Review of Better Detail Preserving Algorithm for Impulse Noise Reduction

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Abstract: ***This paper presents the study and comparison of various salt & pepper noise reduction techniques for the gray scale images. In this paper we have discussed various linear and non-linear filters. Study of all algorithms and compare these to determine better detail preserving algorithm. This survey provides help to researchers for selecting the best algorithm with detail preserving for the removal of salt & pepper noise from the gray scale image.***

Keywords: impulse noise, linear filter, non-linear filter**.**

1. Introduction

Whenever an image is converted from one form to another such as digitizing, scanning, transmitting, storing, etc., some of the degradation occurs at the output [1]. Hence, the output image suffers from a special kind of noise "salt & paper". Salt & paper significantly degrades the image quality [2]. An image denoising is used to remove the noise. The goal of image denoising is to estimate the original image from the noisy image. Denoising is one of the important task and pre-processing step in digital image processing. There are many median filters are available for impulse noise reduction although these methods have been improved, but the quality of denoising image is still not satisfactory [6].Applying the linear and non-linear filters to the gray scale image and we have observed from this survey that the non-linear filters work effectively for the removal of salt& pepper noise.

1.1 Noise

Efficiency of every algorithm is depending on the quality of input images. To enhance the quality of images various images enhancement or denoising techniques are used. Images enhancement techniques vary for different type's noise. Noise is any unwanted signal present in original signal. In Noise we have different noise types generated from different sources for example Impulse noise (salt & pepper), Gaussian noise and speckle noise etc Impulse Noise produces small dots or dark spots on an image. Whereas Gaussian noise (white noise) increases or decreases the brightness of image and speckle noise produce big patches [4].

1.2 Impulse Noise

Main cause of impulse noise is error in camera sensors or transmission cables. A grayscale image represented by a two-dimensional array where a location (i, j) is a position in image and called pixel. Often the grayscale image is store as an 8-bit integer that giving 256 possible different shades of gray going from black to white, pixels range is [0-255] integer interval, but some pixels in an image is considered as a corrupted pixel when it does not lies between the above specified range.

$$img(i,j) = \begin{cases} ORG(i,j) & with\ probability\ 1-pr \\ 0 & with\ probability\ pr_1 \\ 255 & with\ probability\ pr_2 \end{cases}$$

(1). [1]

2. Noise Reduction Techniques

Noise removal techniques basically categories into two types:

1) Linear filters and
2) Non-linear filters.

2.1 Linear filter

In the early development of image processing, linear filters are the primary tools. Their mathematical simplicity with satisfactory performance in many applications made them easy to design and implement. However, in the presence of noise the performance of linear filters is poor. They tend to blur edges, do not remove impulsive noise effectively, and do not perform well in the presence of signal dependent noise [5]. Linear Filters are used to remove the noise from the image but that noise is white or it can also say that types of noise are known as Gaussian Noise. For linear filter on one side remove noise but at the same time seriously blurred image detail, thus nonlinear filtering has become increasingly attractive.

Major drawback of the linear filter is that it replaces the non-noisy pixels also and it produces the blurred image because this algorithm is applied on the both types of pixels whether they are noisy pixel or non-noisy pixels.

Filters which are falling under this category:

1. Average filter: In average filter a square window of size 2k+1 is used. Here value of k changes from 1 to n. Window size (2k+1) is taken only because window width and height must be odd so that we get exactly central pixel (k+1, k+1)[4]. Using window original image is scanned row wise and column wise. Each time of scan value of central pixel of window is replaced by the average value of its neighboring pixels comes within the window.

2. Mean Filter: Working of Mean Filter is same as Average filter but here central pixel value is replace by the mean value of its neighboring pixels comes within the window. The mean filter is mainly used to reduce Gaussian white noise from the gray scale images. The nature of mean filter is linear. Let us consider an image as an M * N array which stands each point by the discrete functions f(x, y). The function of mean algorithm processed image is marked as g(x, y). We process one point at (x, y) in its n by n neighborhood area each time [6]. Disadvantage of mean filter is that it does not work to reduce the impulse noise from the grayscale images. We can say that this kind of linear filter is commonly used in Gaussian white noise [4].

3. Median Filter: Working of Median Filter is same as Average filter but Median filter is used to remove the disadvantage of the mean filter. This filter is mainly used to reduce impulse noise from the gray scale images. In image processing, several filtering algorithms belong to a category called windowing operators. Windowing operators use a window, or neighborhood of pixels, to calculate their output. For example, windowing operator may perform an operation like finding the average of all pixels in the neighborhood of a pixel. The pixel around which the window is found is called the origin. Here central pixel value is replace by the median value of its neighboring pixels comes within the window [7].

2.2 Non-Linear filter

Order statistic filters for noise removal are the most popular class nonlinear filters. A number of filters belong to this class of filters, e.g., adaptive median filter, the weighted median filter, the median hybrid filter etc. These filters have found numerous applications in digital image processing [7].Non-linear filter are basically works in two steps:

1) Noise detection: first stage it detect the noisy pixels in the image.
2) Noise replacement: second stage it replaces only the detected noisy pixels with its estimated median value.

Filters which are falling under this category:

1. min-max median filter:

In this filter (3x3) window is use for scanning the image left to right and top to bottom. The center pixel of window (2, 2) is considered as a test pixel [4]. If test pixel is less than minimum value present in rest of pixel in window and greater than maximum value present in rest of pixel in window. Then center pixel is treated as corrupted pixel and its value is replaced by median value of pixels present in window otherwise pixel is uncorrupted pixel kept pixel value unchanged and move forward. But this filter works well with the very noise and it produces the blurred image. It does not preserve the image detail.

2. Heuristic Median Filter:

This filter is used for noisy pixels and its neighborhood, this heuristic is similar to trim median filter but this method use from average of neighbor pixels by this concept that good replace pixel is similar to neighbor pixel, in below it introduce this heuristic in 3 step such as: There is some noisy pixel in a mask that are zero or 255, thus in step 1 remove all pixels that have 0 or 255 value, then it use from average of other pixels that are not noise in step 2, then in step 3 it replace all noisy pixels [6].

0	0	55	58	59	60	255	255

55	58	58	59	70

Figure 3.4: A graphical depiction of the heuristic median filter operation [6]

3. Adaptive median filter*:* It uses varying window size to noise reduction. Size of window increases until correct value of median is calculated and noise pixel is replaced with its calculated median value. In this filter two conditions are used one to detect corrupted pixels and second one is to check correctness of median value. If test pixel is less than minimum value present in rest of pixel in window and greater than maximum value present in rest of pixel in window then center pixel is treated as corrupted pixel [4]. If calculated median value is less than minimum value present in window and greater than maximum value present in window then median value is treated as corrupted value. If calculated median is corrupted then increase the window size and recalculate the median value until we get correct median value or else window size reach maximum limit. This filter basically aims to reduce the noise density by expanding the window so as to handle the impulse noise of higher intensity and is able to preserve more image detail.

Disadvantage of the adaptive median filter: this filter has also some defects that are;

1) It is failing to find the median corresponding pixels when the window size is maximum at this stage it is unable to filter the gray scale image.
2) It does not filter the image from the edges.

3. Weighted median Filter: The determining of the noise points of the images, which provides an important basis for the classification of image pixels, is the first step of filtering algorithm and also is the crucial step. There are many methods for determining the noise points. A 3 ×3 discrete window is used to determine the noise by calculating the difference between the average gray value of all the pixels within the window and the central pixel, and making a comparison between the difference and a given threshold [8].The pixel whose difference is greater than the threshold value is considered as noise point, otherwise non-noise point.

4. Centre weighted median filter:

The Center weighted median (CWM) filter [4] is an extension of the weighted median filter, which gives more weight to center values within the window. In CWM center pixel of (2k+1) square window considered as test pixel. If center pixel (k+1,k+1) less than minimum value present in rest of pixel in window and greater than maximum value present in rest of pixel in window then center pixel is treated as corrupted pixel. Corrupted pixel is replaced by estimated value of median. Estimated value of median is calculated by sorting all element of window in ascending order and taking median of elements from Lth element to (N-L)th element . N is number of elements present in an array.

3. Performance Metrics

Study the performance of the detection schemes in identifying the noisy pixels in the Lena image at different impulse noise ratios**.**

a. Peak Signal to Noise Ratio (PSNR):
PSNR analysis uses a standard mathematical model to measure an objective difference between two images. The PSNR block computes the peak signal-to-noise ratio, in decibels, between two images. This ratio is often used as a quality measurement between the original and a compressed image. The higher the PSNR, the better the quality of the compressed or reconstructed image. The bigger PSNR the less distortion [9].

PSNR=10log10 (R^2/MSE) [11] (1.1)

b. The Mean Square Error (MSE):
The MSE represents the cumulative squared error between the compressed and the original image, whereas PSNR represents a measure of the peak error. The lower the value of MSE, the lower the error. MSE is smaller, the performance is better, which means the filtered image is close to the original.

$$\mathrm{MSE} = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\left[Y(i,j)-\hat{Y}(i,j)\right]^2$$

[10] (1.2)

4. Conclusion

In this paper a different linear and non linear algorithms for impulse noise detection are studied and compared. This paper gives a review of filtering algorithm that are used to reduce the noise from the grayscale images. Mean filter (linear filter) is just work on to reduce Gaussian white noise but does not work to reduce the impulse noise from the grayscale images. Median filters are not good with the higher percentage of noise. It could effect on edges of the images. We have also discussed other non-linear filters also are work well. but smaller window size can better preserve details but with low noise density on the other hand when the window size bigger, noise supression capability will be enhanced but the edges of the image, corners and fine lines are lost which causes image blur. So we have study the weighted median filter(WMF) to remove the some disadvantage of other median filters like mean filter, standard median filter(SMF),adaptive median filter(AMF) and etc. we conclude that the WMF is work well for maintaining the balance between the noise suppression and image details.

Draw Backs of existing systems

- Existing systems uses fixed or different window size for detection of impulse noise. No algorithm is exist which can remove the noise from the edges of the gray scale image.
- Existing systems not provides consistent output in both low and high noise conditions.
- Exist systems are not well suited for real time applications because of these algorithms are time consuming nature.

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