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Difficulty in Estimation of Salt and Pepper Noise and Suitability of Median Filter to Remove IT from Images

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Abstract— *Salt and pepper noise is an example of impulsive noise which may introduce in the images due to malfunctioning of the pixel elements in the camera sensors, faulty memory locations or timing errors in the digitization process. It can also be introduced due to transmission error. It appears as black and white dots in the images. In the gray scale images white dot have maximum intensity, which is called salt noise and its value is 255's while black dots have minimum intensity which is called pepper noise and its value is 0's. This is a highly non-Gaussian noise signal hence it cannot be removed by using those filters which are suitable to remove those noise signals which have spectral density with Gaussian distribution. Before applying any denoising technique; noise estimation must be required so that efficiency of applied method can be compared with other existing methods. In this paper a noval approach is discussed which can be used to estimate salt and pepper noise signal from the corrupted image. We have also discussed the difficulty and problems come in the estimation of impulsive noise signal. Many filters have been developed to remove salt and pepper noise signals from the images. Among all those filters median filter is very popular filter for removing salt and pepper noise signal. In this pepper suitability of adaptive median filter is also discussed to remove salt and pepper noise.*

Keywords— *salt & pepper noise,median filter, PSNR, MSE.*

1. INTRODUCTION

Images are playing a pivotal role in our daily life. In many areas images are used extensively. Various areas are medical, astronomy, survilliance, law enforcement, remote sensing etc. We can store the images by using memory devices and can retain them for a long and very long duration. Images are two-Dimensional data and this data can be sent from one place to another via different media. Technically the sending end is called the transmitter and the receiving end is called receiver. The media which is to be used to transmit the data is called channel. Ideally a channel must be noise free but practically a noise free channel is not possible and there is some probability of occurrence of error due to introduction of noise signals[1]. Image processing is an area of research with many scopes by which we can serve to society. Now a day image processing reaches to its higher level and its area has become wider and much wider. It includes many applications viz. communication, broadcasting, surveillance, defense, medical etc. Images are stored in the memories and they are transmitted and received from one point to other point; due to which errors occur because media is used to transmit the data and it can never be noise free. If any error occurs in the transmission are reception of the image signals; noise introduces in the images and these noise appears like small dots. In a gray scale images; these noise signals appears as black and white dots. If the level of quantization is 256 i.e. 8 bits are used to represent the intensity of pixel values then the highest intensity is 255 and lowest intensity is 0. Salt and Pepper noise[1-14] typically cause error in pixel elements in camera sensors, faulty memory locations, or timing errors in the sampling process. Salt and Pepper noise can take only the maximum and minimum values in the dynamic range (0,255) and occurs impulsively at pixel positions.

Figure 1 shows a lena image which is corrupted by salt and pepper noise. It is highly corrupted image. To restore the image; median filter is used. However it smothen the image as shown in figure 2.

Fig. 1: Lena image corrupted by salt and pepper noise.

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Fig. 2: lena image denoising by median filter

The rest of the sections are organized as follows: section 2 is an overview of the previous research work. Section 3 describes the methodology in which two different approaches are discussed. In section 4 suitability of median filter is discussed to remove salt and pepper noise. Section 5 gives the conclusion and future scope for work.

2. LITERATURE REVIEW

So far various methods have been proposed by many researchers. Some of the methods are mentioned below.

Esakkirajan et al. (2011) proposed a modified decision based unsymmetrical trimmed median filter algorithm to denoise the gray scale and color images which are highly corrupted by salt and pepper noise. In this algorithm the noisy pixel is replaced by trimmed median value when other pixel values, 0's and 255's are present in the selected window. If all the pixel values are 0's and 255's then the noise pixel is replaced by mean value of all the elements present in the selected window. This algorithm outperforms the other existing methods in terms of Peak Signal-to-Noise Ratio (PSNR) and Image Enhancement Factor (IEF)[1].

Duan et al.(2010) presented a highly effective algorithm to detect the impulsive noise. It consists of two iterations to make the decision as accurate as possible. Two robust and reliable decision criteria are proposed for each iteration. The simulation results show that the false alarm rate and miss detection rate both are very low and it outperforms existing state-of-the-art algorithms. Also, the proposed algorithm is easy to implement because of uncomplicated structure[2].

Khammar et al.(2014) implemented a denoising method to remove high density salt and pepper noise. If the density of noise is higher; then the quality of the image tremendously decreases and denoising becomes a difficult task. The proposed method is an optimal method to suppress the high density noise signals which is based on a nonlinear filter and decision-based approach. A 3×3 fix window scans the image from top-left to bottom-right of the image pixel by pixel. The size of window is taken as smaller as possible which saves the more details and it avoids the image blurring. It consists of two steps; first is the detection of the corrupted pixels and second is the restoration. Detection is provided by using statistical analysis in each window, then the appropriate replacement for the noisy pixel is done from given values inside the current window or adjacent reconstructed pixels based on mean calculation. The reconstruction is based on a recursive approach. Experimental results show that the algorithm suppresses high density salt and pepper noise. It is not computationally complex and the time consumption is also reasonable[4].

Zhang et al.(2009) proposed a switching-based adaptive weighted mean filter to remove salt-and-pepper noise from the images. It is a two-stage algorithm; in first stage, the directional difference based noise detector is used to identify the noisy pixel. It compares the minimum absolute value of four mean differences between the current pixel and its neighbors in four directional windows with a predefined threshold. Then, the adaptive weighted mean filter is adopted to remove the detected impulses by replacing each noisy pixel with the weighted mean of its noise-free neighbors in the filtering window. The proposed filter outperforms many other existing algorithms in term of noise detection, image restoration and computational efficiency.

Toh et al. (2010) presented a novel two-stage noise adaptive fuzzy switching median (NAFSM) filter for detecting and removing the salt-and-pepper noise. The detection stage utilizes the histogram of the corrupted image to identify noise pixels. Now the detected noise pixels are subjected to the second stage for filtering process. In this process noise-free pixels are retained and left unprocessed. Then, the NAFSM filtering mechanism employs fuzzy reasoning to handle uncertainty present in the extracted local information as introduced by noise[6].

Chan et al.(2005) proposed a two-phase scheme to remove salt-and-pepper noise. In the first phase, an adaptive median filter is used to identify pixels which are likely to be contaminated by noise they are called as noise candidates. In the second phase, the image is restored using a specialized regularization method that applies only to those selected noise candidates. This method preserves edges and suppresses noise efficiently as compared to nonlinear filters or regularization methods only. This method can remove high density salt-and-pepper-noise.

Santibañez et al.(2014) introduced Several morphological transformations for detecting the noise. There are two methods to detect noise first method is by using a contrast measurement and second is by applying different proximity criteria into several proposed toggle mappings[8].

3. METHODOLOGY

In this paper estimation of salt and pepper noise has been proposed using two different approaches. One method relates the number of black and white dots with the noise variance of salt and pepper noise and second method relates the mean square error between the original and noisy images.

3.1 First Approach

In this method original image is firstly corrupted by salt and pepper noise with a fixed noise varience which results in a noisy image. Now numbers of black and white dots are to be counted in the noisy image. However this counting of black and white dots cannot give the exact estimation of salt and pepper noise signal present in the noisy image because there might be many pixels which have either 0 or 255 value and they may not be the noisy pixels; in other words some of the pixel values 0 and 255 may be the element of the original image. For example if we consider a very popular image cameraman.tif which contains many black and white pixels having 0 and 255 values respectively. Hence if we count the numbers of black and white pixels only then it will not give the exact value of noise variance of salt and pepper noise.

Fig. 3: Cameraman image

Therefore this method is failed to estimate the noise level. However some modification can be done in this estimator in such a manner that if black and/or white pixels having 0 and 255 values respectively are not the noisy pixels then they are not to be counted. For this purpose 3x3 window must be chosen; if all the neighbor pixels are either 0 or 255 it means that; pixel is not the noisy pixel and if the middle pixel is 0 or 255 and all the neighbor pixels have different values; then it is considered as noisy pixel. However this modification fails if there is an abrupt change in any image. For example; if there is any edges are line of either black or white pixels then also estimation will be wrong for example if any image has fine structures of either black or white in colour then also they can be considered as noisy pixels.

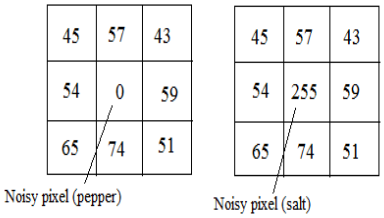

Fig. 4

3.2 Second Approach

In this approach an original image is firstly corrupted by salt and pepper noise with a fixed noise variance to get the noisy image. This noise corrupts the original image by introducing the white and black dots due to which there would be a mean square error between original image and the noisy image. This error can be used as a parameter to estimate the level of noise in the noisy image. This process is repeated many times with different noise level at different images. Finally a relationship can be obtained between the noisy variance and the MSE between the original and noisy images.

Mean Square Error (MSE) is used as the performance parameters in many research papers but in this paper it is used as a parameter to calculate the noise level present in the noisy image in terms of noise variance.

MSE between the noisy and original image and is given by:

$$\text{MSE} = \frac{1}{M}\sum_{i=1}^{M}(g_i - f_i)^2$$

Where g_i is the i^{th} pixel of noisy image

f_i is the i^{th} pixel of original image

M is the total number of pixels

Second approach is better than the first approach because if we calculate MSE between original and noisy image than there may be a relationship between MSE and noise variance. First method increases the chance of mistake in counting of black and white noisy dots because in many images these dots may be the part of the images. Hence modification is requied in the first method.

4. SUITABILITY OF MEDIAN FILTER TO REMOVE SALT AND PEPPER NOISE:

Many filters have been proposed to remove additive and multiplicative noise signals which removes the noise signals from the images and gives good resuts in terms of Peak signal to noise ratio(PSNR); but these filters are failed to remove impulsive noise. However if we calculate the PSNR value between original and noisy image then we get very high value of PSNR because impulsive noise does not affect all the pixel values but affects very few pixels; due to which MSE between both the images is very less and PSNR values becomes high.

Many modification have been done in median filter because the prototype median filter changes all the pixel values. It calculates the median of all the neighbor pixels and replaces the center pixel. If center pixel is noisy pixel then it is good to replace but if it is not noisy pixel even then it is replaced with the fact that the neighbor pixels have almost same pixel value. But due to median filter the denoised image becomes blurred.

5. CONCLUSION AND FUTURE SCOPE

Many methods have been proposed for denoising the images which is an essential preprocessing task. Various types of noise signals corrupt the images; due to which the quality of images gets reduced and many information are suppressed. The performances of filters depend upon various filters viz. type of the images, type of noise signals etc. One filter outperforms to remove Gaussian noise but fails to remove impulsive noise and vice versa. Many estimators have been developed to know the noise level present in the noisy images but still it is very difficult to estimate exact amount of noise in the noisy images. In this paper estimation of salt and pepper noise is discussed using two different approach. First approach is not appropriate because it is dependent upon the total number of noisy pixels; which is a difficult task. Second approach is more practical because MSE is used as a parameter for noise estimation. Suitability of median filter is also discussed for the removal of salt and pepper noise from the images. Many modifications have been done for the betterment of the result because prototype median filter results in a blurred image.

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