A Modified Non-Linear Decision based Algorithm (MNDBA) for Noisy Images

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ABSTRACT
Noise in an image varies from the ideal signal and is caused as a result of un modeled processes in the capture of the signals [1]. There are many algorithms for the removal of impulse noise. Conventional methods achieve a high degree of noise but algorithms perform poorly on mixed impulse noise. An adaptive median filter considers the positive and negative impulses for simultaneous removal but acts poorly on the strip lines, drop lines and blotches [2]. This paper proposes and investigates the performance of a new modified algorithm for noisy images, in low, mid and high noise density ranges and employs the window with smallest possible size to reduce computational time.

General Terms
Pattern Recognition, Security, Algorithms et. al.

1. INTRODUCTION
Noise in images are caused as a result of un-modeled processes caused by a wide range of sources like variations in the detector, nature of radiation, environment or transmission errors. Blotches are significant degradations that mainly originate from the loss of film gelatin and dirt particles covering the film surface. Blotch is an impulsive noise and leads to discontinuity. Strip lines are caused by improper responses of elements compared to the incoming electromagnetic energy, causing heterogeneity in overall brightness of adjacent lines [2]. Drop lines occur when a detector works improperly for even if, for a short period. Most of the image consist of strip and drop lines. Impulse noise is generally caused by malfunctioning pixels in sensors of the camera, memory locations or transmission in a noisy channel. Band missing is caused by corruption of two or more drop/strip lines continuously. Scratches occur in archives of films mainly due to abrasion with mechanical parts. Scratches generally retain their spatial position over several frames and they have a width of about 1 to 5 pixels. It is a really challenging process to detect scratches automatically although they can easily be seen by viewers. Linear filters are less effective if there is non-Gaussian noise [2]. Past studies have shown that nonlinear digital filters can overcome some of the limitations of linear digital filters. Median filters are a class of nonlinear filters and have produced good results where linear filters generally fail. Median filters remove impulse noise and preserve the edges [2]. Silva and Corte-Real gave a remedy for removing the blotches and line scratches in images. Kokaram's method for removal of scratches and restoration of missing data in the image sequences is based on temporal filtering. Though adaptive algorithms are available for removing impulse noises, they fail to address the problem of strip lines, drop lines, blotches, and band missing in images. Recent studies have shown that, application of an adaptive length algorithm is a better solution for removing impulse noise. Fig. 1 depicts different kinds of noises in images.

Drop lines Strip lines White band Impulse noise
Fig 1. Kinds of Noises in Images

This paper demonstrates the median-based algorithms can remove strip lines, missing bands, drop lines and blotches with proper edges Filters are mainly used to suppress high or low frequencies image processing. An image can be filtered in the frequency by transforming the image into the frequency domain and then multiplying it with a frequency for re-transformation to a spatial domain. The function attenuates certain frequencies and enhances others. The process of the spatial domain convolves the filter function h(i,j) with the input image f(i,j) as depicted in equation (1)

$$g(i,j) = h(i,j) * f(i,j) \qquad (1)$$

The results vary in spite of the mathematical operations being identical to multiplication of frequency spaces,. The discrete convolution is a `shift and multiply' operation, since the image is shifted over the kernel and the value multiplied to the pixel values of the image. For a square kernel with size M×M, the output image is calculated by equation (2)

$$g(i,j) = \sum_{m=-M/2}^{M/2} \sum_{n=-M/2}^{M/2} h(m,n)\, f(i-m,j-n) \qquad (2)$$

Implementing non-linear filters in a spatial domain is a possibility [3]. The convolution function summations are replaced with a non-linear operator:

$$g(i,j) = \sum_{m,n} [h(m,n) f(i-m,j-n)] \qquad (3)$$

The h (i,j) are all 1 in most non-linear filters. The median returns the central point of input values . As a first step the convolution process multiplies the kernel elements and matching pixel values when the kernel is centered over a pixel. The resulting array is averaged and the pixel value of the image is replaced by performing the CONVOL function for the entire image. Convolution within a frequency domain is performed by multiplying the Fast Fourier Transformation of the image and then by re-transforming it back into the spatial domain [4] [5] [6]. Zeros are padded to the kernel to match the image size before FFT was applied. The assessment parameters that are used to evaluate the performance of artifact reduction are Mean Square Error and peak signal to noise ratio. Mean Square Error indicates average error of the pixels throughout the image. A definition of a higher MSE does not indicate that the denoised image suffers more errors instead it refers to a greater difference between the original and denoised image. This means that there is a significant artifact reduction. PSNR is most commonly used as a measure of quality of reconstruction in image compression, defined as the mean squared error (MSE) which for two m×n monochrome images I and K where one of the images is considered a noisy approximation of the other. MAXi is the max pixel value possible in an image. Images with three RGB color values per pixel is the sum of the square differences divided by image size and three [7].

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2. FILTERING TECHNIQUES

Filtering modifies or enhances and used to emphasize features or remove unwanted features, from an image. Filtering techniques in Image processing include enhancement of the edges, smoothing or sharpening [8] Filtering is a neighborhood operation and pixel value of the output image is determined by applying an algorithm to the neighbor pixels which are defined by relative locations to the pixel. There are many filtering technique available for image processing.

2.1 Image Linear Filters

Linear filtering in images is a linear combination of pixel values in **its** neighborhood. A linear filter applies a linear operator to a time-varying input signal. Linear filters eliminate unwanted frequencies from input signals or can be used to select a defined frequency [9]. The mathematical theory of Linear filters is universal [10].

2.2 Low Pass Filters

Low pass filters are used for smoothing images. The disparity in pixel values are averaged with nearby pixels. A low pass filter retains the low frequencies in an image.

2.3 High Pass Filters

High pass filters sharpen images. A high pass filter retains high frequency information within an image.

2.4 Non-linear filters

[2] proposed a Nonlinear Decision-Based Algorithm for Removal of Strip Lines, Blotches, Drop Lines , Missing Bands and Impulses in Images and Videos on Image and Video Processing. The algorithm is decision based 'non-linear' because it looks at each data point and decides if that data is noise or valid signal .A variety of smoothing filters have been developed that are not linear. The main difference between linear and non-linear filters is that in linear filters an explicit mask is used, where as in non-linear filters the operation is based directly on the values of the pixels in the neighborhood under consideration. They do not explicitly use coefficients. Non-linear filters locate and remove data that is recognized as non-additive noise. If the point is noise, it is simply removed and replaced by an estimate based on surrounding data points. Linear filters, such as those used in band pass, high pass and low pass, lack such a decision capability and therefore modify all data. The kernel array usually has a single value at the center and surrounded by negative values.

2.5 Mean Filter

Mean filtering smoothens images by reducing the intensity variations between pixels and used to reduce noise. It replaces each pixel with the average value of its neighbours.

2.6 Laplacian/ Laplacian of gaussian

Laplacian is a two dimensional isotropic measure of the 2nd order spatial derivative in an image and used for detecting edges in an image. It is often applied to a smoothed image and reduce its sensitivity to noise. The Laplacian L(x,y) of an image is given by equ (4)

$$L(x,y) = \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2} \quad (4)$$

3. Modified Decision Based Adaptive Median Filter With Reduced Complexity

PMNDBA identifies disturbances in images. It is nonlinear decision based algorithm. It detects corrupted pixels and estimates new pixels for replacing the corrupted pixels. The proposed algorithm can replace several algorithms in image noise removal. The proposed removes positive and negative impulses in images. The window size is restricted to a maximum of 5×5 to minimize blurring [11]. Though this restriction makes it less effective, the algorithm computes the average of uncorrupted pixels. Assuming each pixel at (x, y) is corrupted by an impulse with probability p independent of their corrupted status. The impulse corrupted pixel e(x, y) takes smin with probability p, the smax s(x, y) with a probability of 1 − p. The image corrupted by blotches or scratches becomes c(x, y) = e(x, y) with s(x, y) with 1 – p.

The algorithm first detects degraded pixels and replaces faulty pixels with estimated values. Assume pixel P(i, j), window W (i, j) and corrupted pixels be "n." Let Pmax =225 and Pmin = 0 be the corrupted pixel values and P(i, j) =/ 0, 255 represent uncorrupted pixels.

Case 1: Consider window size 3 × 3 with pixels values shown below. If P(i, j) =/ 0, 255 ,then the pixels are unaltered. As shown in fig 2.

123	57	163
230	134	68
34	211	206

Fig 2 Uncorrupted Pixels

Case 2: If the number of corrupted pixels "n" <= 4, that is, n ≤ 4, then two- dimensional window of size 3 × 3 is selected and median operation is a sorting performed column wise, row wise and diagonally. The spoiled P(i, j) is replaced by the median value in Fig 3

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123	57	213
0	134	68
34	255	206

Fig 3 Corrupted Pixels

The row sorting is done by using Fig 4. column sorting is done by using Fig 5 and diagonal sorting is done in Fig 6

57	123	213
0	68	134
34	206	255

Fig 4 Row sorting

0	68	134
34	123	213
57	206	255

Fig 5 Column sorting

0	68	57
34	123	134
134	206	255

Fig 6 Diagonal sorting

Case 3: If the number of corrupted pixels "n" in the window W (i, j) is greater than or equal to 5, that is, n>= 4, then two- dimensional window of size 3 × 3 is selected and median operation sorts the columns, rows and diagonally. P(i, j) is replaced by median value shown in Fig 7. for corrupted pixels

57	255	212
0	68	0
255	206	255

Fig 7 Replaced median value

3.1 Algorithmic Steps In Median Filtering

Assume the image window size is 3 x 3 and the number of corrupted pixels in the window(n) is calculated.

If n=0, pixels are unaltered.
If n≤4, perform 3x3 median filtering
If n>=5, perform 5x5 median filtering
Replace the processed pixel by average of uncorrupted pixel.
Repeat the procedure for the next window
If the noise value n>=12,normally 3x3 median filtering and 5x5 median filtering are used to replace the corrupted pixel.For higher noise value the efficiency of 3x3 median filter will not provide good result compared with 5x5 median filtering.So 5x5 median filtering alone used to reduce the steps.

4. Simulated Results

The algorithm was tested with different types of degradations, namely, strip lines, drop lines, band missing, blotches, and impulse noise. The results are compared with those of general median filter, Lin's adaptive length median filter, Gonzalez adaptive length median filter and decision-based median filter. There is expected to be increase in performance in terms of 1) PSNR(Peak-Signal-to-Noise Ratio), 2) IEF (Image Enhancement Factor) and 3) MSE (Mean Square Error). The proposed algorithm removes all these degradations more effectively with reduced blurring and edge preservation. Performances are analyzed as mean square error, image enhancement factor, PSNR and compared with standards. The output images of the modified algorithm and artifacts in the images are depicted in Fig. 8.

Input image Gray image filter output 5×5 median filter output 3×3 median

Fig 8 Filter Outputs

4.1 MNDBA Analysis

The performance of the images are calculated by Peak Signal to Noise Ratio and Mean Square Error.PSNR and MSE are inversely proportionally to each other. The performance is illustrated in table 1 and Table 2

Table 1 PSNR Performance comparison

Noise + Degradations	PSNR				
	SMF	AMF	Lin's	NDBA	IMPROVED NDBA
0.05	16.5	17.25	16.24	35.15	39.6

Table 2 MSE Performance comparison

Noise + Degradations	MSE				
	SMF	AMF	Lin's	NDBA	IMPROVED NDBA
0.05	1430.2	1219.8	5212	908	706

4.2 Bar chart representation of PSNR

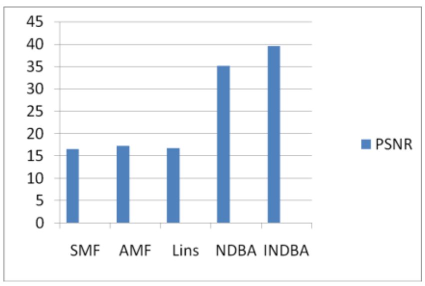

Fig 9 Comparison of filter performance with respect to PSNR

4.3 Comparison of PSNR and IEF of 3X3 median filter and 5X5 median filter for various percentage of impulse noise

From the modified algorithm the result gives the idea about the performance of the impulse noise. The impulse noise performance is illustrated by PSNR and IEF for different percentage of salt and pepper noise. The analysis gives the result when the impulse noise percentage is low then the PSNR value for small window size is high whereas the value for the large window size is low .The comparison of PSNR and IEF is illustrated in Fig 10

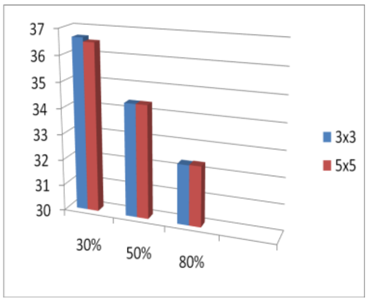

Fig 10 PSNR and IEF for different noise level

When the percentage of impulse noise increases the performance is reversed i.e the PSNR value for the 3x3 median filtering is less compare with 5x5 median filtering.For higher value of noise IEF value for small window size is large .For middle values of noise between 30%to70% both 3x3 median filter and 5x5 median filter have almost same performance.Therefore for middle level values either 3x3 median filter or 5x5 median filter can be used .Since the procedure for calculating 5x5 median filter is very complex.So 3x3 median filter should be used. The 3x3 median filter is suited for less impulse noise.5x5 median filter is suited for high impulse noise. This is illustrated in table 3.

Table 3 Impulse Noise Analysis

Window size	30%		50%		80%	
	PSNR	IEF	PSNR	IEF	PSNR	IEF
3x3	36.58	5.589e+004	34.358	8.15e+004	32.30	3.19e+004
5x5	36.50	6.23e+004	34.36	4.41e+004	32.319	2.85e+004

5. CONCLUSION

An adaptive length median/mean algorithm for removal of drops lines, strip lines, white bands, black bands, blotches, and impulses with minimum of blurring is investigated. The performance is verified in terms of MSE, PSNR, and IEF. The performance is compared with Lin's adaptive median filter, Gonzalez adaptive median filter, weighted median filter, decision-based median filter and adaptive center weighted median filter. The results show that the algorithm is more effective and reduce complexity in the terms of operation. The removal of drop lines, strip lines, white bands, black bands, and blotches along with impulse noise is improved in terms of performance . The performance of the algorithm is studied in low, mid and high noise density ranges.It is found that in the mid randes ,use of high dimensional window does not yield better performance. The algorithm is simplified so that the performance can be obtained at the lowest possible window size. The performance is also demonstrated using lena image. From the modified algorithm the result gives the idea about the performance of the impulse noise.The impulse noise performance is illustrated by PSNR and IEF for different percentage of salt and pepper noise.The analysis gives the result when the impulse noise percentage is low then the PSNR value for small window size is high whereas the value for the large window size is low. The advantage of the proposed algorithm is that a single algorithm with improved performance can replace several independent algorithms required for removal of different artifacts. The modified algorithm have many advantages. It Simultaneously removes all the Artifacts, Reduced Blurring, Preserved Edges, Single Algorithm can replace several independent algorithms, Reduce the complexity in the terms of operation steps, Time required is reduced when compare with NDBA.

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