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A Study on Image Denoising with its Techniques and Types of Noise

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Abstract—Now a days digital images is used in transformation of visual image and it is becoming a communication method. But obtained image is free from noise is difficult task. The generated received image required processing before to be used in any form of applications. Denoising in image involves the working of image data to produce high quality image. In this paper present a survey in which study of various researches, their technique, type of noise, and various filters.
Keywords—Gaussian noise, Salt and Pepper noise, Mean filter, Median filter.

I. INTRODUCTION

Generally, noise is introduced into the image during image transmission. The added noise will be of various kinds like additive random noise (Gaussian noise), salt and pepper noise, etc. Depending on the type of the noise, the degradation of the image will vary. According to the percentage of image quality degradation, the noise removal techniques must be chosen. The traditional methods of noise removal include NLM filter, Total Variation (TV) method, Shrinkage models and different transforms. The wavelet transform, curvelet transform and wave atom transforms are the efficient transforms for image denoising algorithms. Some of the techniques are using fuzzy logic and other tools.

Most of the noise removal techniques suggested till now are based on what type of noise is introduced. Also the application to which the image and video are to be used, decides the required noise removal algorithm. Section I demonstrates the different types of noises and the method of reducing them. Section II deals with the schemes of denoising procedures applied till now for better noise reduction performances and a comparison between several parameters is done. Section III concludes the discussion of all specified algorithms and the method to be proposed for improving image enhancement. This is followed by the references.[1]

Digital images are often distorted by impulse noise during data acquisition, transmission and storage. Noise can enter through image acquisition by a camera, scanner, and recording and/or when the image is transmitted over a noisy channel. Salt-and-pepper noise is a special case of impulse noise, where a certain percentage of individual pixels are randomly digitized into two extreme, intensities, maximum and minimum [2]. The must to the eliminate salt-and-pepper noise is most significant before subsequent image processing tasks are carried out because of the contamination of image by salt-and-pepper noise is caused in great amount and the occurrence of noise can severely harm the knowledge or document contained in the main image. The simplest and the traditional way to remove salt-and-pepper noise is by windowing the noisy image with a conventional median filter [3]. Median filters are the most popular nonlinear filters, are extensively applied to eliminate salt and pepper noise due to its outstanding computational efficiency.

The fuzzy inference rules by else action (FIRE) filter introduced by Russo [5] suggests that effective removal of salt and pepper noise can be achieved by using a fuzzy rule base and employing fuzzy sets, although FIRE filter suffered from a drawback that it was not able to remove noise present at the edges. In recent years, many fuzzy rules based filters have been designed which provide better results than the traditional median filters. Fuzzy filters are capable of removing the noise efficiently without distorting the edges and hence keeping the details of the image intact. Haixiang Xu [6] designed a fuzzy switching filter in which the noisy pixel value is replaced by an estimated value which is based on the median and average values of the selected window. Kenny Kal Vin Toh [7] designed a fuzzy switching median filter in which the value of noisy pixel is replaced by an estimated value which in turn depends

upon the luminance difference between the neighboring pixel and the center pixel and employing a linear membership function In this paper, modifications to work of [4] along with the Fuzzy Rule based approach has been proposed to improve the filter performance in salt-and-pepper noise detection and cancellation.

Image denoising plays an essential role in medical image Most of the Medical images have low contrast objects corrupted by random noise in the input process. During transmission and retrieval of an image there is more possibility of corruption. Denoising is basic task required by medical analysis. Noise removal causes blurring of images,the quality of the image is also lowered.Nonlinear models can hold edges in the an improved mid than linear models. The main properties of a good image are denoising model is that it will eliminate noise while preserving edges. Conventional, linear models have been used. One of the general approach is to use filters. For few purposes, this type of denoising is satisfactory. One of the big benefits is linear noise removal models speed. But the disadvantage of linear models is that they are not able to be preserved edges in a well manner. Edges, which are recognized as cutoffs in the image, are tarnished out. Nonlinear models, on the other hand can handle edges in a better way than linear models. Nonlinear filter is a signal processing device where its output is not a linear function of its input. Competence of this paper can be experienced in both real and simulated medical images.Rician noise utmost occurs in MRI.It adds more problems in low SNR.[8]

II. TYPES OF NOISE

In image denoising different types of noise have their own charsctersitics and inherent in images in many ways :

A. Salt and Pepper Noise

This type of noise is represented as random existence of white and black pixels. Such type of noise is to be reduced by using median. Whenever faulty switching takes place, Salt and pepper noise creeps into images.

B. Gaussian Noise

Gaussian noise is statistical noise that has its probability density function equal to that of the normal distribution, which is also known as the Gaussian distribution. In other words, the values that the noise can take on are Gaussian-distributed. A special case is white Gaussian noise, in which the values at any pair of times are identically distributed and statistically.

C. Poison Noise

This type of noise has a probability density function of a Poisson distribution.

D. Speckle Noise

Speckle noise is a rough noise that naturally exists in and corrupts the quality of images. Speckle noise is a increasing noise. The signal and the noise are statistically independent of each other.

III. FEW TECHNIQUES AVAILABLE FOR DENOISING

While classifying the various denoising filters, we classify the filters in 2 broad categories. These are traditional filters and fuzzy based filters.

A. Traditional Filters

These include filters which are traditionally used to remove noise from images. We further divide traditional filters into two classes: - Spatial domain and transform domain.

1) Spatial Domain: In spatial domain various filters like mean filter [9], median filter, all work directly on the input image. It

means they directly work on the pixels of the original image. Out of various spatial based filters, wiener filter [10], gives best performance in the case of Gaussian, Poisson and speckle noise. For impulse noise, median filter [12], outperforms all other filters. Various enhanced median filters like weighted median filter [13] are also used for this purpose.

2) Transform Domain: It is needed when it is necessary to analyze the signal. Here, we transform the given signal to another domain and do the denoising procedure there and afterwards inverse of the transformation is done in order to get final output. There are several transforms available like the Fourier transform, Hilbert transform, wavelet transform, etc. The Fourier transform is probably the most popular transform. Among different Fourier transforms [9] fast Fourier Transform (FFT) is considered the best. However the Fourier transform does not give high performance in case of image denoising. Wavelet transform is better for this purpose [11]. Wavelet transform further provide different methods for removing noise from an image which includes thresholding, non- orthogonal wavelet transform and coefficient model.

B. Fuzzy Based Filters

Fuzzy based filters are those filters which include the concept of fuzzy logic in their filtering procedure. Fuzzy based filters can also be further classified into two categories: fuzzy classical and fully fuzzy

1) *Fuzzy Classical Filters:* Fuzzy classical filters include the filters which extend the traditional filters using fuzzy logic. There are plenty of fuzzy traditional filters on which many researchers have worked. We here mention only some of them. Popular fuzzy classical filters are:

   a) Fuzzy Median Filter (FMF) [16]
   b) Fuzzy Impulse noise Detection and Reduction Method (FIDRM) [14]
   c) Fuzzy Random Impulse Noise Reduction method (FRINR) [15]
   d) Fuzzy Weighted Mean (FWM) [9]
   e) Adaptive Weighted Fuzzy Mean (AWFM) [18] On fuzzy median filter [16], and fuzzy weighted mean filter [17], fuzzy logic is added to enhance the traditional median and mean filters. Fuzzy Impulse noise Detection and Reduction Method [14] and Fuzzy random impulse noise reduction method [15], is a two step method. In the first step, noisy pixels are detected from the input image and after detection procedure, noise is removed from the detected pixels, this forms second step. The fuzzy logic is used in the detection step by forming the fuzzy rules to decide whether the pixel is corrupted with noise or not. In filtering procedure, traditional filters like mean filter, median filter, weighted mean filter etc. are extended using fuzzy logic

2) *Fully Fuzzy Filters:* Fully fuzzy filters are those Denoising filters which are purely based on fuzzy logic and have no connection with traditional methods. Various methods that come under this category are:

   a) Dual Step Fuzzy Inference Ruled by Else-action filter (DSFIRE) [20]
   b) Piecewise Linear Fuzzy Inference Ruled by Else-action Filter (PWLFIRE) [21]
   c) Gaussian noise reduction filter (GOA)[22]
   d) Histogram Adaptive Filter (HAF) [23]
   e) Fuzzy Inference Ruled by Else-action filter (FIRE) [19] There are other available filters. We only mention some of the popular filters only. FIRE [19], filters are a family of nonlinear filters which adopt fuzzy rules to process image data. Dual Step FIRE filter [20], adopts fuzzy reasoning at two different levels in order to cancel noise pulses without damaging fine image structures. DS-FIRE filter is able to largely outperform other methods in the literature. All fuzzy based filters use fuzzy rules based systems to add fuzzy logic in it.

3) *Denoising Techniques*

a) *Mean Filter:* Mean filtering is usually used as a simple method for reducing noise in an image. Mean filtering is a simple, spontaneous and easy to execute method of smoothing images [24]. The calculated median value is replaced with center value.

b) *Median Filter:* It provides better removal of impulse noise from corrupted images. It replaces the center value with the median of all the pixels in the window. According to window size each pixels in the window is taken and sort the pixel then find the median of the each window. Then this median value is replaced by center value.

c) *Weighted Median Filter:* The basic idea is to give weight to the each pixel. Every pixel is given a weight. This weight is multiply with pixel. According to this weight the pixels are sort into ascending order, and then find the median value from the sorted list. This value is replaced with center value.

d) *Center Weighted Median Filter:* In CWM center pixel of window is considered as test pixel. Check that the center pixel is less than minimum value available in window and center pixel is greater than maximum value available in window then center pixel is considered as corrupted pixel. This corrupted pixel is replaced by calculated value. Weight is given to the center pixel then sorts all element of window in ascending order and calculate median of elements.

e) *Tri-state Median Filter:* This will work according to the threshold value. First take each pixel from the window then check that this pixel is less than the predefined threshold value, and then this pixel is consider as uncorrupted pixel and keep the pixel as it is. Otherwise calculate Center Weighted Median (CWM) filter value and Standard Median (SM) value. Check that the threshold is placed between CWM and SM, and then the corrupted pixel is replaced with CWM value. If the SM is greater than threshold then the SM value is placed instead of noisy pixel. The range of threshold is 0 to 255.

f) *Adaptive Median Filter:* It uses changing window size to denoising. The window size is increases until get the correct value for median is calculated and noise pixel is replaced with calculated median value. Here two conditions are used one to find corrupted pixels and second one is to check accuracy of median value. Check that the pixel is less than minimum value available in window and also the pixel is greater than maximum value present in window then center pixel is considered as corrupted pixel. Then check that the median value is less than minimum pixel value available in window and median is greater than maximum pixel value available in window, then median value is judge as noisy pixel. If the median is noisy one then increase the window size and again calculate the median value of the pixel until get correct median value. While increasing the window size it will consider the previous median value also.

g) Progressive Switching Median Filter: Here one pixel is taken for test pixel from the window. Check that the pixel is less than the minimum value of the pixel available in the window and greater than the maximum value of the pixel available in the window then central pixel is considered as noisy pixel. Second noise pixels are replaced by estimated median value. Then check that the median value is less than minimum pixel value available in window and greater than maximum pixel value available in window, then median value is consider as noisy pixel. If the median is noisy one then increase the window size and again calculate the median value of the pixel until get correct median value. Here median is calculated without considering the noisy pixel available in window. Then check that the calculated median value is less than minimum pixel available in window and greater than maximum pixel available in window then median value is consider as corrupted value. If the median is noisy one then increase the window size and again calculate the median value of the pixel until get correct median value.

h) *Rank-Order Based Adaptive Median Filter:* In RAMF, a pixel is taken if the median of a window is placed between the minimum and the maximum value of the window and the pixel is exactingly between the minimum and the maximum value of the window; In case, the median of the window under concern is exactingly between the minimum and the maximum value of the window and the pixel does not lie between the minimum and the maximum value of the window, then the pixel is replaced by the median value; otherwise, the size of the window is increased and the pixel will be replaced by the median of the increased size window, also the new median is between the minimum and the maximum value of the window, otherwise, the window size is again increased up to pre-fixed maximum level, otherwise the central pixel is keep unchanged.

i) *Minmax Detector Based filter:* The goal of this method is to restructure the true image from the corrupted image. MDB should work at high noise image and superior to other existing techniques. Here the center pixel is taken as tested pixel. Then check that the test pixel is less than minimum value present in the window or test pixel is greater than the maximum value present in the window then test pixel is corrupted. If the test pixel is corrupted then find the median value apply that value to the corrupted pixel. Shift the window row wise then column wise to cover all the pixels in the image, and then continue the above checking.

j) *Adaptive Rank Order Filter:* Here check that center pixel is noisy or not. If yes then sort the pixels in the window in ascending order. Then find the minimum, maximum and median value .Then check that the median value is noisy one or not by checking the median is placed between min and max value, if yes med is not a noisy pixel then replace center value with median value. Otherwise expand the window size. Repeat the steps until all pixels are process.

k) *Robust Estimation algorithm:* First find the median, and then find the minimum value and maximum value from the selected window. Check that minimum value is less than median value and the median value is less than maximum value from the window. If the condition is true, then check that the test pixel is placed between the minimum and maximum value if it is trues then that pixel is not a noisy one. Otherwise find absolute deviation of the each pixel [25]. If the absolute deviation is zero neighbourhood pixel is consider as corrupted one, else calculate robust influence function using this calculated value the pixel is calculate.

l) *Decision Based Adaptive Median Filter:* Here two stages are to remove the noise. In the first stage noise pixel is detect using rank order absolute difference. In the second stage noisy pixel is replaced by calculated median value. Find the absolute deviation for the entire pixel. Then sort the calculated absolute deviation and find the sum of the smallest absolute deviations are calculated, this is called ROAD [26]. The ROAD value is compare with threshold. Based on this comparison the noisy pixel is identified. In the case of filtering, check that flag in the binary image is zero then that pixel is not noisy one, otherwise check that number of non zero pixels are three or above then the pixel is replaced with median of non zero pixels. If the number of nonzero pixel is less than three then increase the initial value and do the steps from the beginning.

m) *Robust Outlyingness Ratio-Nonlocal Mean filter:* This case the denoising consists of two steps, detection followed by filtering. The detection contains two stages coarse and fine stage. Here the steps are same in the both stages only difference is that, in the case of coarse stage large threshold is given through this the false-hit term become small and miss term become large [27]. The output of coarse stage is given to fine stage, here in the fine stage the threshold is taken as small then the false-hit become large and miss term become small. In the detection first calculate the ROR value for each pixel then according to ROR value the pixel is divided into four clusters. Then find the absolute deviation, then compare the absolute deviation with threshold according to this comparison the noise pixel is identified. The result is added to the flag detection matrix. This detection flag matrix is given to nonlocal mean. The Nonlocal Mean is used to filter the noise from the image. It will produce visually good image with high PSNR value. Also produce excellent result and better output compare with other existing methods.

IV. RELATED WORK

Prof.R.Gayathri (2012) et al present that some classical noise elimination algorithms provide better results in the image denoising. The Synthetic Aperture Radar (SAR) Images and hyper spectral images are severely affected because of the several types of noises. Several denoising techniques have been proposed that preserve quality of image in the texture images by eliminating the generated noise. This paper is focused on effective noise eliminating methods and discussed performance metrics are compared with individually.

Kanika Gupta(2013) et al present that Removal of noise from of the main signal is still a bottleneck for researchers. There are several methods and techniques published and each method has its own advantages, disadvantages and assumptions. This paper presents a review of few significant work in the field of Image Denoising. In this paper, numerous amounts of Image Denoising Techniques are discussed and it might be possible to get confused with all the methodologies, so it is important to summarize all of those to regain the full content of the paper.[28]

Rinci Shrivastava (2014) et present that Images contained various kinds of the noises because of belonging factors. Software Artifacts, Lens Distortion, Sensor Defects and blur, etc. are factors that affect the quality of image. There are various procedures which are proposed till now. There is significant development time by time by the researchers In this paper they a survey on different techniques and find a way to provide new and better study in thefield of image denoising.

Rosebell John (2012) et al present that The impulse is present in the image, this will hide the essential details of the image and decrease the clearness of the image. There for the denoising is very important. This paper reviewed on different types of denoising methods. These denoising methods are compared with each other using PSNR value and the efficiency of these methods is calculated. In this paper, we discussed different filtering techniques for denoising from the image. Further these techniques are comparing with each other. Finally conclude that among these techniques ROR-NLM is the good method to removing noise from the image. Even though it will produce high PSNR value it will produce high image quality by removing both Gaussian and impulse noise.[30]

Rupinderpal Kaur(2013) et al present that There are many noise reduction techniques have been developed for removing noise and retaining edge details in images. Choice of de-noising algorithm is application dependent and depends upon the type of noise present in the image. Each technique has its own assumptions, advantages and limitations. The idea behind these techniques is to acquiesce better results in terms of quality and in removal of different noises. This paper covers almost all the de-noising techniques. Denoising or noise decrease has been a permanent research topic for engineers and scientists and one reason for it is the lack of a single technique, which is able to achieve denoising for a wide class of images.[31]

V. CONCLUSION

The purpose of this paper is to present a survey of digital image deniosing approaches. As images are very important in each and every field so Image Denoising is an important pre-processing task before further processing of image like segmentation, feature extraction, texture analysis etc. The above survey shows the different type of noises that can corrupt the image and different type of filters which are used to recover the noisy image. Different filters show different results after filtering .Some filters degrade image quality and remove edges. Among all traditional filters wavelet transform is best suited as it provides high degree of performance. It has various favourable properties like multi resolution and multi scale. It is simple to implement. In this paper, numerous amounts of Image Denoising Techniques are discussed and it might be possible to get confused with all the methodologies, so it is important to summarize all of those to regain the full content of the paper. The selection of Denoising technique depends on what kind of denoising is required. Further, it depends on what kind of information is required.

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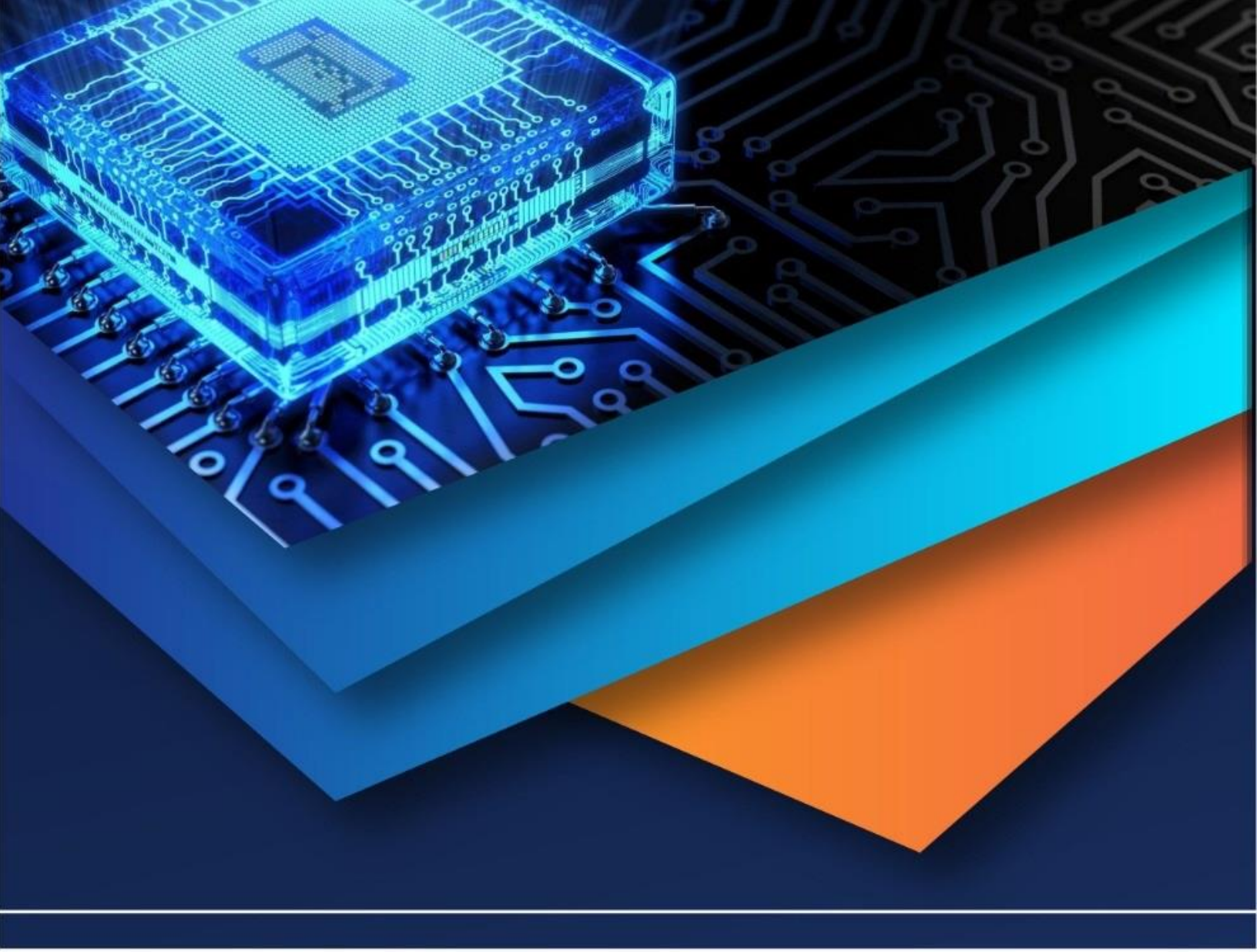

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