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Improved sorted switching median filter for removal of impulse noise

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Abstract— Digital image processing plays important role in our daily life. Digital Image Processing involves the modification of digital data for improving the image qualities with the aid of computer. The processing helps in maximize the clarity, sharpness of image and details of features of interest. The digital image is given as input into a computer and computer is programmed to change data with the help of various computations and then store the values of the computation for each pixel.Noise is defined as unwanted signals. The noise is removed with the help of image denoising algorithm. In this paper a filtering algorithm, improved sorted switching median filter (ISSMF) is introduced. In this algorithm two phases are included. In the first phase, the processing pixel is checked whether it is corrupted or uncorrupted. If processing pixel is uncorrupted then it remains unchanged and if processing pixel is corrupted then it is passed to second phase. In the second phase the filtering process is applied to corrupted pixel and value of corrupted pixel is replaced with the calculated median value using ISSMF.In order to preserve the edges detail, the gradient smoothing is applied. Several extensive simulation results conducted on both grayscale and color images with various density levels and ISSMF performs better than the existing median-based filters.

Keywords—Digital image, Processing pixel, Impulse noise, Denoising, ISSMF, Edge detection, Gradient, PSNR, MSE, RMSE, BER.

INTRODUCTION

With advancement in technology, the digital image processing plays important role in various areas such computational biology, digital art, education, web design, graphics design, virtual reality etc.The digital images are corrupted with the impulse noise during image acquisition, recording and transmission. The image denoising is used to remove the noise from image. Image denoising involves the manipulation of the image data to produce a visually high quality image. The major property of a superior image de-noising model is that it must completely eliminate noise as far as possible as well as preserve edges. In the improved sorted switching median filter method the processing pixel is checked whether it is corrupted or uncorrupted. If the value of processing pixel is between the minimum (0) and maximum (255) then it is treated as uncorrupted pixel. If the value of processing pixel is either minimum (0) or maximum (255) then it is treated as corrupted pixel, the value of corrupted pixel is replaced with the median value.

RELATED WORK

The noise removal is essential part of the image processing. Various methods are introduced to suppress the noise while preserving edge details. One of the most common method is median filter. It is reliable method to remove the impulse noise with preserving the edge detail, but the major disadvantage of median filter is that it operates well at lower intensity level [1]. Adaptive median filter has a variable window size for removing impulse noise while preserving sharp-ness [4].A progressive switching median filter was developed using a switching scheme and progressive method to denoise progressively through several iterations[6].A nonlinear filter, called tri-state median filter is developed for preserving image details while effectively suppressing impulsive noise. The standard median filter and the center weighted median (CWM) filter are incorporated into noise detection framework to determine whether a pixel is corrupted before applying the filtering operation [7].A novel switching median filter is developed for effectively denoising extremely corrupted images is. To determine whether the current pixel is corrupted or uncorrupted, 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[9]. A new decision-based algorithm is used for restoration of images that are highly corrupted by impulse noise. The proposed method removes only corrupted pixel by the median value or by its neighboring pixel value [10].A new method is developed which uses the concept of substitution of noisy pixels by linear prediction prior to estimation. The objective of algorithm is removal of high-density salt and pepper noise in images [11].A new algorithm is introduced to remove high-density salt and pepper noise using modified shear sorting method. The new algorithm has lower computation time when compared to other standard algorithms [12].Various hybrid filtering techniques are introduced for removal of Gaussian noise from medical images. The performance of Gaussian noise removal using hybrid filtering techniques is measured as RMSE and PSNR[14].Adaptive Two-Stage Median Filter (ATSM) is used to denoise the images corrupted by fixed-value impulse noise. In Adaptive Two-Stage Median Filter (ATSM), the corrupted pixels are checked. For each window W, if the central pixel Mij is corrupted then its intensity is estimated using the principle of ASTM.Standard 5-point formula is used for computing the median [17].A Switching Non-Local Means (SNLM) filter is presented for high-density salt and pepper noise reduction. Firstly, the impulse noises are detected, based on the fact that their values must be the extreme gray-level of the image. Then, at the filtering stage, the noise-free pixel remains unchanged and noisy pixels are restored using a modified non-local mean filter. However, to calculate the weights of the filter, only noise-free pixels are considered [20].A hybrid filtering technique is used to enhance the image. In this curvelet transformation, median filter and unsharp mask filters are collectively used to denoise the noise [21].A novel Sorted Switching Median Filter is used for 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 [22].

METHODOLOGY

In improved sorted switching median filter algorithm, the processing pixel is checked whether it is corrupted or uncorrupted. If the value of processing pixel is between the minimum (0) and maximum (255) then it is treated as uncorrupted pixel. If the value of processing pixel is either minimum (0) or maximum (255) then it is treated as corrupted pixel. The value of corrupted pixel is replaced with the median value. If all the values around the processing pixel is 0's and 255's then the value of processing pixel is replaced with the best optimized value. If some values around the processing pixel are 0's and 255's then calculate the median by trimming all 0's and 255's and replace the value of processing pixel with the calculated value. In order to preserve edge details, the gradient smoothing is applied.

PERFORMANCE PARAMETERS

The various performance parameters are available for measuring the quality of the image in terms of qualitative and quantitative measures. In this paper we will calculate the performance of the image in terms of PSNR, MSE, RMSE, BER.

PSNR (Peak Signal To Noise Ratio)

PSNR is defined as the ratio between maximum power of a signal to the power of corrupting noise. It is expressed in the form of logarithmic decibel. If the PSNR will be higher, the quality of image will be higher and is calculated as:

$$\mathrm{PSNR} = 10 \log_{10} \frac{\mathrm{L}^2}{\mathrm{MSE}}$$

MSE (Mean Square Error)

MSE is defined as mean of square of the difference of the estimated values and the observed values and is calculated as:

$$\mathrm{MSE} = \frac{1}{n} \sum_{i=1}^{n} (\hat{Y_i} - Y_i)^2.$$

BER (Bit Error Rate)

The bit error rate or bit error ratio (BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is a unit less performance measure, often expressed as a percentage.

RMSE

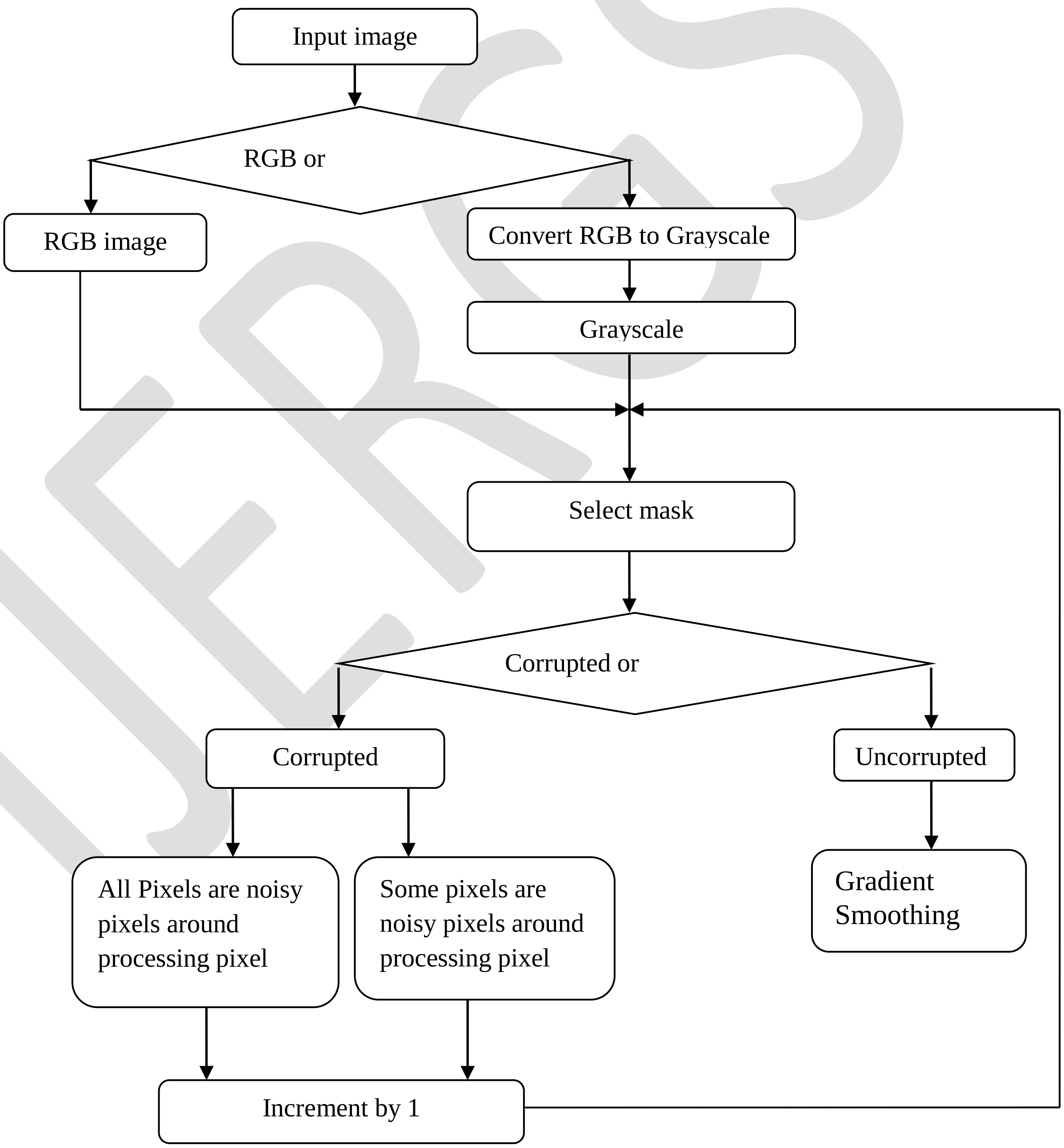
The root-mean-square error (RMSE) is a frequently used measure of the differences between values predicted by a model or an estimator and the values actually observed. The square root of mean square error is known as root mean square error.

RMSE is calculated as

$$\operatorname{RMSD}(\hat{\theta}) = \sqrt{\operatorname{MSE}(\hat{\theta})} = \sqrt{\operatorname{E}((\hat{\theta}-\theta)^2)}.$$

FLOWCHART

Flowchart for improved sorted switching median filter is given below:



EXPERIMENTAL RESULTS

The experimental results are performed on color images as well as on grayscale images. The result of proposed filter is better than the existing filters. The result of various images are performed at noisy density 0.5.The tables(1.1-1.4) and figures(1.1-1.4) shown results.

PSNR Values at noise density 0.5						
Images	Noisy	Median	Adaptive	PSMF	SSMF	Proposed
Image1	7.6972	14.3669	18.7157	19.3456	24.2747	27.2318
Image2	8.062	14.5135	18.2541	18.8162	23.6748	24.7264
Image3	8.1521	14.8572	19.6428	20.6412	26.0089	29.5575
Image4	7.2833	13.9213	18.1005	19.3513	23.8011	26.0625
Image5	7.9680	14.9606	19.9157	21.0807	26.3124	31.4098

Table 1.1 PSNR of various images

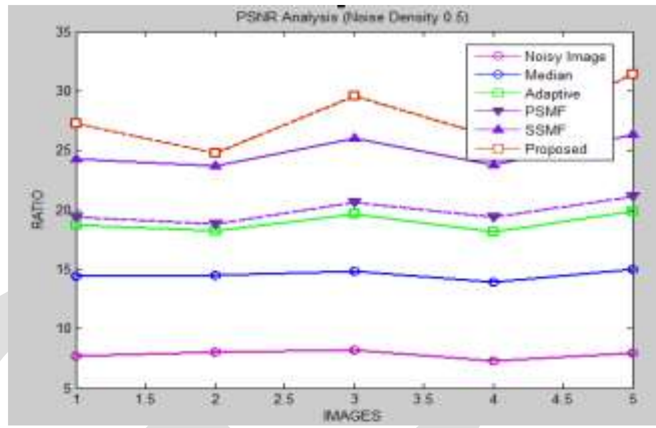


Figure 1.1 PSNR of various images

MSE Values at noise density 0.5						
Images	Noisy	Median	Adaptive	PSMF	SSMF	Proposed
Image1	11050	2379	874	756	243	123
Image2	10164	2300	972	854	279	219
Image3	9951	2125	706	561	163	72
Image4	12155	2636	1007	755	271	161
Image5	10382	2075	663	507	152	45

Table 1.2 MSE of various images

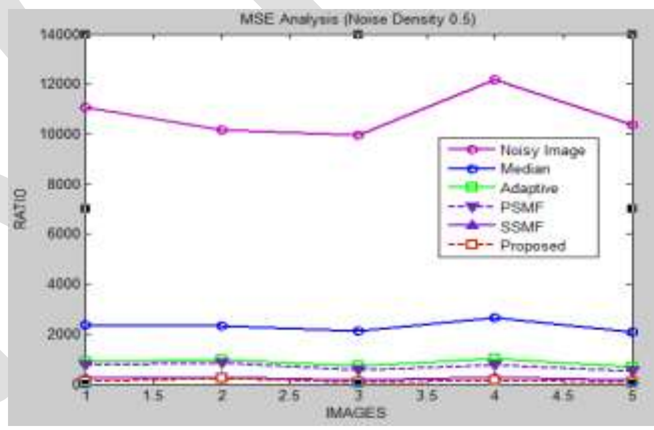


Figure 1.2 MSE of various images

BER Values at noise density 0.5						
Images	Noisy	Median	Adaptive	PSMF	SSMF	Proposed
Image1	0.1299	0.0696	0.0534	0.0517	0.0412	0.0367
Image2	0.1241	0.0689	0.0548	0.0531	0.0422	0.0414
Image3	0.1227	0.0673	0.0509	0.0484	0.0384	0.0338
Image4	0.1373	0.0718	0.0552	0.0517	0.0420	0.0384
Image5	0.1255	0.0688	0.0502	0.0474	0.0380	0.0318

Table 1.3 BER of various images

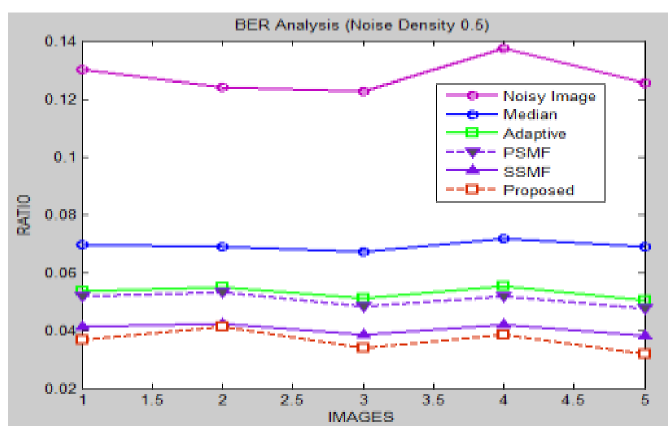


Figure 1.3 BER of various images

RMSE Values at noise density 0.5						
Images	Noisy	Median	Adaptive	PSMF	SSMF	Proposed
Image1	105.1119	48.7750	29.5637	27.4955	15.5885	11.0905
Image2	100.8167	47.9543	31.1769	29.2233	16.7033	14.7986
Image3	99.7547	46.0977	26.5707	23.6854	12.7671	8.4853
Image4	110.2497	51.3420	31.7333	27.4773	16.4621	12.6886
Image5	101.8921	45.5522	25.7488	22.5167	12.3288	6.8557

Table 1.4 RMSE of various images

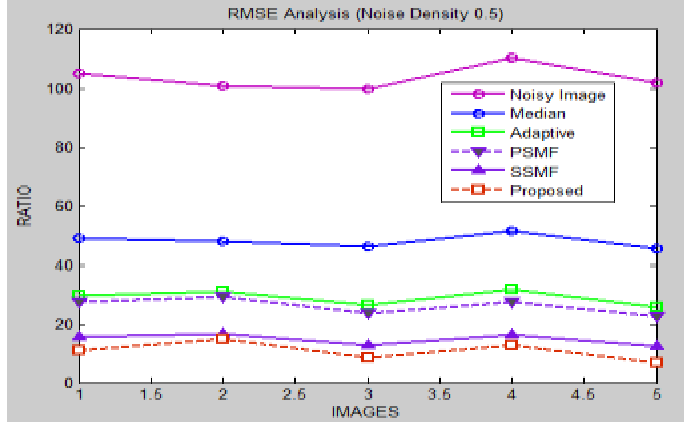


Figure 1.4 RMSE of various images

CONCLUSION

The proposed algorithm identifies the corrupted or uncorrupted pixel. After identification the algorithm replaces the value of processing pixel. The experimental result shows that the proposed algorithm performs better than the existing algorithms.

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