Relaxed Median Filter: A Better Noise Removal Filter for Compound Images

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Abstract- Image filtering techniques are widely used in removing noises in images. But representation of data is becoming popular day by day using compound images. So, noise removal is necessary to maintain the quality of the compound images. Noise can be added to the compound images during image acquisition, image capturing or image transmission. Different literature study shows that many filtering techniques are presented to remove noise or improve the quality of the corrupted images. This paper deals with the performance study of Median, Relaxed median, Wiener, Centre weighted median and Averaging filters to remove Salt and pepper, Gaussian and Speckle noise in the compound images. This paper proposes relaxed median filter performs better for compound images.

Keywords: *Median Filter, Relaxed Median Filter, Wiener Filter, Centre Weighted Median Filter, Averaging Filter, Salt and pepper noise, Gaussian noise, Speckle noise.*

1. INTRODUCTION

In recent development of electronic imaging and scanning devices, documents are presented in web for printing systems [1]. We can see a lot of visual contents in the web as PDF files, web pages, online games as well as images. These visual contents are very complicated and consist of graphics, text and pictures. When they are downloaded or displayed in remote computers, they can be corrupted with various noises. Image filtering [6] is not only used to improve image quality but also is used as a pre-processing stage in many applications including image encoding, pattern recognition, image compression, and target tracking. Noise reduction is used to recover the perfect image from a degraded copy of an image. This paper attempts to remove different types of noise removal in compound images. This paper is organised as follows: The section II has an overview of various types of compound image. In section III & section IV the discussion is made about the basics of different types and characteristics of filters and noises. In section V the experimental results are shown. Finally section VI has the conclusion of this work.

2. COMPOUND IMAGES

Compound images are those, which contains a combination of natural images (photos), text, and graphics. This type of image occurs in many important applications, like document imaging and printing [2]. They exist in both colour and greyscale format. The compound images can be classified into various categories. But the most utilizable forms among them are scanned compound image and compound document image. When scanning a paper document or capturing documents using cameras, the resulting image may contain noise from dirtiness on the page during the acquisition process. This noise may hinder the translation of the image into ASCII characteristics while performing optical character recognition. It may also degrade an image such that key characteristics are damaged [3]. When a user of a website wants to see the website through the internet if this data of a website is stored on a faulty memory location of a server or it is transmitted through a noisy channel then the image of this website is corrupted by salt and pepper noise or Gaussian or speckle noise [4]. So these types of images need noise reduction for further classification and segmentation.

3. DIFFERENT IMAGE FILTERING TECHNIQUES

Image filtering is useful for many applications, including smoothing, sharpening, removing noise, and edge detection. A filter is defined by a kernel, which is a small array applied to each pixel and its neighbours within an image [5]. Filters are normally classified into two types: Linear Filter and Non-linear filter. Among them only the Median filter, Relaxed median, Wiener, Centre weighted median and Averaging filters are considered here.

Median filter:

The Median Filter is performed by taking the magnitude of all of the vectors within a mask and sorted according to the magnitudes [6]. The pixel with the median magnitude is then used to replace the pixel studied. The median filter is given by:

$$\text{Median filter } (x_1 \ldots x_N) = \text{Median}(\|x_1\|_2 \ldots\ldots \|x_N\|_2)$$

Relaxed median filter:

The filter is obtained by relaxing the order statistic for pixel substitution. Noise attenuation properties as well as edge and line preservation are analyzed statistically [7]. The trade-off between noise elimination and detail preservation is widely analyzed. Let m = N+1 and l, u such that $1 \le l < m < u < 2N+1$. The relaxed median filter with

bounds l and u is defined as

$$Y_i = RM_{lu}\{W_i\} = \begin{cases} Xi \ if \ Xi \in [[Wi](l), [Wi](u)] \\ [Wi](m) \ otherwise \end{cases}$$

where $[W_i](m)$ is the median value of the samples inside the window W_i.

Wiener filter:

Wiener filters are characterized by the following [6]:

a. Assumption: signal and (additive) noise are stationary linear random processes with known spectral characteristics.

b. Requirement: the filter must be physically realizable, i.e. causal (this requirement can be dropped, resulting in a non-causal solution).

c. Performance criteria: minimum mean-square error.

The wiener filter is:

$$G(u, v) = \frac{H^*(u,v)Ps(u,v)}{|H(u,v)| 2Ps(u,v) + Pn(u,v)}$$

where

H(u, v) = Degradation function

H*(u, v) = Complex conjugate of degradation function

Pn (u, v) = Power Spectral Density of Noise

Ps (u, v) = Power Spectral Density of un-degraded image

Centre weighted median filter:

Many applications of CWM filters in signal processing have been reported in the literature due to their useful properties known as detail preserving and noise suppressing, particularly

heavy-tailed noise [8]. In a CWM filter, the center sample is assigned a larger weight, i.e. $w(0, 0) = 2K + 1$ where $K \ge 0$, and all other non-zero weights are equal to one, i.e. $w(i,j) = 1$ for $i \ne 0$ and $j \ne 0$. K is a nonnegative integer.

Averaging filter:

It replaces each pixel by the average of pixels in a square window surrounding this pixel. There is a trade-off between noise removal and detail preserving. If the window is larger window, it can remove noise more effectively, but also blur the details/edges [9].

4. IMAGE NOISE

Image noise is the random variation of brightness or color information in images produced by the sensor and circuitry of a scanner or digital camera. Image noise can also originate in film grain and in the unavoidable shot noise of an ideal photon detector [10]. Image noise is generally regarded as an undesirable by-product of image capture. The types of Noise are following:-

Amplifier noise (Gaussian noise): Gaussian noise is a major part of the "read noise" of an image sensor, that is, of the constant noise level in dark areas of the image

Salt-and-pepper noise: This type of noise can be caused by dead pixels, analog-to-digital converter errors; bit errors in transmission, etc. This can be eliminated in large part by using dark frame subtraction and by interpolating around dark/bright pixels.

Speckle noise: Speckle noise is a granular noise that inherently exists in and degrades the quality of the active radar and synthetic aperture radar (SAR) images. It increases the mean grey level of a local area. Speckle noise is caused by signals from elementary scatterers, the gravity-capillary ripples, and manifests as a pedestal image.

5. EXPERIMENTAL RESULT

In this experiment, we have taken an image from web site as a compound image. Our experimental result shows high peak signal to noise ratio (PSNR). To assess the performance of the proposed filters for removing salt-and pepper noise, Gaussian noise and speckle noise, and to evaluate their comparative performance, we computed PSNR in (1) as following way:

$$\text{PSNR}=10\log_{10}\frac{\sum_i\sum_j 255^2}{\sum_i\sum_j\left(S_{i,j}-K_{i,j}\right)^2}\ \text{dB}\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where, $S_{i,j}$ is the original image and $K_{i,j}$ is the restored image pixels respectively and it is the mean square error. The higher the PSNR in the restored image, the better is its quality. The comparative result with PSNR values is shown in Table I.

NOISE	**MEDIAN**	**RELAXED**	**WIENER**	**CWMF**	**AVERAGING**
Salt &Pepper	36.71	36.7483	32.3927	36.4903	33.13
Gaussian	33.5789	34.7775	33.205	34.6073	31.6446
Speckle	33.3147	34.6049	33.1095	32.185	31.2618

Table I: PSNR values for compound images with salt &pepper, Gaussian and speckle noise

According to the table, relaxed median filter is best suited for compound images. The tested results are shown below:


The Toy Store

(a)


The Toy Store

(b)


The Toy Store

(c)


The Toy Store

(d)


The Toy Store

(e)

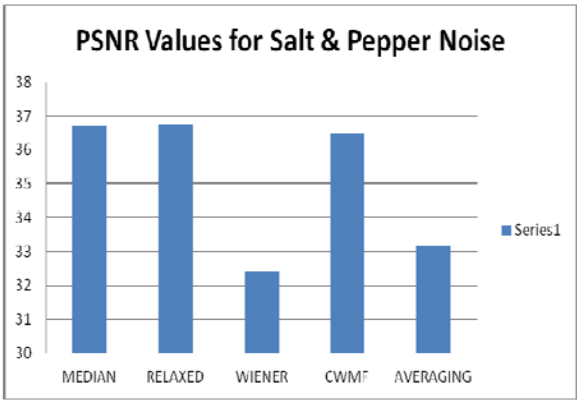

The Toy Store

(f)

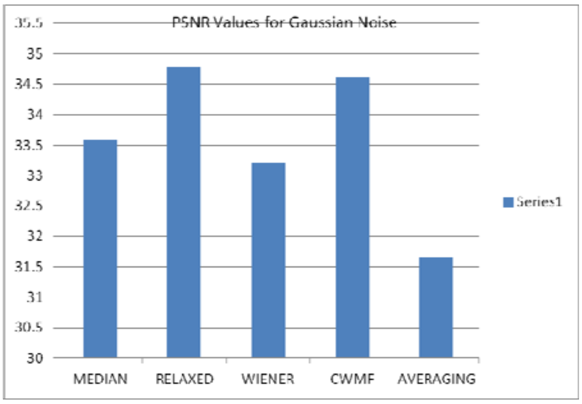
(g)

Fig. 1: Comparative studies of different filters for salt & pepper noise (a) Original image (b) Salt &pepper noise (c) Median filter (d) Relaxed median filter (e) Wiener filter (f) Centre weighted median filter (g) Averaging filter.

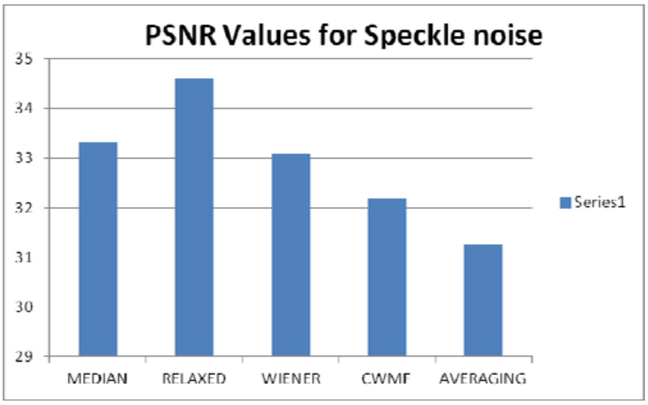
In the Fig.2 and 3, the peak to noise ratio values and Mean square errors are shown as a graph for salt & pepper noise, Gaussian noise and speckle noise. The bar chart also shows that the relaxed median filter shows better result for each noise types.



(a)



(b)



(c)

Fig.2: PSNR Chart for (a) Salt & pepper noise, (b) Gaussian noise, (c) Speckle noise

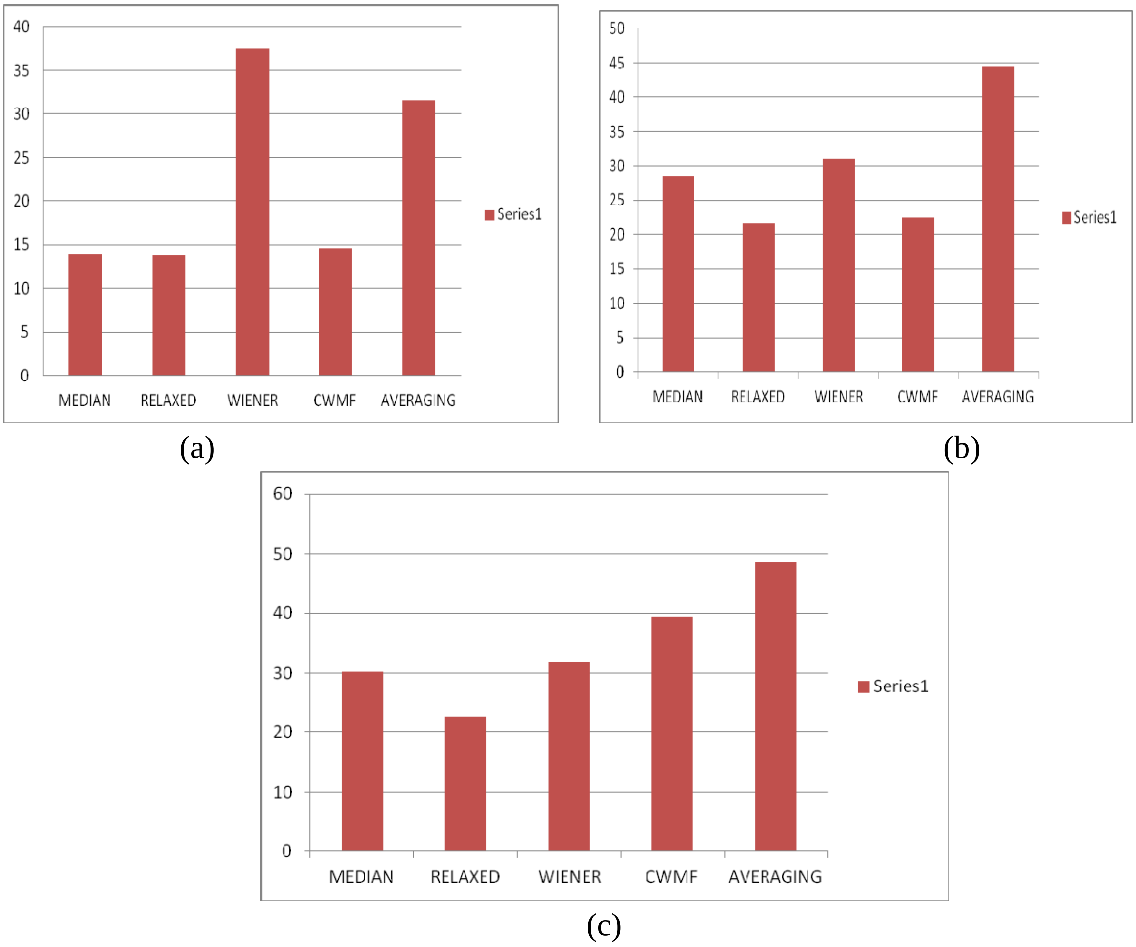


Fig.3: MSE Chart for (a) Salt & pepper noise, (b) Gaussian noise, (c) Speckle noise

6. CONCLUSION

This paper attempts to remove Salt & pepper, Gaussian and Speckle noise from compound images using median filter, relaxed median filter, wiener, centre weighted median and averaging filter . The performance of the different filters with the applied noises using compound images are compared and analyzed according to PSNR value. From the performance analyses the relaxed median filter gives better results for compound images.

7. REFERENCES

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