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A DETAIL PRESERVING FILTER FOR HIGH DENSITY SALT-AND-PEPPER NOISE

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Abstract— **In this paper, a filter for preserving the details in an image (DPF) and removing salt-and-pepper or impulse noise of very high density is proposed. Proposed method works in two stages. In first stage, detection and removal of pixels which contain noise is done using two different parameters namely, synonymy parameter and rectification factor. In the second stage pixels containing noise are replaced by noise free pixels from its neighborhood using rectification factor. Constant areas are identified and preserved in the proposed method using synonymy parameter. Peak-signal-to-noise-ratio (PSNR) and visual comparison was used for comparing the results and it was found through experiments and simulations that the proposed filter provides a significant improvement on the other state-of-the art methods.**

Keywords— Impulse noise, synonymy parameter, PSNR

I. INTRODUCTION

An image is often corrupted by noise during its acquisition and transmission due to imaging sensors quality, errors in the channel while transmitting the image, lack of ideal medium between the imaging object and the imaging system and memory problems in hardware [1].Almost for all the applications of image processing and computer vision, it is important to remove noise from the image and to enhance its quality before doing further processing on the image.

Although various kinds of noise may be present in the image like Gaussian noise, exponential noise but impulse noise is the kind of noise which is mostly found in images [2]. When an image is affected by impulse noise its quality is distorted as impulse noise breaks the homogeneity among the pixels and reduces the smoothness of the image. Various techniques have been proposed for denoising the image and remove impulse noise from the image. Most of these techniques use non linear filtering algorithms which are based on basic principle of ranking the information of the pixels using a window of predefined size and then applying certain operation on them [3].Standard median filter(SMF) is the basic non linear Filtering technique used for removing salt and pepper noise also termed as impulse noise[4]. This kind of filter provides good result if low density noise is present in the image, but in case of high density images the filter is not good at preserving image details. This is because the filter is uniformly applied across the entire image as a result of which it modifies both noisy pixels and the pixels containing no noise. To deal with the weak points and limitations of standard filters used, a number of modified median filters have been proposed over the years. These include weighted median filter (WM) [5], Progressive Switching Median (PSMF) filter [6], Adaptive median Filter (ADMF) [7], Center Weighted Median filter [8]. These filters focus on preserving the image details by giving extra emphasis to some of pixels in the filtering image. These filters work better as compared to standard Median filters but suffer from certain weaknesses like increased computation time, Poor performance in high density noise images, image blurring, loss of information etc.

In later years this single stage approach to filtering converted into two stage approach. In the first stage of filtering, image pixels are classified as noisy pixels and pixels containing no noise using some neighborhood and averaging approach and in the second stage filtering is applied on those pixels which are identified as noisy pixels in the first stage [9, 10]. As fuzzy filters are usually simple and quite efficient, especially when used in adaptive settings many algorithms based on fuzzy filters have been proposed for removing impulse noise. A two step fuzzy filtering techniques with better detail preserving capabilities is used for denoising the image [11, 12]. Another approach which uses Support Vector Machines (SVM) classification based Fuzzy filter has also been proposed in the literature [13]. In this approach a system is trained with an optimal feature set. When an image is processed through the trained system its pixels are classified as noisy and noise-free pixels. In second stage fuzzy filtering is performed according to decision made in testing stage.

This paper presents a novel approach for effectively removing high density salt-and-pepper noise. The algorithm does not affect the edges and maintain the originality of the image. The filter identifies pixels contaminated with noise and replaces them with noise free pixels from their neighborhood using rectification factor. Gray scale or colored images can have

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significant component as pure black or white. Proposed method also identifies such areas and preserves them. Other filters consider these areas as noise and thus become inefficient in preserving these image details. Results obtained show that the proposed filter gives far better results than many existing filters.

II. PROPOSED METHOS

In this paper a detail preserving filter for high density salt-and-pepper noise is proposed. The filter works in two steps. In first step a sliding window V of size n× n, (where n is an odd number) is used. The window should be centered at $x_{ij \text{ and}}$ is used for detecting the candidates of noise pixels in the image. The classification is done on the following basis.

$$x_{ij} = \begin{cases} NFP\ if\ 0 < x_{ij} < 255 \\ NCP\ if x_{ij} = 0\ or x_{ij} = 255 \end{cases} \quad (1)$$

Here NFP represents the pixels which do not contain noise and NCP represents pixels which are noise candidates in the image. Noise candidates may be noisy or part of the image, i.e., noise free. For finding the actual candidates of noise, synonymy or similarity parameter is proposed in this work. In the next step for removing the pixels containing noise the adaptive median (AD_m) is calculated [4].To replace the pixels containing noise, the pixel from the window which is nearest to the adaptive median (AD_m) is selected. To do this rectification factor ($\in_c$) is calculated and this factor is subtracted from AD_m and the pixel containing noise is replaced with the result. For a n× n window the correction factor ($\in_c$) is calculated as,

$$\in_c = min\{A_{dm} - M_{rk}\} \quad (2)$$

Where M_{rk} is the k_{th} noise free neighbor of x_{ij} in the current window

The step wise procedure for proposed filter is described below:

Step 1: A sliding window W_N of size n × n, where n is an odd number initialized as m=3 is used and centered at x_{ij} in the algorithm for finding *NCP*. The algorithm first checks whether x_{ij} is noise free (NFP) or noise candidate (NCP) using eq.(1) .If x_{ij} is NFP no changes are done to the pixel , but if x_{ij} is a NCP then goto step 2.

Step 2: For each pixel which is identified in step 1 the sliding window W_N centered at x_{ij} is used and to check the similarity difference of x_{ij} with all of its neighbors in the window is calculated using eq(3).

$$\delta_k = |x_{ij} - M_{rk}| \quad (3)$$

where $k = 1,2,\ldots n^2-1$

M_{rk} = *the* k_{th} *neighbor of* x_{ij}.

Step 3: Calculate the synonymy parameter using eq(4),

$$\alpha_s = (\alpha_1 - \alpha_2) \quad (4)$$

where α_1 = maximum $\{\delta_k : 1 \le k \le n^2\text{-}1\}$

and α_2 = minimum $\{\delta_k : 1 \le k \le n^2\text{-}1\}$

Based on the value of synonymy parameter calculated in step 3 two cases arises and accordingly the noise is removed as follows:

Case 1: If the value of σ_s = 0, it signifies that all the pixels in the selected window are either all 0 or 1(In case of binary image). It means that the corresponding segments of the image whether gray scaled or colored, are either pure white or black. These pixels in the taken image are to be retained as such.

Case 2: If the value of $\sigma_s \neq 0$, it signifies the center pixel in the selected segment or window is containing noise and needs to be filtered out. Two conditions occur and accordingly the pixel value is changed as follows:

(i)Window consists of both types of pixels (NFP and NCP) .First a noise free pixel form the neighbor in the window taken ,which is nearest to AD_m is selected. Then this pixel is substituted in place of the center pixel which is a possible candidate of noise. As a result of doing this originality of the image is maintained and noise is also removed. The replacement is done using eq (5).

$$x_{ij} = |A_{dm} - \in_c| \quad (5)$$

Here $\in_c$ is calculated using eq (2).

(ii) The window consists of a mixture of 0 and 255. This indicates that major component of the portion of image in the window is containing noise. Therefore not a single pixel from the window can be chosen to replace all the noisy pixels in the window and as a result size of the window is to be increased to the next possible odd number, (*e.g.,* if previously it was working on a 5x5 window now it is increased to 7x7). After increasing the size of the window a noise free neighbor from the increased window which is nearest to ADm is found and is used for removing the noisy pixel. The process of increasing the window size is repeated until a proper pixel for replacing noisy pixels is not found .After finding the proper pixel the noisy pixel x_{ij} is replaced using eq (5),

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III. EXPERIMENT AND RESULT

Experiments were conducted to check the performance of proposed filter (DPF), and comparing the performance with other filters like standard median (SMF) filter, adaptive

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median (ADMF) filter, high performance detection (HPDF) filter and modified decision based unsymmetrical trimmed median filter (MDBUTMF). Peak Signal to Noise Ratio (PSNR) is used to measure the results quantitatively. The degree of similarity between the restored and original image describe the accuracy of the filter. Higher is the value of PSNR higher is the reconstruction quality. Performance evaluation was done on both gray scale and colored images. First variable density salt-and-pepper noise ranging from 30% to 90% is applied to the images for contaminating the image and then it is tested using different filters. The comparison of PSNR values of different filters for Lena image of size (512 * 512) at different noise densities is shown in Table 1.

Table 1: Comparison of different filters based on PSNR values for Lena image using different noise densities.

Method	PSNR in dB						
	30%	40%	50%	60%	70%	80%	90%
SMF	22.1	18.1	14.8	12.0	9.9	8.1	6.6
ADMF	28.3	27.0	25.6	24.3	23.1	20.4	17.4
MDBUTMF	32.1	30.3	28.0	26.1	24.3	21.6	18.1
HPDF	32	31	30.2	29.1	28.7	27.6	25.4
DPF	34	32.9	31.1	30.2	29.6	28.3	26.6

The graphical representation of the results obtained is shown in Fig 1.

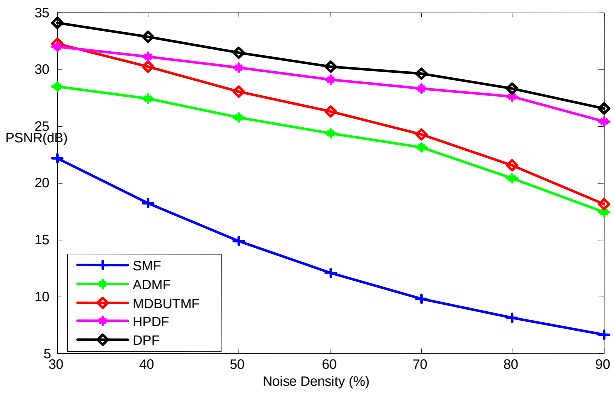

Fig.1 PSNR of different filters

To visually compare the results obtained from different filters are shown in fig. 2 and 3.From the results is can be observed that the proposed filter is giving the best results among all the other state of the art filters even at very high density of noise. The restored images from other filters contain patches due to incomplete removal of noisy pixels or blurring in the image.
The performance of SM filter is very low. In case of ADMF results obtained are not very good due to the the increment in the window size to a great extent, as a result of which the image loses its originality.

In case of MDBUTMF resultant image contain patces because of the replacement of the center pixel with the mean of the window; which is not a part of the original.

HPDF gives better results as compared to other filters but the result obtained from DPF is still better than HPDF also.

The main reasons that DPF performs better as compared to other methods is that in this filter the size of the window taken is increased only when the selected portion of the image contains variable noise .In rest of the cases the noisy pixel is replaced from the predefined window of size 3 x 3 as r result of which the original information in the image is not lost.
The result of the proposed filter on colored Images contaminate with high noise density is shown in Fig.4.It can be seen that DPF also works well for colored images also.

Fig. 2 (a) image contaminated with 60% density of salt-and-pepper noise. Results obtained using (b) SMF (c) ADMF (d) MDBUTMF (e) HPDF (f) Detail Preserving Filter

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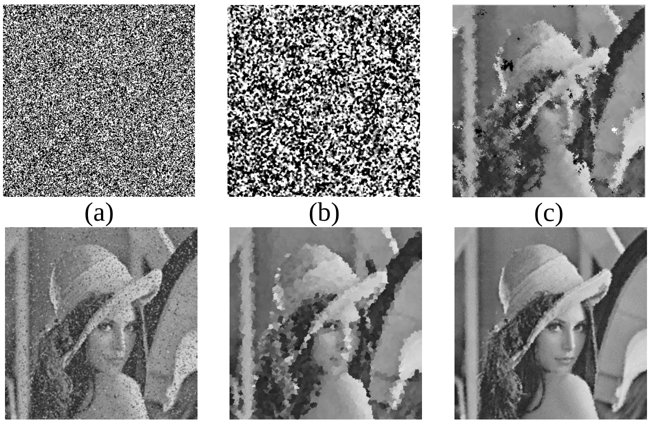
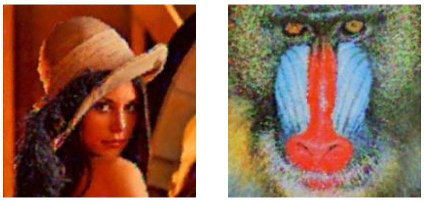


(a) (b) (c)
(d) (e) (f)

Fig.3 (a) image contaminated with 90% of salt-and-pepper noise. Results obtained using (b) SM F(c) ADMF (d) MDBUTMF (e) HPD (f) DPF



(a) (b)

Fig.4 Results obtained using DPF for colored images with 95% density salt-and-pepper noise.

IV. CONCLUSION

In this paper, an algorithm for preserving the details and denoising an image consisting high density salt-and-pepper noise is proposed. The algorithm in the first stage identifies the pixels containing noise. In the next step it replaces the noisy pixels with the appropriate value depending upon three different categories of pixels .The first category is isolated noisy pixel, second category consists a cluster of noisy pixels in the image and in the third category noisy pixel is a part of a uniform region of image containing no noise. From the results obtained it can be concluded that the filter provides better denoising and detail preservation than the other filters. The peak signal to noise ratio also shows that the proposed method works better as compared to other methods.

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