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A Study on Various Algorithm for Salt and Pepper Noise Removal

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Abstract-- **An image is the collection of information, in which it is acquired from digital cameras and these images are often corrupted by noise during transmission due to motion, out of focus problem in the cameras, cloudy weather, atmospheric turbulence, due to sensors, etc. Restoration of noise is an important task in image processing and it is useful for obtaining perfect output from image segmentation, feature extraction, classification and various processes in image processing. Many challenging algorithms were developed for the removal of noise in image. This paper elucidates various filtering algorithms with their merits and demerits in detail for the removal of salt and pepper noise in image.**

I. INTRODUCTION:

During image acquisition or transmission, digital images are contaminated by impulse noise. There are two types of impulse noise such as salt and pepper noise and random-valued noise [1, 2]. If the image is corrupted by salt and pepper noise, the noise pixels are described by maximum and minimum value in the dynamic range. The maximum value considered is 255 and the minimum value is 0 for 8-bit pixel. The corrupted image is recovered using common preprocessing step. This step helps to remove the noise and to obtain better visual properties for further processing [3]. There are two types of filter such as linear and non-linear filter which are used for the purpose of noise removal.

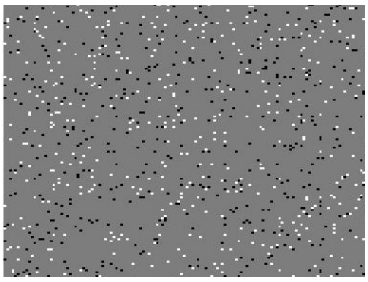

Figure 1: Salt and pepper noise

The most efficient and popular method is Median Filter, under the type of non-linear filter [4]. In a Median Filter (MF), first 3*3 sliding window is taken, and checked whether the fifth pixel of the corresponding window is noisy or not, if it is noisy then the respective pixel value is replaced by median value of the current sliding window. MF is good for smoothing regions and effective for low noise edges. If the noise is over 50% then the original image is corrupted by blurred and distorted features [5].

II. REPRESENTATION OF A DIGITAL IMAGE

A 2-dimensional digital image can be represented as a 2-dimensional array of data I(x, y), where (x, y) represents the pixel position [6]. The pixel value corresponds to the brightness of the image at position (x, y). Some of the most frequently used image types are binary, gray-scale and color images [7].

Binary images are the simplest types of images where data can take only two discrete values, black and white. The value "0" represents black, while the value "1" represents white colour. They are also referred to as 1 bit/pixel images.

Gray-scale images are known as monochrome or one-colour images. They represent no colour information, but represent the brightness or intensity of the image. This image contains 8 bits per pixel data and the grey image has 255 different brightness levels. A "0" represents black and "255" denotes white. As they contain the intensity information, they are also referred to as intensity images.

Colour images are called three band monochrome images, in which each band is a different colour. Each band provides the brightness or intensity information of the corresponding spectral band. Normal colour images are Red, Green and Blue, they are also referred to as RGB images. This is 24 bits per pixel image.

III. DENOISING CONCEPT:

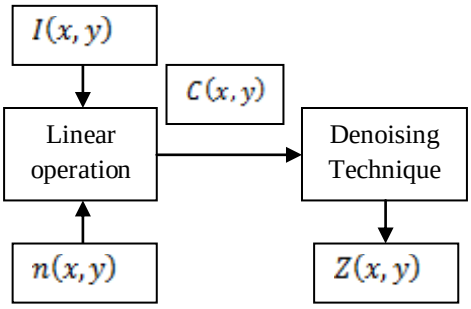

Figure 2: Denoising Concept

Figure 2 illustrates the denoising concept, where n(x,y) denotes the addition or multiplication of noise to an image I(x,y). Once the noise is added to the image, then the original image is corrupted. The corrupted image is denoted as C(x,y). Then several denoising techniques are used to remove the noise from an original image. The final output image is called denoised and it is denoted as Z(x,y).

IV. SEVERAL METHODS

A. *Adaptive MediAn and switched median filter*

Adaptive Median Filtering (AMF) was proposed to overcome the problem of the previous filter, in which the window size is repeatedly increased until it finds a non-

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noisy pixel as a median or it reaches the maximum size of the window. However, the computational complexity of the AMF increases, especially at a high density of impulse noise [8]. A simple solution for this problem [9] is to apply these filters selectively, such that only noisy pixels undergo the filtering operation. This solution requires a detection mechanism to identify candidate noisy pixels in the image reliably. These filters are usually referred to as Switching Median Filters [10 and 11]. The key issue in Switching Median Filters (SMF) is to detect the noisy pixels. Strategy-based filters produce much better results because the importance of specific samples in the current filtering window is well considered by them. However, these filters also process each pixel, even the ones that are not corrupted by noise [12 and 13].

B. Weighted Filter:

Weighted Median Filter (WMF) [14], Center-Weighted Median Filter (CWMF) [15] and Adaptive Center-Weighted Median Filter [16], uses the centre pixel and performs better for slightly corrupted images, but it doesn't provide better performance than MF [17] for highly corrupted images. These types of filters have no distinction between noise and noise-free pixels. Adaptive Weighted Mean filter [18], operation is similar to AMF. In this function, it increases their filtering window size until the equal minimum and maximum value between two successive windows is obtained. After this process, each pixel is assigned depending on minimum and maximum intensity value in the filtering window and the central pixel is replaced with weighted mean.

C. Decision Based Algorithm

In Decision Based Algorithm (DBA) [19], the image is denoised using 3×3 sliding window. In the operation, if the respective processing pixel is contaminated by noise such as 0 or 255, then the noisy pixel is replaced by their neighbouring pixel. This repetition is continuous for overall image through sliding window. Due to this replacement of neighbouring pixel, streaking effect is produced in the original image [20]. To address this problem, Decision Based Unsymmetric Trimmed Median filter is proposed [21].

Modified Unsymmetric Trimmed Mean Filter (MUTMF) is proposed based on Modified Decision Based Median Algorithm (MDBMA) and cascaded filter is proposed in [22]. Here, it is to be checked whether the processing in selected window is noisy or noise free pixels. If the processing pixel in the selected window is noise-free pixel, then it is considered as a denoised image. If it is noise pixel, then 0 and 255 are eliminated from the selected window and median value of the remaining pixel is taken. Finally the noisy processing pixel is replaced by the resultant median value. From the output of MDMBA, the difference is calculated in four direction edges of the window and excluding those which contains 0 and 255. Among four directions, the mean of the edge intensity is to be founded. If the edge intensity is not equal to 0 and 255, then the edge difference is chosen as processing pixel.

In the second case, the processing pixel is selected in the selected window from MDBMA. All the 0 and 255 from selected window is taken and stored as a 1D vector. If the length of the vector is equal to 0, then the size of the sliding window is increased and the process is repeated. If it is not equal to 0, then the processing pixel is replaced by means of a 1D array. Finally, cascaded filter is applied to the selected window.

D. Unsymmetric Trimmed Median Filter

Trimmed Median Filter (TMF) [1] is a decision based Unsymmetric filter. It consists of two stage filter. First, it detects the noisy pixel and noise-free pixel. On the first stage, if the entire pixel in the selected sliding window consists of noise, then the center pixel of processing pixel is replaced by means of the respective sliding window. In the second stage, if both noise and noise- free pixels are present in the sliding window, then processing pixel is replaced by a noise –free pixel in the respective sliding window. TMF has a drawback of producing false colour in the denoised image, due to first stage process.

E. Decision Based Unsymmetric Trimmed Median filter

Decision Based Unsymmetric Trimmed Median Filter (DBUTMF) is proposed [21]. At high noise densities, if the selected window contains all 0 or 255 or both then trimmed median value cannot be found. So this algorithm does not give better results at very high noise density, which is at 80% to 90%. To alleviate this problem, Modified Decision Based Unsymmetric Trimmed Median Filter (MDBUTMF) [22] is used for the removal of salt and pepper noise in the image. MDBUTMF is processed under two stages, first it checks whether the processing pixel is noisy or noise free. On the first stage, if the processing pixel in a selection of window is noise free then it is considered as denoised image. In the second stage, if the processing pixel is noisy, under this stage, two cases are available. First it checks whether the selected window contains not all the elements are 0 and 255. Then the noisy pixel is eliminated and median value for remaining pixel is taken and the noisy pixel is replaced with median value. In the second case, if the entire element in a selected window contains 0 and 255, then the mean value is taken for whole window and the noise pixel is replaced with the mean value.

To improve denoise in Unsymmetric Trimmed Median, Unsymmetrical Trimmed Modified Winsorized Mean Filter (DBUTWMF) is proposed [23], which has two stages for the removal of noise in the image. In the first stage, if the processing pixel in the selected window is noise free then it is considered as denoised image. If the processing pixel is noisy, then 2D array is converted into a 1D array. Two cases are available in second stage.

In the first case, if the processing pixel is noisy, then the noise pixel is eliminated from the sorted array. Then the remaining pixels in the selected window are sorted. In this case smallest and largest values are replicated again. The mean of this new array is taken and noisy pixel in selected window is replaced by this resultant mean value.

In the second case, if the entire element in selected window contains 0 and 255, then the noisy pixel is replaced by means of the selected window.

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F. *Neighborhood Mean Filtering (NMF):*

An algorithm for recovering highly corrupted image from impulse noise is proposed in [24], where the sliding window size of 3×3 is to be selected from the original image. For finding the noises in the gray level pixels, the window is divided by four. After division, the maximum and minimum value is found with the respective window. If the processing pixel is greater than or less than the follow-on minimum and maximum value, then it is considered as a denoised image. If it is not like that, then the processing pixel is a corrupted noise. The size of the window is increased and again the gray value is to be divided by 4.

If all of the pixels in the window are noisy, the window size is 5 × 5, then the mean of the three previously calculated neighbors can be used as the gray level value of the noisy pixel. Finally, the mean and median value for this window is calculated and to find which of them is near to maximum and minimum value. Then the respective value is used to replace the noisy pixel.

Neighborhood Mean Filtering (NMF) approach is proposed in [25]. Here if the processing pixel is noisy then it is replaced by means of this neighborhood pixel. This method overcomes the drawbacks of DBA algorithm. The drawback of NMF method is the low density noise.

G. *RECURSIVE AND ADAPTIVE MEDIAN FILTERING (RAMF)*

To address this problem, Recursive and Adaptive Median Filtering (RAMF) are proposed in [26], where the preprocessing pixel is checked whether it is noisy or noise-free. If it is noise-free, then its value is left unchanged. But if the processing pixel is noisy, RAMF contains two cases. In the first case, if the window contains one or more noise-free pixel, then the noisy pixel is replaced with a median value of remaining noise-free pixels.

In the second case, if all the pixels in respective window are noisy, then this case consists of two sub-cases.

In the first sub-case, the sliding window size is increased from (3 × 3) to (5 × 5), this window contains one or more noise –free pixels, and then noisy pixel is replaced by the median of the remaining pixel.

In second sub-case, if all pixels of this (5 × 5) window are noisy, then the noisy pixel is replaced by the median of already processed four adjacent neighboring pixels in the (3 × 3) window.

V. CONCLUSION:

This paper analyses linear and nonlinear filtering techniques for denoising an image. These filters are used for the removal of salt and pepper noise from an original image. Each algorithm provides their advantage and disadvantage of the techniques. Mean filter is concentrated only in a small portion of the image, and it is very easy to implement. Median Filter provides better performance than Mean Filter.

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