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Comparative Analysis of Various Image Denoising Techniques: A Review Paper

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***Abstract*—** Removing noise from the image frame remained a difficult task for researchers. Image denoising is an important issue in image processing and computer vision. A good image denoising model should completely eliminate noise and preserve edges. There are several existing methods for denoise image. Each method has its advantages and disadvantages. In this paper a review of some important works done in the field of image denoising is presented. This paper also contains a comparative study of different image denoising techniques.

***Keywords*—**Denoising; Wavelet transforms; Gaussian noise; Speckle noise; linear filters; Thresholding

I. INTRODUCTION

In today's increasingly digital world, digital images play an important role in the day today life as well as in areas of research and technology such as in Magnetic Resonance, satellite TV including geographic information System etc.....
Noise is unwanted signal that interferes with the original image and degrades the visual quality of original image. The main sources of noise in digital images are imperfect instruments, problems with the data acquisition process, natural phenomena interference, transmission and compression [1]. Image noise removal is a phenomenon for removal of noise from digital image which gets affected during the acquisition or while maintaining visual quality. Thus, it is necessary to design some effective techniques for denoising of digital images.

Reduce image noise is a fundamental problem in the field of image processing. This document provides several techniques for eliminating noise and also gives us knowledge about which method will provide reliable and rough estimate of the original image, given its degraded version [17].

One of the methods used to remove noise is the wavelet converted into digital image. A wavelet has a mathematical useful role in digital signal processing and image compression. The use of wavelets for denoising of digital image is a recent development, although the theory is not new. They are similar to the principles of Fourier analysis. In signal processing, wavelets make it possible to recover weak signals noise. This has proven especially useful in the processing of X-ray and magnetic resonance images medical applications. Images processed in this manner can be "Cleaned" without blurring or confusing details. Techniques based on wavelet coefficients thresholds are gaining popularity for denoising data. The idea is transform the data in the wavelet base, where the great are mainly the signal coefficients and smaller represent noise.

Noise modeling depends on several factors such as data collection instruments, transmission media, and Image quantification discrete radiation sources. Depending on the noise model, different algorithms can be used. In ultrasound imaging, speckle noise [2] is observed while in the MRI [3] Rice noise is observed.

II. IMAGE DENOISING TECHNIQUES

Image denoising is the fundamental problem in the image processing. Wavelet gives an excellent performance in the field Image denoising because of its features such as shortage and structure of various resolutions. With the popularity of Wavelet Transforming for the last two decades, several algorithms have has developed in the wavelet domain. The focus moves to Wavelet domain from the spatial domain and Fourier. From The Donoho 's approach based on wavelet threshold published in 2003, was an increase in removing image noise papers being published. Although his approach was not revolutionary, it did require monitoring and correlation of the wavelet maxima and minimum at different scales as proposed by Mallat [4] Thus there is renewed interest in the wavelet approach and that of [5] Donoho demonstrated a simple solution for difficult problem domain. The researchers published different approaches to estimate the simulation parameters for wavelet coefficients. To achieve optimal threshold adaptation data threshold [6] is introduced. Substantial improvements in the perceptual quality could be obtained by translation invariant thresholding method based on a non-decimated wavelet

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transform [7] much effort has been devoted to Bayesian denoising in the wavelet domain. Gaussian scale mixtures, Hidden Markov Models (HMM) have also become popular and more research has continued to be published.

III. VARIOUS NOISE MODELS

Noise present in the image, either additive or multiplicative form [8]

A. Additive Noise Model

Signal is additive in nature to the original signal is added to produce a noisy signal corrupted and follows the following pattern noise:

$$w(x,y) = s(x,y) + n(x,y) \quad (1)$$

B. Multiplicative Noise Model

In this model, the noise signal is multiplied to the original signal. The multiplicative noise model follows the rule:

$$w(x,y) = s(x,y) \times n(x,y) \quad (2)$$

When $s(x,y)$ is the intensity of the original image and $n(x,y)$denotes the noise introduced to produce corrupted signal $w(x,y)$at (x,y) pixel location.

IV. TYPES OF NOISE

Various noises have their own characteristics and are inherent in the images of different ways.

A. Gaussian Noise

Gaussian noise [9] is uniformly distributed over the signal. Each pixel of image noise is the sum value of true pixel and a value of Gaussian noise randomly distributed. This noise has a probability density function [PDF] of the normal distribution. It is also known as the Gaussian distribution. It is an important part of the readout noise of an image sensor is the constant noise in dark areas of the image [24].

B. Salt and Pepper Noise

The noise of salt and pepper also called shot noise, impulse noise or noise peak is usually caused by the positions of defective memory, malfunction of the pixels in camera sensors, or there may be timing errors in the scanning process .In salt and pepper noise there are only two possible values a and b there is the probability of each is less than 0.2.If numbers greater than these numbers sweep noise image. 8-bit image to the typical value of 255 for noise and salt-pepper noise is 0 [29].

Reasons for Salt and Pepper Noise:

- Fault memory cells.
- By the malfunction of the cells of the camera sensor.
- By timing errors in digitizing the image or transmission.

C. Speckle Noise

Speckle [10] [11] is the multiplicative noise. This type of noise occurs in almost all systems as coherent SAR images, ultrasound images, etc. The source of this noise is random interference between coherent returns.

V. VARIOUS DENOISING AND FILTERING TECHNIQUES

Several noise denoising techniques have been proposed so far and their application depends on the type of image and noise present in the image. Removing image noise is classified into three categories: Spatial Filtering, Domain Filtering Transform and Wavelet Threshold Method. Objectives of any filtering approach are:

- To suppress noise effectively in the uniform regions.
- To preserve the edges and other features of the similar image.
- To provide a visually natural appearance [13].

A. Spatial domain filtering

This is the conventional way to remove noise from digital images to employ spatial filters. You filtering in the spatial domain are classified into linear filters and nonlinear filters [14].

1) Linear Filters: A filter medium is optimal for Gaussian noise linear in the sense of mean square error. Linear filters tend to blur the sharp edges, destroy lines and other fine image details. It are includes Mean filter and Wiener filter [14].

a) Mean Filter: This filter acts in a softening her image. Reduce the intensity variations between adjacent pixels [15]. The mean filter is a linear average. Here the filter calculates the average value of the noisy image in a predefined area and the intensity value of the central pixel is then changed by the average value of pixels in the neighborhood. This process is repeated for all pixel values in the whole image.

b) Weiner Filter: Weiner filtering [16] the method requires information about the noise spectrum and the original signal and works well only when the underlying signals is smooth. Weiner method implements spatial smoothing and control model complexity corresponds to choosing the size of the window. $H(u,v)$ is the degradation function, $G(u,v)$ is the degraded image and $H(u,v)^*$ is the complex conjugate. Function $Sf(u,v)$ and $Sn\,(u,v)$ are power spectra of the original image and noise. Wiener filter assumes the noise and power spectra object a priority.

$$f(u,v) = \left[\frac{H(u,v)^*}{H(u,v)^2+[Sn\,(u,v)/Sf(u,v)]}\right] G(u,v) \quad (3)$$

2) Non- Linear Filters: In recent years, a variety of non-linear filters such as average conditioning range, weighted median, the relaxed median, range selection have been developed to overcome the deficiency of the linear filter. With the nonlinear filter, noise is eliminated without attempts to explicitly identify. Spatial filters employ a low-pass filtering in the pixel group with the assumption that the noise occupies the upper region of the frequency spectrum. Generally spatial filters eliminate noise to a reasonable degree, but at the cost of blurring of images which in turn makes the edges of the invisible image.

a) The median filter: The median filter is a static Median Filter, the best order nonlinear filter whose response is based on the positioning of pixel values range based on the region contained below the filter. Median filter performance good result for salt and pepper noise. These softeners are basically filters for image processing, and in the signal processing. The benefit of the median filter on linear filters is that the median filter can remove the effect of noise input values with huge quantities [29].

B. Transform domain filtering

The filtering transform domain can be divided according to the choice of the basic functions.

1) Spatial Frequency Filtering: Domain of spatial frequency denoising method is a kind of transform domain filtering where low-pass filters (LPF.) Used by using Fast Fourier Transform (FFT) .Here noise removal is carried out by designing a cutoff frequency. The main disadvantage of fast Fourier transform (FFT) is the fact that edge information spans frequencies because FFT base function and not localized in time or in space means that the time information is lost and therefore the results of lowpass filtering in spots edges. But these methods are time consuming and can produced artificial frequencies in image processing [18].

2) Wavelet Domain Filtering: Working in the wavelet domain is preferable because Discrete Wavelet Transform (DWT) make the concentrate signal power on a small number of coefficients, therefore, the DWT of the image noise is a small number of coefficients having a high signal to noise ratio (SNR) while relatively large number of coefficients is having a low SNR. After removal of low SNR ratios (ie, the coefficients of noisy) image is reconstructed using the inverse DWT. As a result, the noise is removed or filtered from observations [18]. An important advantage of the methods of the wavelet is that it provides time and frequency location simultaneously. Moreover, the methods characterized wavelet such signals much more efficiently than the original domain or transformed with global basic elements such as the Fourier transform [19].

C. Wavelet Based Thresholding

Wavelet thresholding is a signal estimation technique that exploits the capabilities of the wavelet transform to the signal denoising. It removes noise killing coefficients that areirrelevant to some threshold that turns out to be simple and effective, depends largely on the choice of a threshold parameter and the choice of this threshold determines largely the noise removal efficiency.There are several studies on Wavelet thresholding coefficients [20]. The process, commonly called Wavelet Contraction, is to follow the main [21] stages:

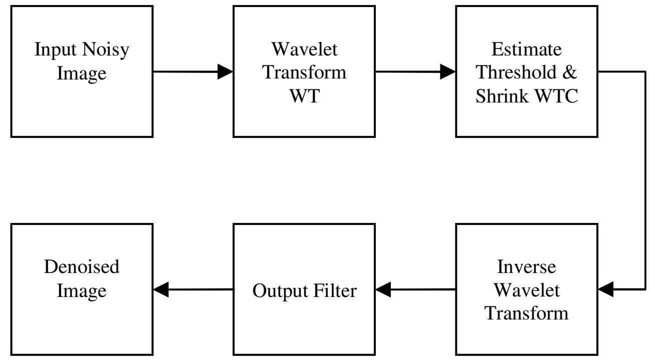

Fig. 1: Block diagram of Image Denoising using Wavelet Transform

1) Thresholding Method: Several thresholding techniques used to purpose of removing image noise such as hard and soft thresholding. Hard thresholding based on honor and rule instinctively kill more attractive and also introduces artifacts in the recovered image [22], while soft threshold is based on reducing and kill rule, since it reduces the coefficients above the threshold in absolute value [23]. In practice, soft thresholding has been used for a long threshold, as it gives more visually pleasing picture as compared with the hard threshold and reduces sudden rapidchanges that occur in the hard [24] thresholding. In MATLAB, default hard threshold is used for compression and soft threshold denoising [25]

2) Threshold Selection Rules: In applications of image denoising, the threshold selection value must be such that the peak signal to noise ratio (PSNR) will maximize [20]. Finding an optimum value for thresholding is not an easy task. A small input spend all noisy coefficients and thus the resulting images may still be noisy threshold while a large number of coefficients becomes more to zero, leading to soften the image and image processing can cause blur and artifacts, and therefore, the resulting images may lose some signal values [26]. Threshold selection is based on non-adaptive threshold and adaptive threshold.

a) Non Adaptive Threshold: Visu Shrink is no universal adaptive threshold, which only depends on a number of data points. It is to produce an estimate too smooth. We suggest a better performance in terms of mean square error (MSE), where number of pixels comes to infinity. Its threshold is quite large due to its dependence on number of pixels image [27]. The downside is that you cannot remove the Speckle noise. You can only deal with additive noise. Threshold T can be calculated using the formulas,

$$T = \sigma\sqrt{2\,logn^2} \tag{4}$$

Where σ is the noise level and n is the length of the noisy signal [19].

b) Adaptive Threshold: There are two types of adaptive threshold Clear Shrink say and Bayes Shrink. Clear

Shrink minimizes derivative Risk unbiased estimator Stein, an estimate of the MSE risk. It is a combination of universal threshold and SAFE threshold is used for noise suppression empirical coefficient wavelet thresholding. The objective Shrink course is to minimize the mean square error. You sure contraction suppresses noise by thresholding the empirical wavelet coefficient [21]. Bayes method has the Shrink I been attracting attention recently as an algorithm for setting different thresholds for each subband. you here subbands are frequency bands that differ from one another in level and direction [28]. The purpose of this method is to estimate a threshold value that minimizes the Bayesian assuming risk Generalized Gaussian Distribution (GGD) above.

VI. CONCLUSION AND FUTURE SCOPE

In this work, numerous amounts of Image Denoising Techniques are discussed. Selecting Denoising technique depends on what type of noise removal is required. It also depends on what type of information required.

The purpose of this paper is to present a study of digital technology approaches to image denoising. Because images are very important in every field so Denoising Image is an important preprocessing task before image processing as segmentation, feature extraction, etc. Texture analysis previous survey shows the different types of noise that can corrupt the image and different types of filters used to improve the image with noise. The study of various denoising digital imaging techniques show that wavelet filters outperforms other standard spatial domain filters. Space by smoothing filters operate on a fixed window and produces artifacts around the object and sometimes causes on softening and cause image blur. Therefore, Wavelet transform is the most suitable for operation because their properties as scarcity, multiresolution and multiscale nature.

As the prospect of future you can see, the methods mentioned can be implemented to look at how it can be used in different images. With different spatial resolution, different behaviors of the same image would be quite interesting.

Since the selection of the right procedure of removing noise plays an important role, it is important to experiment and compare methods. As future research, we would like to continue working on the Comparison of denoising techniques. If the characteristics of the noiseless signal are input into a neural network pattern recognizer, then the rate of successful classification must determine the last measure by which to compare different procedures for noise removal.

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