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A SURVEY ON METHODS OF REMOVAL OF SALT AND PEPPER NOISE

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Abstract*—Image restoration is the process of restoring degraded images which cannot be taken again or the process of obtaining the image again is costlier. We can restore the images by prior knowledge of the noise or the disturbance that causes the degradation in the image. Image restoration is done in two domains: spatial domain and frequency domain. In spatial domain the filtering action for restoring the images is done by directly operating on the pixels of the digital image. In frequency domain the filtering action is done by mapping the spatial domain into the frequency domain by taking Fourier transform of the image function. By mapping the image into frequency domain an image can provide an insight for filtering operations. After the filtering, the image is remapped into spatial domain by inverse Fourier transform to obtain the restored image. Different noise models were studied. Different filtering techniques in both spatial and frequency domains, were studied and improved algorithms were written and simulated using Matlab. Restoration efficiency was checked by taking peak signal to noise ratio (PSNR) and mean square error (MSE) into considerations

***IndexTerms*— Adaptive median filter, Decision based filter, Median filter, Weiner filter, Salt-and-pepper noise**

I. INTRODUCTION

Image De-noising is one of the fundamental problems in image processing and computer vision. The major concern in image processing is estimation of pixel values. For example, interpolation or resizing is to estimate plausible pixel values located between known ones while de-noising or de-blurring is to estimate clean pixel values from corrupted ones. Filling missing parts of an image in order to obtain a visually plausible outcome is the problem addressed in three distinct but related fields of study [1]. Image de-noising is an important image processing task, both as a process itself, and as a component in other processes. Very many ways to de noise an image or a set of data exists. The main property of a good image de-noising model is that it will remove noise while preserving edges. Traditionally, linear models have been used. One common approach is to use a Gaussian filter, or equivalently solving the heat-equation with the noisy image as input-data, i.e. a linear, 2nd order PDE model [2]. For some purposes this kind of de-noising is adequate. One big advantage of linear noise removal models is the speed. But a drawback of the linear models is that they are not able to preserve edges in a good manner: edges, which are recognized as discontinuities in the image, are smeared out. Nonlinear models on the other hand can handle edges in a much better way than linear models can. One popular model for nonlinear image de-noising is the Total Variation (TV) filter, introduced by Rudin, Osher and Fatemi. This filter is very good at preserving edges, but smoothly varying regions in the input image are transformed into piecewise constant regions in the output image [3]. The noisy pixel is replaced by the median/mean/mid-point value of the window or by its neighborhood values. For high density salt and pepper noise it might so happen that the replaced pixel (median/mean) might be a noisy pixel which does not help in suppression of noise. The Modified Decision Based Unsymmetric Trimmed Median Filter replaces the noisy pixel by the trimmed median value (excluding the either 0 or 255 the noise pixel is replaced by the mean value of all the elements present in the current window [4]

II. VARIOUS SOURCE OF NOISE

Noise is introduced in the image at the time of image acquisition or transmission. Different factors may be responsible for introduction of noise in the image. The number of pixels corrupted in the image will decide the quantification of the noise. The principal sources of noise in the digital image are: a) The imaging sensor may be affected by environmental conditions during image acquisition. b) Insufficient Light levels and sensor temperature may introduce the noise in the image. c) Interference in the transmission channel may also corrupt the image. d) If dust particles are present on the scanner screen, they can also introduce noise in the image.

Noise is the undesirable effects produced in the image. During image acquisition or transmission, several factors are responsible for introducing noise in the image. Depending on the type of disturbance, the noise can affect the image to different extent. Generally our focus is to remove certain kind of noise. So we identify certain kind of noise and apply different algorithms to remove the noise. Image noise can be classified as Impulse noise (Salt-and-pepper noise), Amplifier noise (Gaussian noise), Shot noise, Quantization noise (uniform noise), Film grain, on-isotropic noise, Multiplicative noise (Speckle noise) and Periodic noise. Impulse Noise (Salt and Pepper Noise):- The term impulse noise is also used for this type of noise [5]. Other terms are spike noise, random noise or independent noise. Black and white dots appear in the image [6] as a result of this noise and hence salt and pepper noise. This noise arises in the image because of sharp and sudden changes of image signal. Dust particles in the image acquisition source or over heated faulty components can cause this type of noise. Image is corrupted to a small extent due to noise. Show the effect of this noise on the original image (Fig 1).

Figure 1: Original Image without Noise, Image with Salt & Pepper Noise

Gaussian Noise (Amplifier Noise):- The term normal noise model is the synonym of Gaussian noise. This noise model is additive in nature [7] and follow Gaussian distribution. Meaning that each pixel in the noisy image is the sum of the true pixel value and a random, Gaussian distributed noise value. The noise is independent of intensity of pixel value at each point.

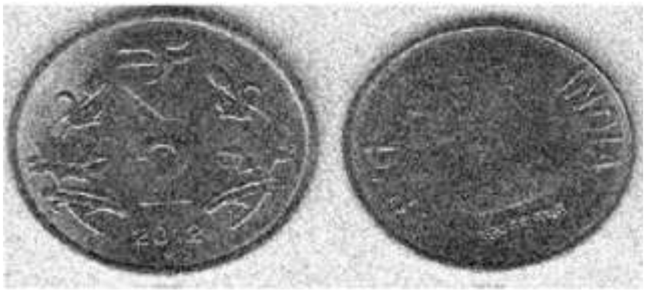

Figure 2: Gaussian noise

Poisson Noise (Photon Noise):- Poisson or shot photon noise is the noise that can cause, when number of photons sensed by the sensor is not sufficient to provide detectable statistical information [4]. This noise has root mean square value proportional to square root intensity of the image. Different pixels are suffered by independent noise values. At practical grounds the photon noise and other sensor based noise corrupt the signal at different proportions [3].

Figure 3: Image with Poisson noise

Speckle Noise:- This noise is originated because of coherent processing of back scattered signals from multiple distributed points. In conventionalradar system this type of noise is noticed when the returned signal from the object having size less than or equal to a single image processing unit, shows sudden fluctuations.

Figure 4: Image with speckle noise

III. Image Denosing

Image de-noising is very important task in image processing for the analysis of images. Ample image de-noising algorithms are available, but the best one should remove the noise completely from the image, while preserving the details. De noising methods can be linear as well as non-linear. Where linear methods are fast enough, but they do not preserve the details of the images, whereas the non- linear methods preserve the details of the images. Broadly speaking, De-noising filters can be categorized in the following categories:

- Adaptive Filter
- Order Statistics Filter
- Mean Filter
- Averaging
- Median Filter

Adaptive Filter: - These filters change their behavior on the basis of statistical characteristics of the image region, encompassed by the filter region.BM3D is an adaptive filter. It is a nonlocal image modeling technique based on adaptive, high order group-wise models. This de-noising algorithm can be divided in three steps [7-8]:

1. Analysis. Firstly similar image blocks are collected in groups. Blocks in each group are stacked together to form 3-D data arrays, which are de-correlated using an invertible 3D transform.
2. Processing. The obtained 3-D group spectra are filtered by hard thresholding.
3. Synthesis. The filtered spectra are inverted, providing estimates for each block in the group. These block wise estimates are returned to their original positions and the final image reconstruction is calculated as a weighted average of all the obtained block-wise estimates.

Order Statistics Filter: **-** Order-Statistics filters are non-linear filters whose response depends on the ordering of pixels encompassed by the filter area. When the center value of the pixel in the image area is replaced by 100th percentile, the filter is called max-filter. On the other hand, if the same pixel value is replaced by 0th percentile, the filter is termed as minimum filter. In this filtering technique, the pixel is replaced with the median of the neighboring pixels. A window is chosen, which vary for the 1D signal and 2D signals, and the window slides over each pixel value. Some issues with median filter includes that the majority of the computational effort and time is spent on calculating the median of each window.

Mean Filter:- Mean filter is an averaging linear filter [6]. Here the filter computes the average value of the corrupted image in a predecided area. Then the center pixel intensity value is replaced by that average value. This process is repeated for all pixel values in the image. Figure 5-8, show the effect of using mean filter of size 5X5 on different types of noise.

Figure 5: Mean Filter used on Salt Pepper Noise

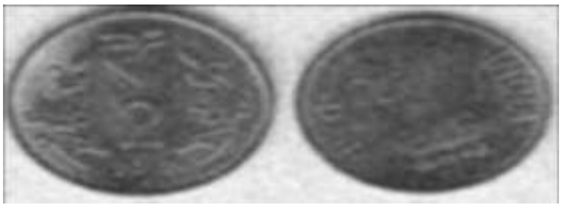

Figure 6: Mean filter used on Gaussian noise

Figure 7: Mean filter used on Poisson noise

Figure 8: Mean filter used for Speckle noise

Averaging Filter:- The averaging filter is used to restoring gray scale and color images highly corrupted by salt and pepper noise and overcoming the drawback of mean filter. As in mean filter here also first the corrupted pixel is detected and then one of the below case is applied to that pixel: Case 1: If the selected window contains noisy pixel (255 or 0) and all the neighboring pixel values are also noisy pixels, then their median value will also be noisy. Hence to avoid this, the mean is calculated of the pixels in the selected window and the noisy pixel is replaced by that value. Case 2: If the selected window contains noisy pixel (255 or 0) and some of the neighboring pixel values are noisy, then their median value will also be noisy. Hence to remove noise from the image, 1-D array of the selected image region is obtained so that the 0/255 values will be eliminated and after this the median of remaining values is calculated and the noisy pixel value is replaced by this value. Case 3: If there is no noisy pixel in the selected window, then no changes are done and the pixel value is left unchanged. This algorithm shows better results than the other filters but the drawback is that it leads to blurring of the image at higher noise densities.

Median Filter: **-** Median filter is a best order static, non- linear filter, whose response is based on the ranking of pixel values contained in the filter region. Median filter is quite popular for reducing certain types of noise. Here the center value of the pixel is replaced by the median of the pixel values under the filter region [9] [10]. The median filter is a non-linear filtering technique which is used to remove noise. In this filtering technique, the pixel is replaced with the median of the neighboring pixels. A window is chosen, which vary for the 1D signal and 2D signals, and the window slides over each pixel value. Some issues with median filter includes that the majority of the computational effort and time is spent on calculating the median of each window. As the filter must process every entry in the signal therefore for large signals, the efficiency of median calculation is a critical in determining how fast the algorithm can run. Also median filter is only effective at low noise densities and fails at higher noise densities.

Modified Median Filter: - The Modified median filter algorithm is a variation to Decision Base Partial Trimmed Global Mean Filter or DBPTGMF algorithm. The major drawback of DBPTGMF algorithm [6], is when a selected window contains only 0 and 255 value then the restored value is either 0 or 255(again noisy), leads us to propose MDBPTGMF. In this algorithm when a selected window contain both the 0 and 255 values then the processing pixel is replaced by mean value of the selected window. The detail of the algorithm is given below.

Algorithm:

Step 1: Select a 3 x 3 2-D window. Assume that the processing pixel is Pij, which lies at the center of window.
Step 2: If 0 < Pij< 255, then the processing pixel or Pij is uncorrupted and left unchanged.
Step 3: If Pij = 0 or Pij = 255, then it is considered as corrupted pixel and four cases are possible as given below.
Case i): If the selected window has all the pixel value as 0, then Pij is replaced by the Salt noise (i.e. 255).
Case ii): If the selected window contains all the pixel value as 255, then Pij is replaced by the pepper noise (i.e. 0).
Case iii): If the selected window contains all the value as 0 and 255 both. Then the processing pixel is replaced by mean value of the window.
Case iv): If the selected window contain not all the element 0 and 255. Then eliminate 0 and 255 and find the median value of the remaining element. Replace Pij with median value.
Step 4: Repeat step 1 to 3 for the entire image until the process is complete.

IV. Conclusion

This paper reviews techniques for removal of salt-and-pepper noise from images. Salt-and-pepper noise is a frequently encountered noise during image acquisition. Salt-and-pepper noise is impulsive in nature. It can be removed/reduced using linear and non-linear filtering techniques.In this paper, we have discussed different types of noise that creep in images during image acquisition or transmission. Light is also thrown on the causes of these noises and their major sources. In the second section we present the various filtering techniques that can be applied to de-noise the images. Experimental results presented, insists us to conclude median filters performed well. Whereas averaging and minimum filters are performed worst. Median filter is the best choice of removing the Salt and pepper noise. In further work of my dissertation is modified median filter and improved PSNR (peak signl noise ratio) and reduced mean square error (MSE) for gray an color image.

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