Performance of A Hybrid Salt and Pepper Noise Removal Technique

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Abstract - Salt and Pepper Noise is one of the most disturbing corruption for any images. Many types of Image Processing techniques have been applied to remove this type of noise and restore the original image. This paper is based on a comparative study of three filters. Here we have taken Mean Filter, Median Filter and their combination, i.e., the Hybrid Filter. We have taken sample images, added Salt and Pepper noise in them, passed them through these three filters and studied the outcomes.We have presented the histograms and the data chart of correlation of the noisy image with that of the restored one through these three filters. We have seen the Mean filter performs the best all the time. We should however make the detection and filtering more robust and adaptive to draw any definite conclusion.

Keywords – Salt and Pepper Noise, Mean and Median Filter, Histogram correlation

I. INTRODUCTION

Salt-and-pepper noise is a form of noise sometimes seen on images. It presents itself as sparsely occurring white and black pixels. An effective noise reduction method for this type of noise is a median filter or a morphological filter. For reducing either salt noise or pepper noise, but not both, a contra-harmonic mean filter can be effective.

Images are corrupted with the noise when they are transmitted or during image acquisition process. Mostly, images are corrupted with an impulsive noise that is, bipolar in nature. The occurrence of salt & pepper noise can severely damage the information or data embedded in the original image. So, it must be removed before subsequent image processing tasks such as edge detection or segmentation is carried out.

The proposed work is a recursive filter used to remove salt & pepper noise. The detection stage detects the noisy pixels and they are further passed to the next filtering stage. The noise-free pixels are retained as they are. The noisy pixels with maximum intensity (255 or white) is known as salt noise and with minimum intensity (0 or black) is known as pepper noise. The detection and filtering stage includes 3x3 scanning and merge scanning process and applying the histogram approach.

In 3x3 scanning, the scanning is performed by comparing the centre pixel with the rest of the pixels in a 3x3 matrix of an image. The algorithm applied for 3x3 scan by considering centre pixel is:

$$p(i,j) = \left| X(i+k, j+l) - X(i,j) \right| \text{ with } (i+k , j+l) \neq (i,j)$$

where

p(i,j) is the absolute luminance difference

X(i,j) is the noisy pixel.

Little bit of salt & pepper noise is eliminated in this process.

The rest of the paper is organized as follows. Some of the existing noise removal techniques are reviewed in section II. Objective and our own technique is described in section III. Experimental results are presented in section IV. Concluding remarks are given in section V.

II. BACKGROUND

Nopise remova l technique is a very popular item for worldwide researchers in Image Processing. Most of these techniques take an adaptive approach for noise detection and then use some form of filtering based on statistical implication (like the Mean filtering).

In [1], the author takes a different approach. She uses an adaptive fuzzy based filtering approach to detect noise (via a preset thresholding mechanism), applies a Mean filter and then a Median filter to improve the restoration process.

In [2], the authors use a Median filtering based approach to detect and remove noise for the center pixel covered by a Median filter. The Signal to Noise ratio (SNR) is used to find the noisy pixel and the correction applied to that effect. (The author uses another pass through a Wiener filter to remove the blurredness but this is beyond the scope of this paper).

In [3], the authors take a combination of Mean and Median filtering, applying one after the other, so that the image restoration can be done to the best effect possible. Our approach starts from this direction and does more enhancements.

III. OBJECTIVE & OUR WORK

Figure 1: Example of an Image with Salt & Pepper Noise

When we studied the mean filter we got the following advantages and disadvantages.

Sometimes we are confused by median filter and average filter, thus let's do some comparison between them. The median filter is a non-linear tool, while the average filter is a linear one. In smooth, uniform areas of the image, the median and the average will differ by very little. The median filter removes noise, while the average filter just spreads it around evenly. The performance of median filter is particularly better for removing impulse noise than average filter.

In Figure 2 shown below are the original image and the same image after it has been corrupted by impulse noise at 10%. This means that 10% of its pixels were replaced by full white pixels. Also shown are the median filtering results using 3x3 and 3x3 window.

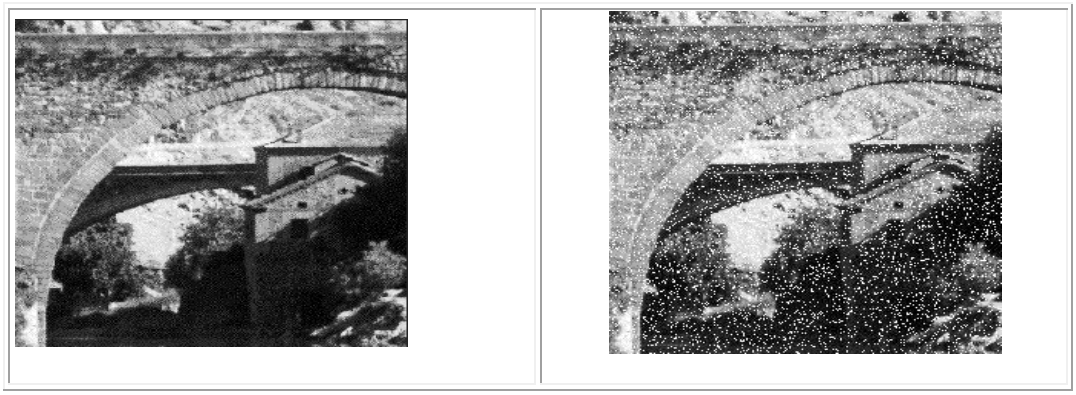
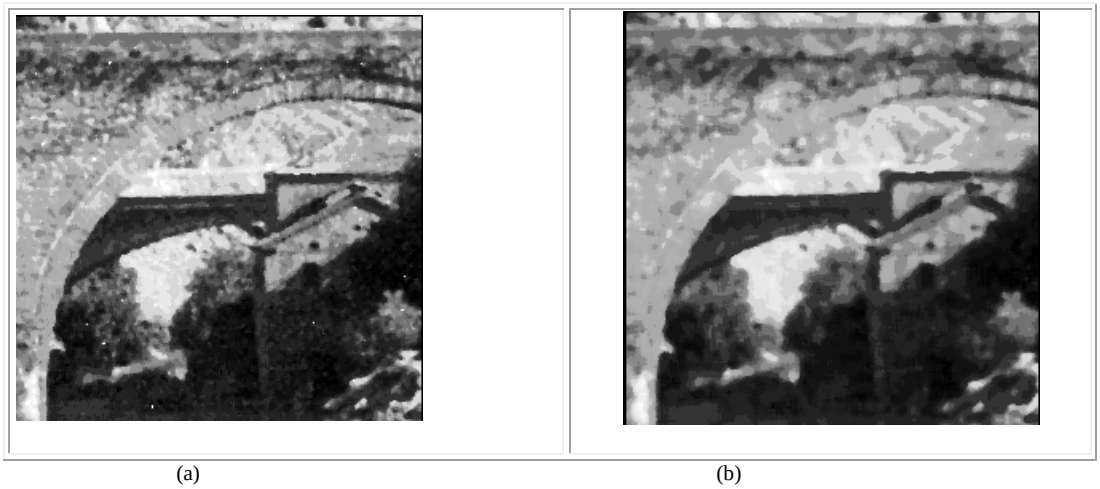


Figure 2: a) Original image; b) Added Impulse Noisy at 10%



(a) (b)

Figure 3: (a)3x3 Median Filtered; b)3x3 Median Filtered

Now here we made a hybrid filter combining the Mean and the Median filter to overcome the disadvantages of both the filters and compare the results. We have drawn the correlation and tabulated them in the proper form.

The uniqueness of our rests in the fact that we are applying the Mean and Median filtering simultaneously during the same pass of the filtering process. This is in contrast to [2], where the passes are sequential. Also since we have access to the internal pixel values at the same time, we can use a weighted combination of both these filters to make a hybrid approach on the fly. Finally we have done the matching using histogram correlation technique. All our algorithms are implemented using MATLAB R2013a.

Spatial Mean Filter:

Mean filtering is a simple, intuitive and easy to implement method of smoothing images, i.e. reducing the amount of intensity variation between one pixel and the next. It is often used to reduce noise in images.

The idea of mean filtering is simply to replace each pixel value in an image with the mean (`average') value of its neighbours, including itself. This has the effect of eliminating pixel values which are unrepresentative of their surroundings. Mean filtering is usually thought of as a convolution filter. Like other convolutions it is based around a kernel, which represents the shape and size of the neighbourhood to be sampled when calculating the mean. Often a 3×3 square kernel is used, as shown in Image 5, although larger kernels (E.G. 5×5 squares) can be used for more severe smoothing. (Note that a small kernel can be applied more than once in order to produce a similar but not identical effect as a single pass with a large kernel).

$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$
$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$
$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$

Figure 4 : 3×3 averaging kernel often used in mean filtering

Spatial Median Filter:

Like the mean filter, the median filter considers each pixel in the image in turn and looks at its nearby neighbours to decide whether or not it is representative of its surroundings. Instead of simply replacing the pixel value with the MEAN of neighbouring pixel values, it replaces it with the MEDIAN of those values. The median is calculated by first sorting all the pixel values from the surrounding neighbourhood into numerical order and then replacing the pixel being considered with the middle pixel value. (If the neighbourhood under

consideration contains an even number of pixels, the average of the two middle pixel values is used.) Image (9) illustrates an example calculation.

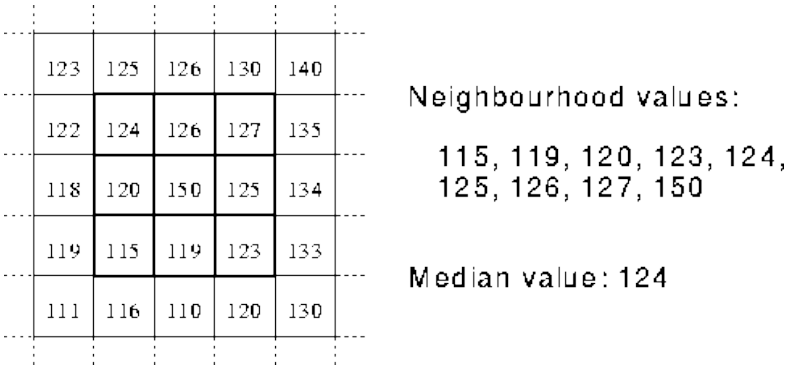


Figure 5: Spatial Median Filter

As can be seen, the central pixel value of 150 is rather unrepresentative of the surrounding pixels and is replaced with the median value: 124. A 3×3 square neighbourhood is used here --- larger neighbourhoods will produce more severe smoothing.

Proposed Filter:

Now the speciality of our proposed algorithm is we have combined the idea of spatial mean filter and spatial median filter together to check if we can get better results. We have taken a survey based on three filters and tabulated the result as follows.

IV. Result and Observations

Figure 6: Original Image

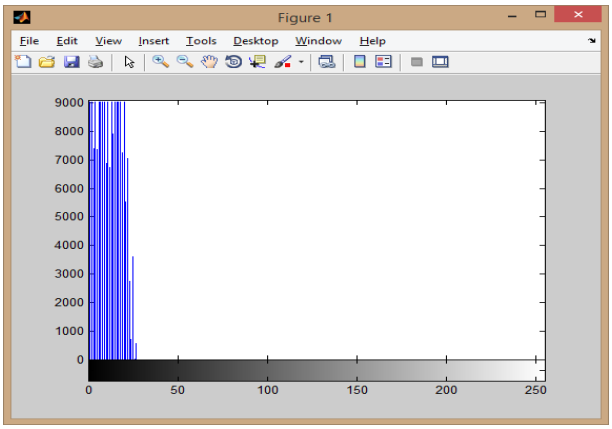


Figure 7: Histogram for Figure 6

The above Figure 6 and Figure 7 are the original image that we took for the observation and it's corresponding histogram respectively

Figure 8: Noisy image

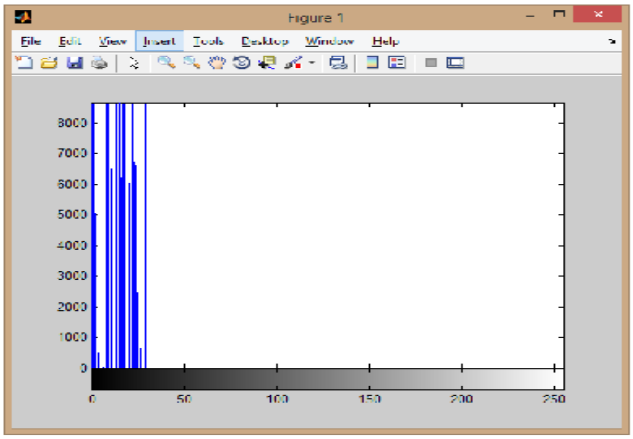


Figure 9: Histogram for Figure 8

Figure 8 is the image after infected by noise and Figure 9 is the corresponding histogram.

Now we have executed our algorithm to remove noise from that of noisy image. We have used total 3 filters 1. Mean Filter 2. Median Filter 3. Hybrid Filter (the mixture of Mean and Median Filter). We have provided here the restored image.

Figure 10: The Restored Image

Now we have done our comparative study between the three filters. We have presented our observation in tabular form.

Table 1: Mismatch between Original Image and Restored Image at various Noise Levels

Image Name	5% Noise level			8% Noise level			10% Noise level		
	Median	**Hybrid**	**Mean**	**Median**	**Hybrid**	**Mean**	**Median**	**Hybrid**	**Mean**
Lena	5.27%	5.68%	5.07%	8.41%	8.81%	8%	10.01%	10.16%	9.54%
Camera man	5.56%	6.98%	5.25%	10.48%	12.88%	9.93%	13.28%	16.34%	12.6%

The mismatch value is calculated as follows. We have used the correlation between the original and the restored images at various noise insertion levels. Let us call this value C. Then (100 –C) (in %) is a good indicator of the mismatch between the two images.

We have also taken another image Cameraman.jpg and added noise to it. Then we removed the noise through these three type of filters and tabulated the result.

Figure 11: Original Image

Figure 12: After noise addition

Figure 13: Image after restoration

V. CONCLUSION

We have used a Mean, median and a hybrid filter to restore an image suffering from the addition of Salt and Pepper noise. We have tested with various noise levels. We found that the best performance is given by the Mean filter, followed by the Median filter and the Hybrid filter performs worst in all cases uniformly. This result however does not include a proper adaptive noise detection technique and hence may be introducing noisy pixels when it is perfectly in order. Hence we need to carry further experiments to establish out result conclusively.

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