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A REVIEW PAPER: DENOISING TECHNIQUE FOR DIFFERENT TYPE OF IMAGES.

Vasudha[1], Om Prakash Agrahari[2]
[1]Master of Technology, [2]Assistant Professor, Department of Computer Science, UCER Allahabad

ABSTRACT: An Image is the collection of large number of digital data and this digital data is much prone to digital noise. This noise is added during the time of image acquisition or transmission due to various reasons. Removing noise from digital images is always a big challenge in the field of image processing. Now days there are several techniques and algorithms are developed which are successful in removing the large amount of noise .This review paper presents the different types of images used during the image processing and how to denoise them. The present denoising techniques are classified into different groups and a brief overview of various algorithms and analysis is provided.
Keywords: Denoising, Filtering, Image, Noise Models, Review, Spatial Domain, Transform Domain

I. INTRODUCTION

A normal image is defined as a two-dimensional function, f(x, y), where x and y are spatial coordinates, and the amplitude of f at any pair of coordinates (x, y) is called the intensity or gray level of the image at that point. When x, y, and the intensity values of f, are all finite, discrete quantities, we call the image a digital image [1]. A digital image is made up of finite number of small elements called pixels, each of which has a particular location & values. Image Processing is a technique to enhance raw images received from cameras or other resources. Whenever an image is captured through a camera or any other devices, it contains some amount of noise. Noise is mainly the disturbance or unwanted signal that are added with the image and it may change the basic characteristic or the properties of any image. In other words, Noise is the unwanted signal that interferes with the original signal and degrades the overall visual quality of digital image. The main sources of noise in digital images are imperfect data capturing instruments, transmission media, quantization of image, discrete sources of radiation, problem with data acquisition process, interference natural phenomena, transmission and compression. Denoising has been a critical and long-standing problem in the field of image processing. It is a challenging problem as the process of denoising causes blurring and introduces some anomalies in the image. Image denoising methods tend to be problem specific and depend on the type of image and noise model. Different types of images consist of different types of noise and different noise models are used to represent different noise types. The paper is organized as follows: Section 2 contains Evolution of Image Denoising Techniques. Section 3 shows different types of images used during image processing. Section 4 defines the different type of noise generally found in the images. Sections 5 define some operations performed on images. Section 6 contains survey of the related work in which various image denoising techniques along with some explanations.

II. EVOLUTION OF IMAGE DENOISING TECHNIQUES

Image Denoising has remained a fundamental problem in the field of image processing. Wavelets give a superior performance in image denoising due to properties such as sparsity and multi resolution structure. With Wavelet Transform gaining popularity in the last two decades various algorithms for denoising in wavelet domain were introduced. The focus was shifted from the Spatial and Fourier domain to the Wavelet transform domain. Ever since Donoho's Wavelet based thresholding approach was published in 1995, there was a surge in the denoising papers being published. Although Donoho's concept was not revolutionary, his methods did not require tracking or correlation of the wavelet maxima and minima across the different scales as proposed by Mallat [2]. Thus, there was a renewed interest in wavelet based denoising techniques since Donoho [3] demonstrated a simple approach to a difficult problem. Researchers published different ways to compute the parameters for the thresholding of wavelet coefficients. Data adaptive thresholds [4] were introduced to achieve optimum value of threshold. Later efforts found that substantial improvements in perceptual quality could be obtained by translation invariant methods based on thresholding of an Undecimated Wavelet Transform [5]. These thresholding techniques were applied to the non orthogonal wavelet coefficients to reduce artifacts. Multi wavelets were also used to achieve similar results. Probabilistic models using the statistical properties of the wavelet coefficient seemed to outperform. The thresholding techniques and gained ground. Recently, much effort has been devoted to Bayesian Denoising in Wavelet domain. Hidden Markov Models and Gaussian Scale Mixtures have also become popular and more research continues to be published. Tree Structures Ordering the wavelet coefficients based on their magnitude, scale and spatial location have been researched. Data Adaptive transforms such as Independent Component Analysis (ICA) have been explored for sparse shrinkage. The Trend continues to focus on using different statistical models to model the statistical properties of the wavelet coefficients and its neighbors. Future Trend will be towards finding more accurate probabilistic models for the distribution of non-orthogonal wavelet coefficients.

III. TYPE OF IMAGE

There are five types of images used in image processing:-

- Grayscale. A grayscale image M pixels for column and N pixels for row is represented as a matrix of double datatype of size [M× N]. Element values (e.g., MyImage(m,n)) denote the pixel grayscale intensities in [0,1] with 0=black and 1=white.
- Truecolor RGB. A truecolor red-green-blue (RGB) image is represented as a three-dimensional [M× N×3] double matrix. Each pixel has red, green, blue components along the third dimension with values in [0,1], for example, the color components of pixel (m,n) are MyImage(m,n,1) = red, MyImage(m,n,2) = green, MyImage(m,n,3) = blue.
- Indexed. Indexed (paletted) images are represented with an index matrix of size [M× N]and a colormap matrix of size[K× 3]. The colormap holds all colors used in the image and the index matrix represents the pixels by referring to colors in the colormap. For example, if the 22nd color is magenta MyColormap(22,:) = [1,0,1], then MyImage(m,n) = 22 is a magenta-colored pixel.
- Binary. A binary image is represented by an M× N logical matrix where pixel values are 1 (true) or 0 (false).
- uint8. This type uses less memory and some operations compute faster than with double types. For simplicity, this tutorial does not discuss uint8 further.

IV. TYPE OF NOISE

Normally images are affected by different types of noise. Various types of noise have their own characteristics and are inherent in images in different ways. All the types of noises can be categorized into two models:

Additive Noise Model
Additive noise is the signal that gets added to the original image to generate the resultant noisy image. In the

Multiplicative Noise Model
Multiplicative model the noisy image is generated by multiplication of the original image and the noise signal. The most common noise types found in images are Gaussian Noise, Salt & Pepper Noise and Speckle Noise.

Gaussian Noise
It is evenly distributed over the signal. Each pixel in noisy image is the sum of true pixel value and a random Gaussian distributed noise value [6]. Gaussian noise is an amplifier noise which is independent at each pixel and independent of the signal intensity. Gaussian noise is statistical noise that has its probability density function equal to that of the normal distribution. It arises due to electronic circuit noise & sensor noise due to poor illumination or high temperature. It is a constant power additive noise [7].

Salt & Pepper Noise or Impulse noise
The salt-and-pepper noise is also called shot noise, impulse noise or spike noise. An image containing salt-and pepper noise will have dark pixels in bright regions and bright pixels in dark regions. It can be caused by dead pixels, analogue-to-digital converter errors, and bit errors in transmission [7]. It has only two possible values, a high value and a low value. The probability of each is typically less than 0.1 [6]. It is independent and uncorrelated to image pixels. Its two types are the salt-and pepper noise and the random-valued noise. In Salt and pepper type of noise, the noisy pixels takes either salt value (gray Level -225) Or pepper value (grey Level - 0) And it appears as black and white spots on the images In case of random valued impulse noise, noise can take any gray level value from zero to 225

Speckle Noise
Speckle noise is a granular noise that inherently exists in and degrades the quality of the active radar and synthetic aperture radar (SAR) images. Speckle noise in conventional radar results from random fluctuations in the return signal from an object that is no bigger than a single image-processing element. It increases the mean grey level of a local area [7]. It is a multiplicative noise. The source of this noise is random interference between the coherent returns [6].

Poisson Noise
Poisson noise is also known as Photon noise. It arises when number of photons sensed by the sensor is not sufficient to provide detectable statistical information. This noise has root mean square value proportional to square root intensity of the image. Different pixels are suffered by independent noise values. The photon noise and other sensor based noise corrupt the signal at different proportions.

Uniform Noise
The Uniform noise caused by quantizing the pixels of image to a number of distinct levels is known as Quantization noise. It has approximately uniform distribution. In this type of noise, the level of the gray values of the noise are uniformly distributed over a specified range. It can be used to create any type of noise distribution. This type of noise is mostly used to evaluate the performance of image restoration algorithms. This noise provides the most neutral or unbiased noise.

V. TYPE OF OPERATION PERFORMED ON IMAGE

Smoothing Operation:
Image smoothing is a method of improving the quality of images. The image quality is an important factor for the human vision point of view. The image usually has noise which is not easily eliminated in image processing. The quality of the image is affected by the presence of noise. Many methods are there for removing noise from images. Many image processing algorithms can’t work well in noisy environment, so image filter is adopted as a preprocessing module. However; the capability of conventional filters based on pure numerical computation is broken down rapidly

when they are put in heavily noisy environment. Median filter is the most used method , but it will not work efficiently when the noise rate is above 0.5.

Edge Detection Operation:
An edge may be regarded as boundary between two dissimilar regions in an image . The edges for an image are the significant characteristics that put forward an indication for a higher frequency. Edge detection is a terminology in image processing and computer vision, mainly in field of feature detection and feature extraction that plays an important role in segmentation of an image for identification of objects. The process of detecting edges for an image may facilitate in image segmentation, data compression, and also help for image reconstruction.

Sharpening Operation:
Sharpening is the process of manipulating an image so that image is more suitable than the original image [6]. In general if single image enhancement method will be implemented, actual requirements will be obtained. To get better visual effect for images, researcher performs filtering of image first and then sharpens the image.

VI. IMAGE DENOISING TECHNIQUES

There are different Image denoising techniques developed so far each having its own advantages and limitation. One should choose the technique according to the type and amount of noise present in the image. One should also consider the other factors like performance in denoising the image, computational time, computational cost. Denoising can be done in various domains like Spatial Domain, Frequency Domain and Wavelet Domain.

6.1. Linear Filters:
Linear filters are used to remove certain type of noise. Here filtering is generally done by blurring the image. These filters blur the edges and destroy the fine details of an image. They have poor performance in removing signal dependent noise. Gaussian and Averaging filters are commonly used linear filters [9]. They are of following types :
Gaussian Filter:
Gaussian filter is a non-uniform low pass filter. Gaussian filter is used to blur images and remove noise and detail. It does not remove salt & pepper noise effectively [8].
Average Filter:
The output of average filter is simply the average of pixels contained in the neighborhood of filter mask. It calculates the average of all intensities of the neighborhood of the central pixel and repacles the pixel with that average value . It is mostly used in removing irrelevant details from an image. It has a limitation that it blurs the edges of the image [11].

6.2 Non-Linear Filters:
In recent years, a variety of non-linear filters such as median filter, min filter, max filter have been developed to overcome the shortcoming of linear filter. Non-linear filters exhibit better performance than linear filters [10]. They are discussed below :

Mean Filter:
It is one of the most simplest filter among the existing spatial filters. It uses a filter window which is usually square. The filter window replaces the center value in the window with the average mean of all the pixels values in the kernel or window.

Median Filter:
It is also known as order statistics filter. It is most popular and commonly used non linear filter. It removes noise by smoothing the images. This filter also lowers the intensity variation between one and other pixels of an image. In this filter, the pixel value of image is replaced with the median value The median value is calculated by first arranging all the pixel values in ascending order and then replace the pixel being calculated with the middle pixel value. If the neighboring pixel of image which is to be consider, contains and even no of pixels, then it replaces the pixel with average of two middle pixel values. The median filter gives best result when the impulse noise percentage is less than 0.1 It does not perform well in removing high density salt & pepper noise [11]

Min Filter:
Min filter is also known as 0th percentile filter. It replaces the value of pixel by the minimum intensity level of the neighborhood of that pixel. This filter finds darkest points in an image. It removes salt noise from an image containing salt and pepper noise due to its high intensity value [11].

Max Filter:
Max filter is also known as 100th percentile filter. It replaces the value of pixel by the maximum intensity level of the neighborhood of that pixel. This filter finds brightest points in an image. It removes pepper noise from an image containing salt and pepper noise due to its very low intensity value [11].

6.3 Adaptive Filters:
These filters works accordingly the statistical characteristics of image inside inside the filter region defined by the [m×n] rectangular window. They are more complex and gives better performance than existing spatial filters.
The most commonly used spatial filter is adaptive median filter which is discussed below:

Adaptive Median Filter:
It performs well on images containing high density salt & pepper noise. It preserves the details of an image while smoothing non impulse noise. It changes its windows size during its operation depending on the certain conditions [11]. It works in two stages. First it calculates the minimum, maximum and median values of sub image window of the corrupted image. In stage one , it checks whether the calculated median itself is a salt or pepper noise or not. If the median is salt or pepper noise, then it increase the size of sub

image window and recalculates the minimum, maximum and median values otherwise it proceeds to stage two. In stage two, it checks whether the selected pixel is a salt or pepper noise or not. If it is salt or pepper noise, then it replaces the selected pixel with previously calculated median otherwise the pixel remains unchanged.

6.4 Wavelet Thresholding:

Donoho and Johnstone [14] pioneered the work on filtering of additive Gaussian noise using wavelet thresholding. Wavelet coefficients calculated by a wavelet transform represent change in the time series at a particular resolution. By considering the time series at various resolutions, it is then possible to filter out noise.The term wavelet thresholding is explained as decomposition of the data or the image into wavelet coefficients, comparing the detail coefficients with a given threshold value, and shrinking these coefficients close to zero to take away the effect of noise in the data. The image is reconstructed from the modified coefficients. There are various thresholding techniques. Some of these are discussed below:

VisuShrink:

VisuShrink was introduced by Donoho [13]. It uses a threshold value t that is proportional to the standard deviation of the noise. It follows the hard thresholding rule. It is also referred to as universal threshold and is defined as t = 2log n VisuShrink does not deal with minimizing the mean squared error [12]. It can be viewed as general-purpose threshold selectors that exhibit near optimal minimax error properties and ensures with high probability that the estimates are as smooth as the true underlying functions [13]. However, VisuShrink is known to yield recovered images that are overly smoothed. This is because VisuShrink removes too many coefficients. Another disadvantage is that it cannot remove speckle noise. It can only deal with an additive noise. VisuShrink follows the global thresholding [15] scheme where there is a single value of threshold applied globally to all the wavelet coefficients.

SureShrink:

A threshold chooser based on Stein's Unbiased Risk Estimator (SURE) was proposed by Donoho and Johnstone [14] and is called as SureShrink. It is a combination of the universal threshold and the SURE threshold. SureShrink suppresses noise by thresholding the empirical wavelet coefficients. SureShrink produces the best SNR as compared to VisuShrink and BayesShrink.

BayesShrink:

BayesShrink was proposed by Chang, Yu and Vetterli [12]. The goal of this method is to minimize the Bayesian risk, and hence its name, BayesShrink. It uses soft thresholding and is subband-dependent, which means that thresholding is done at each band of resolution in the wavelet decomposition. Like the SureShrink procedure, it is smoothness adaptive. The output from BayesShrink method is much closer to the high quality image and there is no blurring in the output image unlike the other two methods.

VII. CONCLUSION

This brief study on the topic of Image Denoising attempts to illustrate the recent research work that has been done in the field. Some research papers were discussed, all focusing on different aspects & techniques of image denoising. Although no experimental comparisons were made the essence of the reviewed papers has been presented. All algorithms have some pros & cons of their own and this can be cleaned from this review. The major role of this paper is to draw a picture of the state of the art of the image denoising techniques.

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