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A New Approach for De-noising of an Image Corrupted by Salt & Pepper Noise

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ABSTRACT

The de-noising of an image corrupted by salt and pepper has been a classical problem in image processing. In the last decade, various modified median filtering schemes have been developed for image denoising to deliver improved performance over traditional methods. In this paper a simple method called Inerpolate Median Filter (IMF) is proposed to denoise the images corrupted by salt and pepper noise. The proposed method works better in preserving image details by suppressing noise. The simulation results show that the proposed algorithm outperforms the conventional Median filter and other algorithms like mimum-maximumum exclusive mean filter (MMEM), Adaptive median filtering(AMF) in terms of peak signal to noise ratio.

Keywords: Image de-noising, Interpolate median filter, salt and pepper noise.

1. INTRODUCTION

An image is often corrupted by noise during its acquisition and transmission. Image de-noising is used to reduce the noise while retaining the important features in the image. Always there exists a tradeoff between the removed noise and the blurring in the image. The intensity of impulse noise has the tendency of being either relatively high or relatively low, which will degrade the image quality. Therefore image de-noising is used as preprocessing to edge detection, image segmentation and object recognition etc.

A variety of filtering techniques has been proposed for enhancing images degraded by noise. The classical linear digital image filters, such as averaging lowpass filters, tend to blur edges and other fine image details. Therefore nonlinear filters[1-5] are most preferred over linear filters due to their improved filtering performance in terms of noise suppression and edge preservation. The standard median (SM) filter[6,7] is the one of the most robust nonlinear filters, which exploits the rank-order information of pixel intensities within filtering window. This filter is very popular due to its edge preserving characteristics and its simplicity in implementation. Various modifications of the SM filter have been introduced, such as the weighted median (WM)[8] filter. By incorporating noise detection mechanism into the conventional median filtering approach, the filters like switching median filters[9,10] had shown significant performance improvement. The median filter, as well as its modifications and generalizations[11] are typically implemented invariably across an image. Examples include the mimum-maximumum exclusive mean filter (MMEM)[12], Florencio's[13], Adaptive median filter (AMF)[14]. These filters have demonstrated excellent performance but the main drawbacks of all these filters are, they are prone to edge jitters in the cases where noise density is high, large widow size results in blurred images and significant computational complexity. To solve this problem, a modified median filter algorithm called Interpolate Median filter that employs Interpolated search in determining the desired central pixel value is proposed.

The paper is organized as follows: Section II gives brief review of mean and median filtering. The new approach, The Interpolate Median filter technique is explained in section III. Experimental results are presented in section IV. Finally in section V, we give the conclusion.

2. MEAN & MEDIAN FILTERING

Mean Filter

Mean filtering is a simple and easy to implement method of smoothing images, i.e. it reduces 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 neighbors, including itself. The drawback of this algorithm is, it has the effect of eliminating pixel values which are unrepresentative of their surroundings. With salt and pepper noise, image gets smoothed with a 3×3 mean filter. Since the shot noise pixel values are often very different from the surrounding values, they tend to significantly distort the pixel average calculated by the mean filter.

Median Filter

The median filter is normally used to reduce noise in an image like the mean filter; however, it does well in preserving useful details in the image. Unlike the mean filter, the median filter considers each pixel in the image and instead of simply replacing the pixel value with the mean of neighboring pixel values; it is replaced with the median of those values. The median is calculated by first sorting all the pixel values from the surrounding neighborhood into numerical order and then replacing the pixel being considered with the middle pixel value. For example, in a 3 x 3 neighborhood the median is the 5th largest value, in a 5 x 5 neighborhood the 13th largest value, and so on. Suppose a 3 x 3 neighborhood has values (10, 20, 20, 20, 15, 20, and 25,100). These values are sorted as (10,15,20,20,20,20, 20,25,100), which results in a median of 20. The median filter, especially with larger window size destroys the fine image details due to its rank ordering process. Figure1. illustrates an example calculation.

Neighborhood values: 115, 119, 120, 123, 124, 125, 126, 127, 150

Median value: 124

110	125	125	130	140
123	124	126	127	136
114	120	150	125	134
118	115	119	123	134
111	116	111	120	131

Fig. 1. Calculating the median value of a 3x3 pixel neighborhood. The central pixel value of 150 is rather unrepresentative of the surrounding pixels and is replaced with the median value: 124

3. INTERPOTATE MEDIAN FILTER AND ITS IMPLIMENTATION

The Interpolate Median filter method considers each pixel in the image in turn and looks at its neighbors to decide whether or not it is representative of its surroundings. Instead of replacing the pixel value with the median of neighboring pixel values, it replaces it with the interpolation of those values.

The interpolation is calculated by first sorting all pixel values from surrounding neighborhood into numerical order and then replacing the pixel being considered with the interpolation pixel value. The calculation of interpolation value is derived from the Interpolation search technique used for searching the elements. It can be called as a Non-linear filter or order-static filter because there response is based on the ordering or ranking of the pixels contained within the mask. The advantages of this filter over mean and median filter are, it gives more robust average than both the methods, for some pixels in the neighborhood; it creates new pixel values like mean filter and for some it will not create new pixel value, but retain the pixel value like median filter, Thus it has the characteristics of both mean and median filters.

The algorithm uses the fallowing formulas

$$Key=(a[l])+a[h])/2 \quad (1)$$

where K is the 'key', Here we make an intelligent guess about 'key' which is the mid value of the array 'a', and *a[l], a[h]* are values of bottom and top elements in the sorted array.

$$Mid=l+(h-l)*((K-a[l])/(a[h]-a[l])) \quad (2)$$

Here value 'Mid' gives the optimal mid-point of the array and a[mid] gives the interpolated value. This interpolated value is the new value of the pixel

Implementation

The steps of implementing Interpolate Median filter is given followed by the corresponding flowchart in figure 4.4.

Step 1: Read the original standard image (Lena.png, Barbara.png,Goldhill.png).

Step 2: The preprocessing of image is done which resizes the loaded image to a standard size of 512 x 512, suitable for further processing.

Step 3: The noise is added to the standard test images. In this work Salt & pepper noise is used as it is the simplest type of noise among all. According to a given density D more or less pixels are flipped randomly to black (0) or white (1). D is just measure of the amount of noise to be added, not a value! This type of noise is also independent of the image it is added to.

Step 4: The noisy image is then subjected to Interpolate Median Filtering. The resultant image is the denoised image.

Step 5: The peak signal to noise ratio (PSNR) is calculated for all the standard images with their noisy and denoised counterparts, respectively. The PSNR values are compared with some traditional standard methods.

4. EXPERIMENTAL RESULTS

To validate proposed method, the experiments are conducted on some natural grayscale test images like Lena, Barbera and Goldhill of size 512*512 at different noise levels Table 1, illustrates the comparison of PSNRs of the six de-noising methods.

The peak signal-to-noise ratio (PSNR) in decibels (dB), is defined as

$$PSNR = 10 \times \log \frac{255^2}{MSE}(dB) \quad (3)$$

with $$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\left(I(i,j) - K(i,j)\right)^2 \quad (4)$$

where I and K being the original image and denoised image, respectively. Figure 2, shows the original test images used for experiments and Figure 3, shows the Lena image corrupted by salt and pepper noise by 20% (dB).

a b c

Fig.2 The original test images with 512x512 pixels: (a) Lena; (b) Barbara; (c) Goldhill.

a b

Fig 3. (a) Lena image corrupted by salt & pepper noise(dB) (20%), (b) Denoised image

Table 1. PSNR Performance of Different Algorithms for Lena image corrupted with salt and pepper noise

Algorithm	Noise Density in dB		
	10%	20%	30%
MF(3x3)	31.19	28.48	25.45
MF(5x5)	29.45	28.91	28.43
MMEM [8]	30.28	29.63	29.05
Florencio's [9]	33.69	32.20	30.95
AMF(5x5) [10]	30.11	28.72	27.84
IMF(Proposed)	**33.86**	**30.59**	**25.75**

The performance analysis of the method for Lena and Barbara image is given in Table 2, the noise density is varied fron 10% to 50% in steps of 10 and PSNR values are tabulated.

Table 2. Performance analysis

Noise Density in dB (in %)	**Lena**	**Barbara**
10	33.86	24.83
20	30.59	23.82
30	25.75	21.80
40	20.02	19.00
50	17.23	16.08

5. CONCLUSION

In this paper, the proposed algorithm called Interpolate Median filter employs Interpolated search in determining the desired central pixel value. Interpolation mean filtering is a simple, and easy to implement, for image de-noising.the simulation results show that the proposed method performs significantly better than many other existing methods.

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