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Improved Gradients & Global Mean Based Switching Median Filter

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Abstract

Noise in images has become one of the significant concerns in digital image processing. Many digital image based techniques produce inaccurate results when noise is presented in the digital images. So much researchers has proposed new and modified techniques so far to reduce or remove noise from images. Different kind of enhancement in the filters has been proposed so far. But most of filters put artefacts while doing their work. Many filters fails when noise density in the images is very high. Some filters results in over smoothed image i.e. poor for edges. This paper has proposed a new improved global mean based switching median filter which has the capability to decrease the high density of the noise from images and also outperforms over others when input image is noise free. The proposed method has also ability to preserves the edges by using the gradient based smoothing. The proposed technique has been designed and implemented in MATLAB tool using image processing toolbox. Different kind of the digital images has been taken for experimental purpose. Comparative analysis has shown that the proposed algorithm is quite effective over the available techniques.

Indexing terms/Keywords

Salt and pepper noise, Median filter, Smoothing and Sharpening.

1. Introduction

In image processing, noise reduction and restoration of image is expected to improve the qualitative inspection of an image and the performance criteria of quantitative image analysis techniques. Digital image is inclined to a variety of noise which affects the quality of image. The main purpose of de-noising the image is to restore the detail of original image as much as possible. 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 types of linear and non linear filtering techniques have been proposed. Different approaches for reduction of noise and image enhancement [1] have been considered, each of which has their own limitation and advantages. Image de-noising is a vital image processing task i. e. as a process itself as well as a component in other processes. There are many ways to de-noise an image or a set of data and methods exists. The important property of a good image de-noising model is that it should completely remove noise as far as possible as well as preserve edges. Traditionally, there are two types of models i. e. linear model and non-liner model. Generally, linear models are used. The benefits of linear noise removing models is the speed and the limitations of the linear models is, the models are not able to preserve edges of the images in a efficient manner i.e. the edges, which are recognized as discontinuities in the image, are smeared out. On the other hand, Non-linear models [2] can handle edges in a much better way than linear models. This paper has proposed a new approach which will use decision tree kind of structure to replace the noisy pixel in given window. The proposed technique seems to be effective as it will replace the noisy pixel with its best suitable alternative. Proposed method is divided into two parts: (1) Algorithm will evaluate the center pixel's value i.e. whether or not it is equal to 0 or 255 if yes then we will go to find the alternative noise free value for the same else window will switched further. (2) This part will find the neighborhood pixels of the center value and see whether all are having 0 or 255 as its value or not. If no then median will be evaluated

and replaced with center value and window will switched further else we will use decision tree to evaluate the value by taking the global mean and recently evaluated mean to replace the same. Global mean will be replaced when no median is found recently.

2. Related work

A [1] new algorithm Modified Decision Based Unsymmetric Trimmed Median Filter (MDBUTMF) which gives better performance in comparison with existing noise removal algorithms in terms of PSNR and MSE. Even at high noise density levels the MDBUTMF gives better results in comparison with other existing algorithms. A novel Sorted Switching Median Filter (SSMF) [2] can effectively denoising extremely corrupted images while preserving the image details. The center pixel is considered as ''uncorrupted'' or ''corrupted'' noise in the detecting stage. The corrupted pixels that possess more noise-free surroundings will have higher processing priority in the SSMF sorting and filtering stages to rescue the heavily noisy neighbors. Enhancement of a noisy image [3] is necessary task in digital image processing. Filters are used best for removing noise from the images. Filters techniques [3] are divided into two parts linear and non-linear techniques. After studying linear and non-linear filter each of have limitations and advantages. In the hybrid filtering schemes, there are two or more filters are recommended to filter a corrupted location. The decision to apply a particular filter is based on the different noise level at the different test pixel location or performance of the filter scheme on a filtering mask. Adaptive Two-Stage Median Filter (ATSM) [4] is used to denoise the images corrupted by fixed-value impulse noise. ATSM is proved to be better in terms of Peak Signal-to-Noise Ratio and human visual perception. This filter is effectual in denoising the highly corrupted image. **N**ew method [5] has used the concept of substitution of noisy pixels by linear prediction prior to estimation. A novel simplified linear predictor is developed for this purpose. The objective of the scheme and algorithm is the removal of high-density salt and pepper noise in images. A novel switching median filter [6] incorporating with a powerful impulse noise detection method can be used for effectively denoising extremely corrupted images. To determine whether the current pixel is corrupted, the algorithm first classifies the pixels of a localized window, centering on the current pixel, into three groups-lower intensity impulse noise, uncorrupted pixels, and higher intensity impulse noise. The adaptive median filter algorithm [7] is achieved by detecting the pollution level of the image, ascertaining the specific location of the noise and determining the size of the median filtering window adaptively. The algorithm has improved the accuracy of noise detection and the fidelity of image filtering, and has a better performance on different noise densities.**A**n improved median filtering algorithm [8] has used the correlation of the image to process the features of the filtering mask over the image. It can adaptively resize the mask according to noise levels of the mask. The statistical histogram is also introduced in the searching process of the median value. A statistical filter [9] is a modified version of Hybrid Median Filter for speckle reduction, which computes the median of the diagonal elements and maximum of the horizontal and vertical elements in a moving window and finally the two values are compared with the central pixel and the median value of the three values will be the new pixel value. The filter is tested on phantom Ultrasound image.Relaxed median filter[10] is obtained by relaxing the order statistic for pixel substitution. Noise attenuation properties as well as edge and line preservation are analyzed statistically. The trade-off between noise elimination and detail preservation is widely analyzed. It is shown that relaxed median filters preserve details better than the standard median filter, and remove noise better than other median type filters.

3. Gaps in study

The survey has shown that the most of existing researchers has neglected at least one of the following.

1. The effect of the global mean in case of all the noisy pixels in a given mask has been ignored.
2. The noisy pixels 0 or 255 are considered in the input set while calculating the median; so centre pixel may be sometimes replaced by the noisy pixel again.

Most of the existing research has also neglected the effect of the high density of the noise

3. Research Motivation

After conducting the literature survey it has been found that for the removal of noise(salt and pepper noise) from the digital images different techniques had been used and the median filter has proved best filter for the removal of impulse noise(salt and pepper noise).this filter has proved best results for low noise density but fails when the noise density is high

1. In previous research work of removal of noise placement, the technique followed was to find median of selected window and remove the noisy pixel with the median value of selected window But in this scenario problem creates when the 0median value is also noisy. So a modified median filter is used.
2. The high density of noise is also ignored in the existing techniques so an high density noise removal technique is required to enhance the results further.

So reducing the high density noise from images is the main motivation of this research work.

3. Proposed algorithm

Noise in the images also degrades the performance of the image segmentation. So removal of noise in an image is a very important task. Image denoising is an important pre-processing task before further processing of image. The purpose of denoising is to remove the noise while retaining the edges and other detailed features as much as possible. In this research work we will improve the results of the digital

images using relaxed median filter. The proposed algorithm is seems to be justifiable as proposed algorithm has ability to reduce the high density of the noise This dissertation proposes a new approach will use decision tree kind of structure to replace the noisy pixel in given window. The proposed technique seems to be effective as it will replace the noisy pixel with its best suitable alternative. Proposed method is divided into two parts:

(1) Algorithm will evaluate the centre pixel's value i.e. whether or not it is equal to 0 or 255 if yes then we will go to find the alternative noise free value for the same else window will switched further.

(2) This part will find the neighborhood pixels of the centre value and see whether all are having 0 or 255 as its value or not. If no then median will be evaluated and replaced with centre value and window will switched further else we will use decision tree to evaluate the value by taking the global mean and recently evaluated median to replace the same. Global mean will be replaced when no median is found recently.

ALGORITHM

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 [ ] 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 [ ] is an uncorrupted pixel (that is, 0< [ ] <255), then its value is not changed.

Step 4: If [ ] = 0 or 255, then [ ] is a corrupted pixel.

Step 5: If all pixels in the selected window are 0's and 255's, then replace [ ] with the median of the pixels in the window else go to step 6.

Step 6: Replace [ ] with the global mean.

Step 7: Repeat steps 2-6 until all the pixels of whole image are processed.

Step 8: Apply gradient based smoothing to preserves edges in more efficient manner.

6. Experimental Results

This section contains the results of experimental results. The overall section contains the ground truth image, noisy image of the same and the result of various filtering techniques.

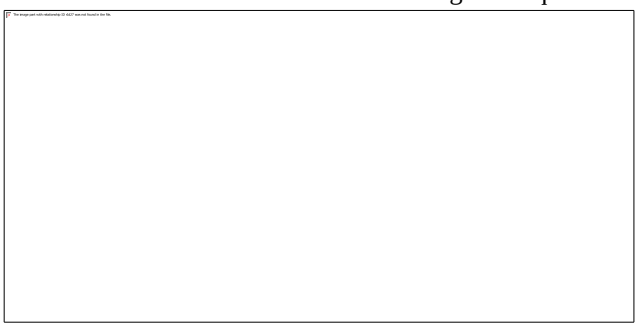
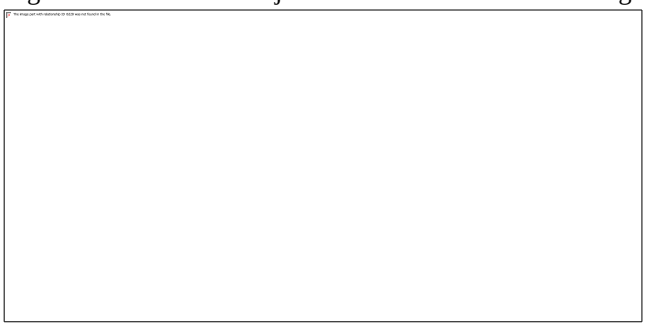


Fig.1 The input image

Figure 1 has shown the input image without any noise also called the ground truth image. It has been clearly shown that the no noise exists in this image.

Figure 2 has shown the noisy image with density =.7. It is clearly shown that the noise has degrades the visibility of the image a lot. Most of the objects are even hidden in this image.



0Fig.2 The noisy image

Figure 3 has shown the filtered image using the traditional median filtered image. It is clearly shown that the image is somehow filtered but has not shown the accurate results as in the input image shown in figure 3.

Fig. 3 Traditional median filtered image

Figure 4 has shown that the results are quite effective and has much more better results than the traditional median filter. Thus the switching median filter has shown quite significant

improvement over the available methods. But still some noise is there.

Fig. 4 switching median filtered image

Figure 5 has shown that the results are quite effective and has much more better results than the traditional filtering techniques. Thus the proposed global mean based switching median filter has shown quite significant improvement over the available methods. Results are almost equal to the ground truth image.

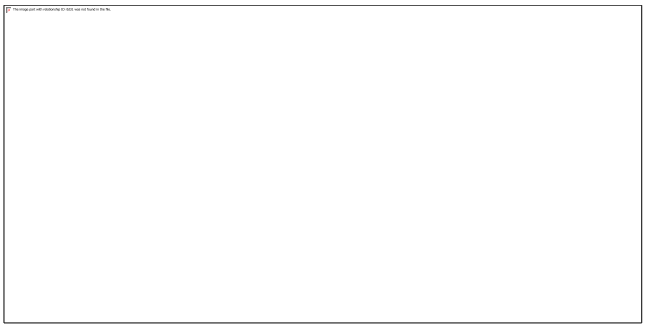


Fig. 5 Proposed filtered image

7. Performance analysis

This section shows the results between existing and proposed techniques. Some well-known image performance parameters for digital images have been selected to prove that the performance of the proposed algorithm is quite better than the existing methods.

Table 1 has shown the quantized analysis of the mean square error. As mean square error need to be reduced therefore the proposed algorithm is showing the better results than the available methods as mean square error is less in every case.

Table 1 MSE analysis

MSE EVALUTION FOR DIFFERENT FILTERS AT NOISE DENSITY 0.8				
IMAGE	NOISY IMAGE	MEDIAN FILTER	SSMF	GMF
1	15523	10480	695	521
2	17543	11867	445	324
3	17702	11844	479	339
4	16088	10587	779	665
5	15753	10479	1277	1093
6	17619	11959	689	440
7	16803	11348	850	723

Table 2 PSNR analysis at the different Images

PSNR EVALUTION FOR DIFFERENT FILTERS AT NOISE DENSITY 0.8				
IMAGE	NOISY IMAGE	MEDIAN FILTER	SSMF	GMF
1	6.2210	7.9272	19.7110	19.8636
2	5.6898	7.3874	21.6472	22.4021
3	5.6506	7.3958	21.3274	21.7062
4	6.0658	7.8831	779	665
5	6.1572	7.9276	17.0689	17.3644
6	5.6710	7.3539	19.7486	20.8069
7	5.8769	7.5816	18.8366	18.9768

Table 2 is showing the comparative analysis of the Peak Signal to Noise Ratio (PSNR). As PSNR need to be maximized; so the main goal is to increase the PSNR as much as possible. Table 2 has clearly shown that the PSNR is maximum in the case of the proposed algorithm therefore proposed algorithm is providing better results than the available methods.

Table 3 is showing the comparative analysis of the Root Mean Square Error (RMSE). As RMSE need to be minimized; so the main goal is to decrease the RMSE as much as possible. Table 3 has clearly shown that the RMSE is minimum in the case of the proposed algorithm therefore proposed algorithm is providing better results than the available methods.

Table 3 RMSE analysis for different images

RMSE EVALUTION FOR DIFFERENT FILTERS AT NOISE DENSITY 0.8				
IMAGE	NOISY IMAGE	MEDIAN FILTER	SSMF	GMF
1	124.5913	102.3719	26.3629	25.9037
2	132.4500	108.9358	21.0950	19.3391
3	133.0489	108.8301	21.8861	20.9523
4	126.8385	102.8931	28.2666	27.6586
5	125.5110	102.3670	35.7351	34.5398
6	132.7366	109.3572	26.2488	23.2379
7	129.6264	106.5270	29.1548	27.6880

Table 4 is showing the comparative analysis of the BIT ERROR RATE (BER). As BER need to be minimized; so the main goal is to decrease the BER as much as possible. Table 3 has clearly shown that the BER is minimum in the case of the proposed algorithm therefore proposed algorithm is providing better results than the available methods.

Table 4. BER analysis for different images

BER EVALUTION FOR DIFFERENT FILTERS AT NOISE DENSITY 0.8				
IMAGE	NOISY IMAGE	MEDIAN FILTER	SSMF	GMF
1	0.1607	0.1261	0.0507	0.0403
2	0.1758	0.1354	0.0462	0.0346
3	0.1770	0.1352	0.0469	0.0361
4	0.1649	0.1269	0.0523	0.0418
5	0.1624	0.1261	0.0286	0.0576
6	0.1763	0.1360	0.0506	0.0481
7	0.1702	0.1319	0.0531	0.0427

Table 5 is showing the comparative analysis of the Mean Difference (MD). As MD need to be minimized; so the main goal is to decrease the MD as much as possible. Table 5 has clearly shown that the MD is minimum in the case of the proposed algorithm therefore proposed algorithm is providing better results than the available methods.

Table 5 MEAN DIFF analysis for different images

MEAN DIFF EVALUTION FOR DIFFERENT FILTERS AT NOISE DENSITY 0.8				
IMAGE	NOISY IMAGE	MEDIAN FILTER	SSMF	GMF
1	2.7962	2.7730	0.1129	0.0091
2	46.6043	29.0833	1.9301	1.6451
3	18.7140	13.4709	0.2926	0.0385
4	22.6774	11.8253	2.9340	2.6349
5	23.1960	13.6906	1.7390	1.0468
6	36.3208	23.4670	2.0362	1.4074
7	29.2246	19.3710	0.6711	0.5144

Figure 6 has shown the quantized analysis of the mean square error. As mean square error need to be reduced therefore the proposed algorithm is showing the better results than the available methods as mean square error is less in every case.

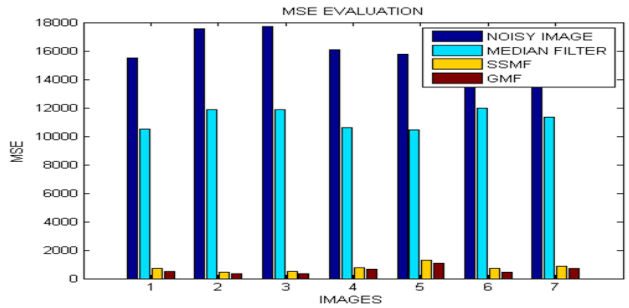


Figure 6 Analysis of the mean square error

Figure 7 is showing the comparative analysis of the Peak Signal to Noise Ratio (PSNR). As PSNR need to be maximized; so the main goal is to increase the PSNR as much as possible. Figure 7 has clearly shown that the PSNR is maximum in the case of the proposed algorithm therefore proposed algorithm is providing better results than the available methods.

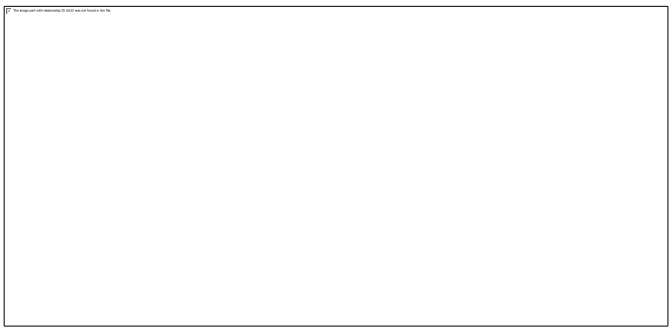


Figure 7 Analysis of the Peak signal to noise ratio

Figure 8 is showing the comparative analysis of the Root Mean Square Error (RMSE). As RMSE need to be minimized; so the main goal is to decrease the RMSE as much as possible. Figure 8 has clearly shown that the RMSE is minimum in the case of the proposed algorithm therefore proposed algorithm is providing better results than the available methods.

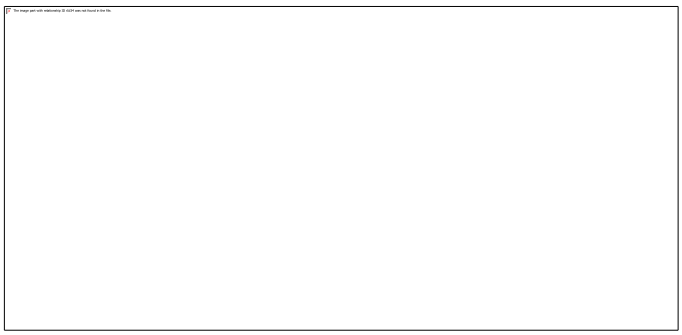


Figure 8 Comparative analysis of the Root Mean Square Error (RMSE)

Figure 9 is showing the comparative analysis of the BIT ERROR RATE (BER). As BER need to be minimized; so the main goal is to decrease the BER as much as possible. Table 3 has clearly shown that the BER is minimum in the case of the proposed algorithm therefore proposed algorithm is providing better results than the available methods.

Figure 9 Analysis of the BIT ERROR RATE (BER)

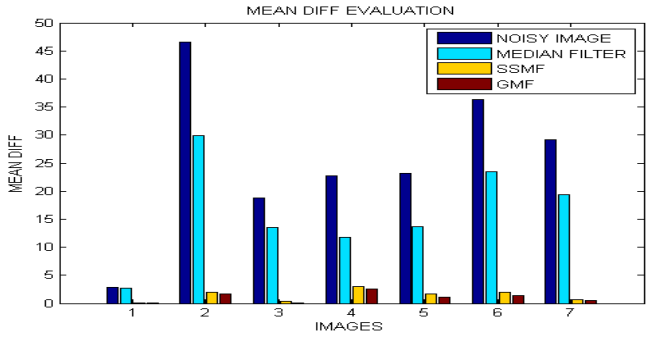


Figure 9 Analysis of the Mean Difference (MD)

Figure 10 is showing the comparative analysis of the Mean Difference (MD). As MD needs to be minimized; so the main goal is to decrease the MD as much as possible. Figure 10 has clearly shown that the MD is minimum in the case of the proposed algorithm therefore proposed algorithm is providing better results than the available method

8. Conclusion and Future work

Image filtering is the process of eliminating or reducing the noise from a noisy image with an aim to produce a filtered image that is closed to the original image i.e. the ground truth image. Noise is a eminence deprivation influence that is restrained as unsolicited/unrelated material existing in the digital image. Several median based filters have been projected for the filtering of the noisy images polluted by salt and pepper noise. The switching median filter based algorithm eliminates impulse noise even in case of high noise density and produce better results over available filters but it does not preserve edges or boundaries of the digital images. To overcome this problem a new improved global mean based switching median filter has been proposed in this paper which has the capability to decrease the high density of the noise from images and also outperforms over others when input image is noise free. The proposed method has also ability to preserves the edges by using the gradient based smoothing. The proposed technique has been designed and implemented in MATLAB tool using image processing toolbox. Different kind of the digital images has been taken for experimental purpose. Comparative analysis has shown that the proposed algorithm is quite effective over the available techniques.

In near future we will modify this technique further using fuzzy set theory to evaluate the best alternative to replace the noisy pixel value.

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