself and two neighbouring pixels which are uncorrupted. Corrupted pixels are not properly removed in single processing therefore in iterative manner the noise is removed from image. This processing can damage the image edges therefore in order to preserve the image edges L0 smoothing is employed with each iteration. Finally for removing the remaining noise effect a median filter is applied over the image. The implementation of the desired technique is performed using MATLAB simulation

environment. Result of the proposed technique measure in term of visual quality, histogram and PSNR (pick signal to noise ratio). The proposed technique demonstrates the effectiveness with respect to the previously available technique.[1,2] The proposed method is adoptable due to their less memory and time consumption.

KEYWORDS: *Image de-noise, Gray-scale, impulse noise, comparative study, performance analysis.*

INTRODUCTION

Image is a set of pixels defined in terms of a 2D vector. This 2D vector contains real world knowledge in form of colour distributions and pixel combination values. In order to refine the contents of this information image processing is performed on the image data. Image processing is a classical domain of image data manipulation and enhancement. Due to diversity of information storage and lightning effect the researchers and developers are attracted in this domain. There are huge contributions are available for enhancing the quality of images. For that purpose various kind of image processing techniques are developed in recent years. In this proposed work image processing based image filtering techniques are evaluated and issues and challenges over image filters are addressed. In addition of that for resolving these issues a new concept in image processing and image data correction is placed in this work.

In order to design efficient and effective filters there are some simples steps to follow. The raw image is accepted as input and then the noise is measured, this measurement shows the composition of noise in the input noisy image. Basically the noise corrupts image pixels, therefore in this phase the corrupted pixels and uncorrupted pixels are separated. In next step using the mathematical model and concepts the corrupted pixels are replaced with newly calculated pixel values.

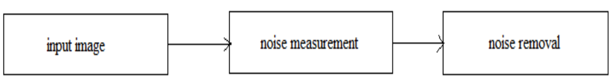

Figure 1: basic filter.

The proposed technique is also a two-step process for filtering the noise effect, in addition of that for improving the image quality additional smoothing filters are also employed with the target image. The entire image filtering and quality improvement technique is discussed in detail in further section.

PROPOSED WORK

In order to implementing the efficient image filtering algorithm a set of subsystems are required. Thus proposed system consists of different components in order to implementing the proposed image de-noising systems. These sub components are described in this section.

Input image: that is an input interface which accepts the grey scaled images, the grey scaled image is created using the manipulating the coloured image pixels. For that purposed the below given formula can be helpful for conversion.

$$grey\ pixel = \frac{R + G + B}{3}$$

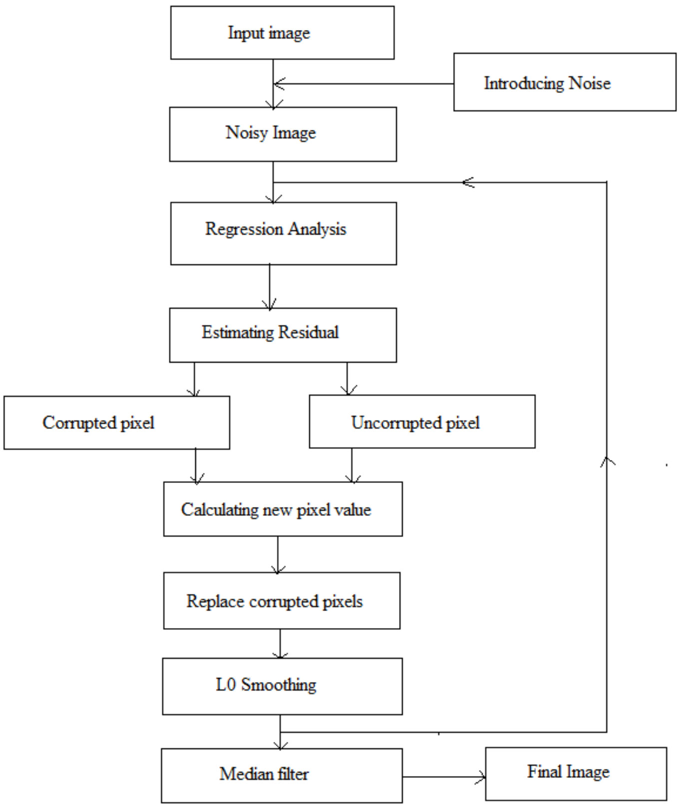

Figure 2: Process flow.

Introducing noise: that is additional provision for introducing noise into digital image for demonstration of filtering effectiveness. Therefore the impulse noise is introduced using this subsystem.

Noisy image: after composing the noise with the input image the image becomes noisy, the noisy image is represented separately for improving their quality.

Regression analysis: regression analysis is a statistical method of for finding the relationship between the input data. In linear analysis the data is modelled using linear predicator function and known model is estimated from the data. The key advantage of working with the regression analysis is that, it allows additional inputs and outputs relevant to statistical analysis. By implementation of the using the MATLAB the regression analysis returns a vectored output.
[betahat, Ibeta, res, Ires, stats]

Where,

- Betahat: betahat is the least-squares estimator. It is unbiased, with expected value β. In addition of that it has minimum variance among all unbiased estimators created using linear combinations of response data. In general terms betahat is a maximum likelihood estimator.
- Ibeta: That is a p-by-2 matrix of 95% confidence intervals for the coefficient estimates, using a 100*(1-alpha) % confidence level. The first column contains lower confidence bounds for each of the p coefficient estimates; the second column contains upper confidence bounds.
- Res: An n-by-1 vector of residuals.
- Ires: That is n-by-2 matrix of intervals that can be used to diagnose outliers. If the interval Ires (i, :) for observation i does not contain zero, the corresponding residual is larger than expected in 100*(1-alpha) % of new observations, suggesting an outlier.
- Stats: It is 1-by-4 vector that contains, in order, the R2 statistic, the F statistic and its p value, and an estimate of the error variance. The statistics are computed assuming the model contains a constant term, and are incorrect otherwise.

Estimating residual: Using the previous steps outcome the two parameters are used for estimating the outliers from the input pixel values. That can be performed using rcoplot function defined in MATLAB.

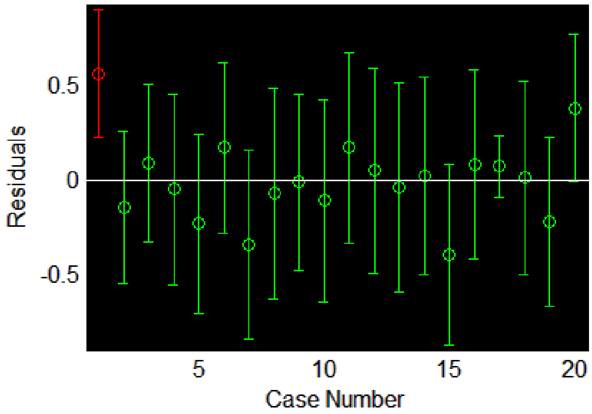

Figure 3: Outlier Detection.

According to the above given figure the red line shows the higher error than defined confidence interval. Therefore that is an error among the available data. That is desired to fix during processing of the digital image. Using the multiple linear regression analysis the outlier points or corrupted and uncorrupted pixels are located first.

Calculating new pixel value: using the neighbour pixel values (those are uncorrupted) of the corrupted pixels new pixel value for replacing the corrupted pixel is estimated. The estimated pixel value is a mean value of the corrupted pixel and their uncorrupted neighbour pixel.

Replace corrupted pixel: the calculated new pixel value is assigned to the corrupted pixel value for creating a new and enhanced image.

L0 smoothing: L0 smoothing is a gradient minimization technique for smoothing edges.[28] This technique used to preserve the edges of the input image, during the noise removal the edge pixels are also treated according to the decisions of regression analysis, therefore the edge pixels are also altered during the process of filtering thus, required preserving noisy image edges during filtering process that may help to enhance the image quality.

Median filter: the above given processes are repeated according to the density of image noise, to remove impulse noise from image. This process able to remove the entire noise from input image, but in order to insure the quality of image the median filter is employed for removal of remaining noise from image.

Final image: that is final phase of impulse noise removal, which recreate the original image after removing all the noise from image and enhances the quality of image.

This section provides the overview of the entire process of the image filtering technique, in the next section summarized step of the algorithm is provided.

Proposed Algorithm

This section provides the steps of the proposed algorithms steps, which described the input and output of the systems using the processing, involved in the proposed algorithm.

Table 1: Proposed Algorithm.

Input : noisy image I, number of iterations ni
Output: filtered image I’

Process:
1. [m n]= sizeof(I);
2. P=zeros(sizeof(I));
3. For k=1 to ni
a. For i=0 to n
i. $[\beta_0, \beta_1, R, R_i, stat] = regress(D)$; //where R is linear and R_i is 2D array
ii. Recoplot(R, R_i); // shows the outlier points
iii. For i=0 to m
1. If $R_{i,1} \le 0\ and\ R_{i,2} \le 0$
a. $p_{i,j} = \frac{p_i+p_{i-1}+p_{i-2}}{3}$
2. Else if $R_{i,1} \ge 0\ and\ R_{i,2} \ge 0$
a. $p_{i,j} = \frac{p_i+p_{i-1}+p_{i-2}}{3}$
3. Else
a. $p_{i,j} = I$
4. End if
iv. End for
b. I’= L0smooth(P)
c. I’=midfilter(I’, 3,3)
d. I=I’
e. End for
4. End for

4.1 Implementation overview

There are various methods and techniques are available for impulse noise removal from the image. Among them a new model for impulse noise is designed in previous chapter. In order to justify the proposed solution’s effectiveness a comparative analysis is desired to perform with traditionally available de-noising model. Therefore the below given simulation architecture is suggested for implementation and comparative analysis.

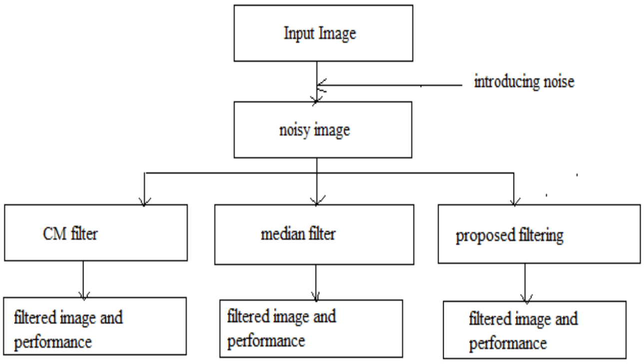

Figure 4: Proposed simulation model.

The simulation architecture of the presented work is given using figure 4, in this model first a input image is provided to the simulation system. The input image must be in the grey scale image format. In order to simulate the noise and their effect the additional noise is added to the input image. The noisy image is then filtered using the median filter based method as given in,[27] CM (cloud model) based filter.[21] and the proposed image filtering scheme. After de-noising of image the performance of all the algorithms are evaluated in terms of PSNR (peak signal to noise ratio) and MSE (mean squire error). This section provides the simulation architecture of presented de-noising technique. In next section simulation environment is learned.

RESULTS ANALYSIS

In this chapter obtained results are presented for justifying the proposed solution. In order to simulate the effect of proposed impulse noise removal technique the results are evaluated in terms of visual quality, histogram and PSNR (peak signal noise ratio). Additionally a comparative study is given with respect to the available Fuzzy Logic based Adaptive Median Filter and CM Filter.

A. PSNR (Peak signal to noise ratio)

The PSNR measures the peak signal-to-noise ratio between two images. This ratio is often used as a quality measurement between the original and a compressed image. Higher the PSNR means better the quality of the compressed or reconstructed image. The PSNR value can be calculated as:

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

B. Result of the proposed Technique

This section demonstrates the evaluation of performance parameters of the proposed filtering Techniques.

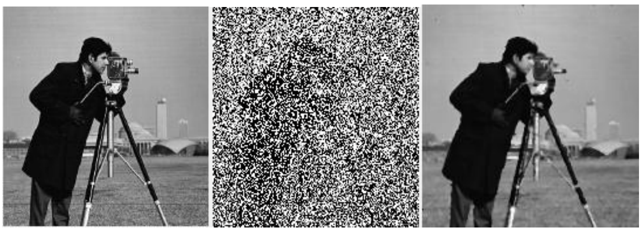

Figure (a) Figure (b) Figure (c)

Figure 5(a): Original Gray-scale Cameraman image. Figure 5 (b) Cameraman image corrupted by 60% impulse noise. Figure 5 (c) represents output of the proposed algorithm.

For an input image as given figure 5 (a) after composing the noise of 60% the outcomes of the noisy image is given using figure 5 (b). And after processing of image the filter is able to produce the image given in figure 5 (c) the quality of can also be estimated using their histogram as given figure 5.

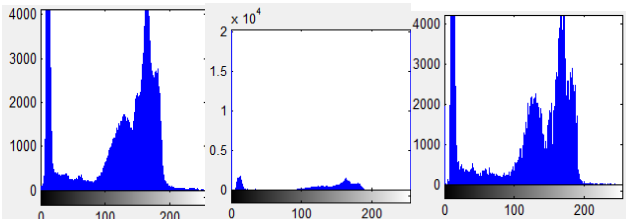

Figure (a) Figure (b) Figure (c)

Figure 6: (a) Histogram of original gray-scale Cameraman image. Figure 6 (b) Histogram of Cameraman images corrupted by 60% impulse noise. Figure 6 (c) represents Histogram of de-noised image.

The histogram plot of figure 5 (a) is given using figure 6 (a) that shows, after introducing the 60% of noise the figure 6 (b) shows their histogram plot, and after the recovery of image the histogram of filtered image is given using figure 6 (c). That represents the approximately similar quality of image as given in figure 6 (a). In addition of that the PSNR values of the recovered images with different number of iterations and different noise compositions are given using table 2.

Table 2: Estimated PSNR of proposed algorithm.

		Noise density						
Iteration	**Images**	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**
1	Lena	50.9	50.2	49.0	46.7	43.6	39.1	35.3
	Baboon	50.9	50.1	49.2	46.7	43.8	39.1	35.1
	Cameraman	50.9	50.0	49.0	46.9	43.6	39.6	35.7
2	Lena	50.8	50.3	49.0	47.7	46.5	43.6	39.1
	Baboon	50.8	50.0	49.2	47.6	46.7	43.7	39.1
	Cameraman	50.8	49.9	49.0	47.8	46.3	39.6	35.7
3	Lena	50.7	49.7	48.8	47.8	46.7	45.4	41.7
	Baboon	50.7	49.9	49.0	47.5	47.0	45.1	41.6
	Cameraman	50.6	49.6	48.7	47.8	46.7	45.5	42.0
4	Lena	50.6	49.3	48.6	47.7	46.7	45.7	43.3
	Baboon	50.6	49.7	48.8	47.5	47.0	45.5	43.1
	Cameraman	50.5	49.5	48.5	47.8	46.7	45.8	43.3
5	Lena	50.5	49.1	48.5	47.7	46.7	45.7	44.1
	Baboon	50.5	49.6	48.6	47.4	46.9	45.6	43.8
	Cameraman	50.4	49.3	48.3	47.7	46.7	45.9	44,0
6	Lena	50.4	48.9	48.3	47.6	46.6	45.7	44.4
	Baboon	50.4	49.4	48.5	47.3	46.9	45.6	44.1
	cameraman	50.2	49.0	48.1	47.6	46.1	46.0	44.3
7	Lena	50.0	48.6	48.2	47.5	46.5	45.6	44.6
	Baboon	50.1	49.1	48.2	47.2	46.8	45.5	44.2
	cameraman	48.7	48.7	48.0	47.4	46.6	45.9	44.3
8	Lena	48.4	48.1	47.8	47.1	46.3	45.4	44.6
	Baboon	48.4	48.2	47.5	46.6	46.2	45.2	44.1
	cameraman	48.6	47.9	47.5	46.9	46.1	45.6	44.2

C. Fuzzy Logic Based Adaptive Noise Filter

This section describes the fuzzy logic based adoptive filter’s performance, therefore first the visual quality of image is provided using figure 7, where first input image is given using figure 7 (a) and their corresponding histogram is given using figure 8 (a). after that the image is composed with 60% of noise which is demonstrated using figure 7 (b) and their corresponding histogram plot is given using figure 8 (b). finally after applying the fuzzy logic filter the obtained filtered image is given using figure 7 (c) and their respective histogram plot is given using figure 8 (c).

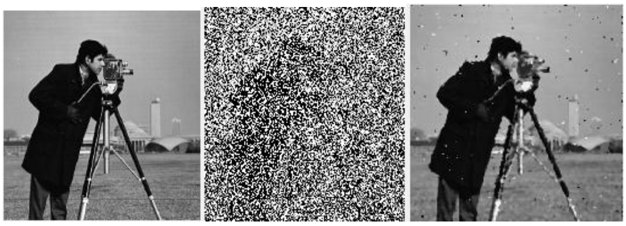

Figure (a) Figure (b) Figure (c)

Figure 7 (a) original gray-scale Cameraman image. Figure 7 (b) Cameraman image corrupted by 60% impulse noise. Figure 7 (c) represents output of the Fuzzy Logic Based Adaptive Noise Filter.

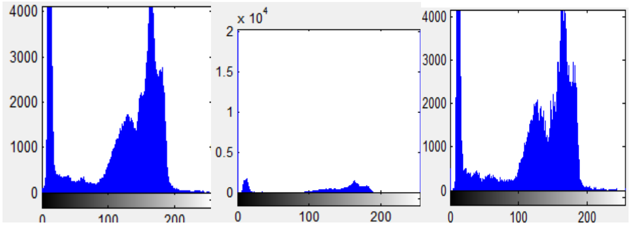

Figure (a) Figure (b) Figure (c)

Figure 8: (a) Histogram of original Gray-scale Cameraman image. Figure 8 (b) Histogram of Cameraman image corrupted by 60% impulse noise. Figure 8 (c) represents Histogram of de-noised image.

After evaluating the filters performance using their visuals and their histogram plots the performance of the fuzzy logic based impulse noise filter. The PSNR value for given filter is evaluated with different noise composed Gray scale images are given using table 3.

Table 3: Evaluated PSNR of fuzzy filter.

		Noise Density						
Methods	**Images**	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**
Fuzzy Logic Based Adaptive Noise Filter	Lena	34.1	34.1	34.1	34.0	33.8	33.6	32.4
	Baboon	30.6	30.6	30.6	30.5	30.5	30.3	29.8
	Cameraman	35.3	35.2	35.2	35.1	34.9	34.5	33.2

D. Result of the CM Filter

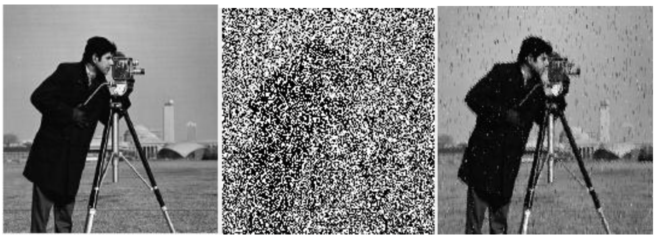

Figure (a) Figure (b) Figure (c)

Figure 9: (a) original gray-scale Cameraman image. Figure 9 (b) Cameraman image corrupted by 60% impulse noise. Figure 9 (c) represents output of the Cloud Model Filter.

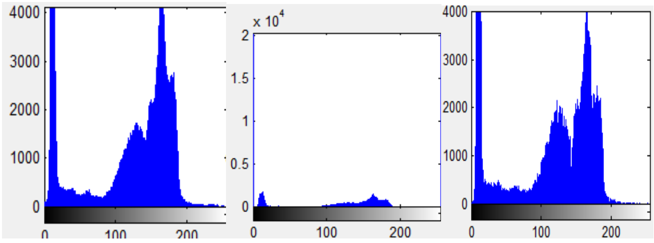

Figure (a) Figure (b) Figure (c)

Figure 10: (a) Histogram of original gray-scale Cameraman image. Figure 10 (b) Histogram of Cameraman image corrupted by 60% impulse noise. Figure 10 (c) represents Histogram of de-noised image.

The cloud model claims to remove 80% noise from the impulse noise, there evaluated performance with the 60% noise composition is given in this section. The input image and their histogram is given using figure 9 (a) and 10 (a). After including the impulse noise of 60% the image is given using figure 9 (b) and their corresponding histogram is plotted in figure 10 (6). Finally after removing the impulse noise from image the restored image is given by 9 (c) and their histogram analysis is given using figure 10 (c).

In addition of that for image quality assessment after enhancing the image is given using PSNR values. The obtained PSNR values with different noise levels are given in table 4.

Table 4: CM filter PSNR.

		Noise Density						
Methods	**Images**	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**
CM Filter	Lena	28.40	227.81	26.6	24.5	21.9	19.1	16.6
	Baboon	24.08	23.7	23.0	21.8	20.1	18.1	16.8
	Cameraman	26.94	26.4	25.3	23.6	21.2	18.4	15.7

E. Comparative Performances

The comparative performance of all three filters with increasing amount of noise is given in figure 11. According to the figure proposed technique provides good quality of restored images as compared to the Fuzzy Logic Based Adaptive Noise Filter and CM filter. The given comparison of performance is given in term of PSNR values. In this given diagram the performance of the CM filter is demonstrated using blue line which shows the least PSNR value as compared to other two filters. Additionally the performance of fuzzy logic based adoptive filter is given using red line which shows effective results as compared to the cloud model based impulse noise filter and shows less effectiveness as compared to the proposed filtering technique. The proposed impulse noise filtering technique's PSNR values are provided using green line which shows the higher PSNR values as compared to both traditionally found filters. In this diagram for simulating performance the different noise levels in image is given using X axis and their respective PSNR values are given in Y axis of graph.

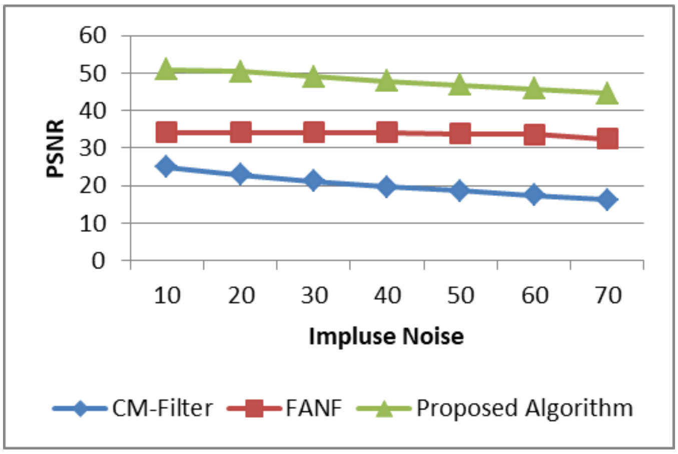

Figure 11: Comparative PSNR.

The obtained result of the proposed technique, Fuzzy Logic Based Adaptive Noise Filter and CM Filter is provided. The evaluation of given filters are performed in term of visual quality, histogram and PSNR (peak signal to noise ratio). The experimentation of presented techniques is performed on different noise levels of gray- scale images. Fuzzy Logic Based Adaptive Noise Filter is able to remove impulse noise up to 40% of noise composition, when composition or density of noise is higher than 40% than some noise candidates are remain. On the other hand CM (cloud model) Filter is good for removal of higher percentage of noise but when image size is large then requires time for process the noisy image is also larger. Additionally that can affect the edges of input image. The proposed technique provides good result even in higher percentage of noise up to 70% is introduced in input image. This technique also able to preserving edges and sharpness. The result of the proposed technique calculated in term of PSNR values in different iteration. Finally comparative result with other two techniques is reported; according to the result proposed technique provides higher quality of images as compared to traditional approaches.

CONCLUSIONS

This section draws the conclusion of the performed investigation and new algorithm development. The observed facts and advantages of the proposed system is given in this chapter. In addition of that the based on the limitations future extension of the proposed technique is also listed in this chapter.

A. CONCLUSION

Image is an organization of pixel values which consists the real world information. Using the different compositions and variations of these pixel values the real world objects are represented. This information source is produced using the digital cameras and sensors. During the capturing of images that can be affected by the impact of light source, sensors disturbance and transmission media, thus the actual composition of pixels are also affected. This phenomenon is known as noise in digital images. According to the effect of noise the image is manipulated in different ways and according to their effects that can be categorized in different types of noise. In order to remove the noise from the captured images different noise filters are prepared. Thus according to these noisy patterns their filters are also different in effect.

In this presented study the impulse noise and their effect on digital images are investigated. In addition of that its de-noising techniques are evaluated for finding the optimum filter design for impulse noise affected images. Therefore a number of different image filtering techniques are explored and after evaluation of different research articles and papers two more promising techniques are found in Ruxian Wang et al.[29] and Zhe Zhou.[21] These techniques are efficient and effective techniques of impulse noise removal. But some of deficiencies are found in these techniques, therefore a new de-noising technique is proposed in this work. The proposed filter design includes the regression analysis for differentiating the corrupted and uncorrupted image pixels. Than after using uncorrupted neighbour pixels the corrupted pixels are replaced. This process is performed in iterative manner for removing the noise. On the other hand the processing of corrupted pixels can damage the edges of image thus a L0 gradient minimization technique is employed for preserving and smoothing the edges of image. Finally for removing the remaining noises and assuring the removal of noise from image the median filter is applied at the end of filtering process.

The implementation of the proposed de-noising technique is reported using MATLAB environment. That is a mathematical simulation environment which provides the tools and techniques for implementing and demonstrating the mathematical models efficiently. The performance and comparative study of the proposed technique for impulse noise removal technique is given using visual quality analysis, histogram analysis and the PSNR values. According to the simulated performance the proposed filtering technique is efficient and effective for higher level of noise reduction.

B. Future Work

The noise is major limiting factor of digital images. Therefore a number of filtering techniques are designed in recent years for improving the image quality. In this presented work a de-noising technique is designed and implemented for removing impulse noise from digital images which is an effective and efficient technique as compared to the recently found techniques in,[21] and.[29] In near future, the presented work is extended for developing more efficient technique that consumes less amount of time and less number of iterations during noise removal. In addition of that, it is desired to implement for other noise detection and removal technique.

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