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IMAGE DENOISING TECHNIQUES FOR RESTORATION: A SURVEY

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ABSTRACT

Visual information communication in form of digital images has become a method of communication in today's world, but these images often get corrupted with noise while in transmission. Need of processing is important before it can be used in applications. Denoising of images involve the change of the image data for producing a visually high quality images. This paper reviews some of the existing denoising processes, such as filtering, wavelet, and multi-fractal approach. Different noise models like the additive and multiplicative are shown. They include noise forms like Gaussian noise, salt and pepper noise, speckle noise and Brownian noise. Selection of the image denoising algorithm is totally dependent on application. In this we review all the main factors required in denoising system for images.

***KEYWORDS-* Image Denoising, Additive Noises, Multiplicative Noises, and Denoising Techniques.**

1. INTRODUCTION

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 image is also lowered. Nonlinear models can hold edges in an enhanced mode than linear models. The properties of an image denoising system are that it removes noise while preserving all edges in an image denoised. Nonlinear models 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 on both real and simulated medical images. Rician noise utmost occurs in MRI. It adds more problems in low SNR.

The research in restoration algorithm development and routine is goal oriented in image processing. The image restoration is removing or reducing degradations incurred while the image is being obtained [1]. Degradation is often caused from blurring and noise due to electronic and photometric system sources. Blurring is caused by the inefficient image formation processes like motion between the camera and original scene or when camera is out of focus [2]. In addition to blurring, the captured image is corrupted by noise. A noise introduced transmission medium due to a noisy medium, errors generated during the measuring processes and during quantizing of the digital storage data. Elements of imaging process like the lenses, digitizers, etc. Also contributes to this degradation.

2. TYPES OF NOISES

Images get corrupted with noise either a Gaussian, uniform models, or salt and pepper form. Another common noise form is a speckle noise it has a multiplicative nature. Noises are present in an image in an additive or multiplicative form function.

Additive noise follows the stated rule

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

On the other hand multiplicative noise satisfies

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

Where s(x,y) is original signal, n(x,y) is noise function present in the original signal to produce the corrupted image w(x,y), and (x,y) gives the pixel location in the produced image. Image addition has applications in image morphing systems [3].

2.1 Gaussian Noise

Gaussian noise is even distribution of noisy signal over the original signal [Um98]. Each pixel in the noisy image is the cumulative sum of the original pixel and a randomly distributed Gaussian noise. This type of noise, which has a bell form probability distribution.

2.2 Salt and Pepper Noise

Salt and pepper noise [3] is impulse in nature, which is also referred to as intensity spiked noise. This noise has only two possible variant values, a and b. The probability of each value is less than 0.1. The affected pixels are set alternatively to the minimum or maximum value, providing the image a “salt and pepper” like visual appearance. The unaffected pixels remain unchanged in form. The typical value for pepper noise is 0 and for salt noise 255 for an 8-bit image. The salt and pepper noise show in general, the malfunctioning of sensor pixel elements in the cameras, faulty memory locations, or timing errors in the digitization process.

2.3 Speckle Noise

Speckle noise [Ga99] is a form of multiplicative noise signal. This form of noise is present in many coherent imaging systems like laser, acoustics and SAR (Synthetic Aperture Radar) imagery systems. Sourcing of this type of noise is due to random interference between the coherent returns. A fully developed speckle noise has the characteristic of multiplicative noise.

3. METHODOLOGY RELATED TO IMAGE DENOISING

3.1 Curvelet Transform for Image Denoising

Here, ridgelet alone cannot provide capable work. So curve let along ridge let methods are used. Localize the ridgelets, Edges are always discontinuities where curvelets give exact curve like appearance but ridge lets are straight rather than a curve. Curvelets based on multi-scale ridge lets show sparsity in representation of smooth edges and high perceptual quality. Software for computing is still in decisive stage. Discrete curvelet rigelet shows spasity in representation of smooth and fine edges. Input is taken as a digital input on catesian grid by considering the problem like white noise apply threshold in curvelet to produce denoised output. Pro is Curvelets obtains small MSE of reconstruction than wavelets. Con is Software for computing is in formative stage.

3.2 Non Local Means Denoising

Based on rician model iterative NL-Means and other method NL-PCA are compared. In this paper the proposed method has distinctive features like firstly, usage of restricted local neighbourhood secondly, weight calculation, finally applying kernel. PSNR (peak signal to noise ratio) value is high and they use another similarity measure named SSIM (structural similarity index matrix) It measures the similarity between two image value ranges between 0 and 1. PSNR and MSE are inconstant with human eye perception so they calculated SSIM.

3.3 Spatial Filtering

Spatial filtering is the method of choice in situations when only additive noise is present. It can be further classified into 2 categories: Linear filters and Non Linear Filters.

4. LINEAR FILTERS

It is the method of choice in situations when only additive noise is present [4]. A mean filter is the optimal linear for Gaussian noise in the sense of mean square error. It blurs sharp edges; destroy lines and other fine details of image. It includes Mean filter and Wiener filter.

4.1 Mean filter

This filter provides smoothness in an image by reducing the intensity variations between the adjacent pixels. [5]. Mean filter is essentially an averaging filter. It applies mask over each pixel in the signal. Therefore, to make a single pixel, each of components of pixel which falls under mask average filter. The main disadvantage is that edge preserving criteria is poor in Mean filter [6].

4.2 Wiener Filter

It is a filter that takes statistically approach to filter out noise that has corrupted a signal. Desired frequency response can be acquired using this filter. The Wiener filter approaches filtering from a different angle. For performing filtering operation it is essential to have knowledge of the spectral properties of the original signal and the noise, in achieving the criteria one can get the LTI filter whose output will be as close as original signal as possible [7].

5. NON LINEAR FILTERS

It is the method of choice in situations when multiplicative and function based noise is present [6].With non-linear filters, the noise can be removed without identifying it exclusively. In this case, the median of the neighbourhood pixels determine the value of an output pixel [8]. Spatial filters make use of a low pass filtering on groups of pixels with the statement that the noise occupies the higher region of frequency spectrum. Normally, spatial filters eliminate noise to a reasonable extent but at the cost of blurring images which in turn makes the edges in pictures invisible.

5.1Median Filter

Median filter belongs to the class of non linear filters. Median filtering is performed by, finding the median value by across the window, and then replacing each entry in the window with the pixel's median value [9]. If the windows have an odd number, median is then simple to define: the middle values of the windows are used for numerical sorting. For even entries there are many possible medians. It is a robust filter. Median filters used for providing smoothness in image processing and time series processing [10]. The advantage of using median filtering is that it's much less sensitive in comparison to extreme mean values (called outliers). Therefore, it is able to remove these outliers without reducing the sharpness of image.

6. TRANSFORM DOMAIN FILTERING

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

6.1 Spatial Frequency Filtering

It refers the use of low pass filters using fast Fourier Transform. The noise is removed by deciding a cut-off frequency and adapting a frequency domain filter when the components of noise are decor related from useful signal [11]. The main disadvantage of Fast Fourier Transform (FFT) is the fact that the edge information is spread across frequencies because of FFT basis function and it is not being localized in time or space which means that time information is lost and hence low-pass filtering results in smearing of the edges. But the localized nature of Wavelet Transform both in time and space provides a particularly useful method for image denoising when the preservation of edges in the scene is of importance [12].

7. WAVELET DOMAIN FILTERING

Working in Wavelet domain is preferred because the Discrete Wavelet Transform (DWT) make the signal energy concentrate in a small number of coefficients, hence, the DWT of the noisy image consists of a small number of coefficients having high Signal to Noise Ratio (SNR) while relatively large number of coefficients is having low SNR. After removing the coefficients with low SNR (i.e., noisy coefficients) the image is reconstructed by using inverse DWT. As a result, noise is removed or filtered from the observations [12]. A major advantage of Wavelet methods is that it provides time and frequency localization simultaneously. Moreover, wavelet methods characterize such signals much more efficiently than either the original domain or transforms with global basis elements such as the Fourier transform [13].

8. NON ADAPTIVE THRESHOLD

Visu Shrink is non adaptive universal threshold, which depends only on a number of data points. It is found to yield an overly smoothed estimate. It suggests a best performance in terms of mean square error (MSE), when number of pixels reaches infinity. Its threshold value is quite large due to its dependency on number of pixels in image [14]. The drawback is that it cannot remove the Speckle noise. It can only deal with additive noise.

9. ADAPTIVE THRESHOLD

There are two types of adaptive threshold i.e. Sure Shrink and Bayes Shrink. Sure Shrink derived from minimizing Stein's Unbiased Risk Estimator, an estimate of MSE risk. It is a combination of universal threshold and SURE threshold. It is used for suppression of noise by thresholding the empirical wavelet coefficient.. The goal of Sure Shrink is to minimize the mean square error. Sure shrink suppresses the noise by thresholding the empirical wavelet coefficient [15]. The Bayes Shrink method has been attracting attention recently as an algorithm for setting different thresholds for every sub-band. Here sub-bands are frequency bands that differ from each other in level and direction [16]. The purpose of this method is to estimate a threshold value that minimizes the Bayesian risk assuming Generalized Gaussian Distribution (GGD) prior.

10. ANISOTROPIC DIFFUSION

Anisotropic diffusion [17, 18] is an iterative procedure based on smoothing that can be used for image denoising. The method attempts to fulfill the following requirements:

(i) Object boundaries should be preserved, and
(ii) Noise should be efficiently removed in homogeneous (at) regions.

Images can be considered to consist of regions (e.g. one region per object), in which case the goal of anisotropic diffusion is to preferentially perform smoothing within regions rather than between regions. The name of the procedure comes from the fact that it bears mathematical similarities to heat diffusion equations and from the fact that the diffusion or smoothing process is not performed uniformly over the whole image: Smoothing adapts to the image content.

Table 1 shows the various work done by authors in the image recovery domain

Paper Name	Author Name	Year of Publish	Method Used	Discussion
Group-Based Sparse Representation for Image Restoration	Jian Zhang, Debin Zhao, Wen Gao	2014	Sparse filter	In this paper authors have presented the idea of respective sifting for edge-saving smoothing. The all inclusive statement of respective separating is similar to that of conventional sifting, which called space is separating in this paper. The express authorization of a photometric separation in the reach segment of a reciprocal channel makes it conceivable to process shading pictures in a perceptually proper style.
Comparative Analysis of Image Denoising Techniques	Jappreet Kaur, Manpreet Kaur, Poonamdeep Kaur, Manpreet Kaur	2012	Mean filter, Wiener filter, wavelet filter	The similar investigation of different denoising strategies for advanced pictures demonstrates that wavelet channels outflank the other standard spatial area channels. In spite of the fact that all the spatial channels perform well on advanced pictures yet they have a few requirements in regards to determination corruption. These channels work by smoothing over a settled window and it creates relics around the article and once in a while causes over smoothing accordingly bringing about smearing of picture. Wavelet change is best suited for execution as a result of its properties like sparsity, multiresolution and multiscale

				nature. Thresholding procedures utilized with discrete wavelet are least complex to execute.
Wavelet Thresholding Approach for Image Denoising	Pankaj Hedaoo and Swati S Godbole	2011	Wavelet thresholding method	The primary issues with respect to denoising were tended in this paper. A versatile limit for wavelet thresholding pictures was proposed, construct with respect to the summed up Gaussian conveyance demonstrating of sub band coefficients, and test outcomes demonstrated astounding execution. The outcomes demonstrate that Proposed Shrink evacuates commotion fundamentally. In this paper, the authors compare the outcomes with delicate thresholding, hard thresholding.
Image De-noising by Various Filters for Different Noise	Pawan Patidar, Manoj Gupta, Sumit Srivastava, Ashok Kumar Nagawat	2010	Median, mean and wiener	The authors test by including four clamor (Dot, Gaussian ,Poisson and Salt & Pepper) in unique picture with standard deviation(0.025). The execution of the Wiener Filter in the wake of denoising for all Speckle, Poisson and Gaussian clamor is superior to Mean channel and Median channel. The execution of the Median channel in the wake of denoising for all Salt & Pepper clamor is superior to Mean channel and Wiener channel.

11. CONCLUSION

The purpose of this paper is to present a survey of digital image denoising 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 improve the noisy image. The study of various denoising techniques for digital images shows that wavelet filters outperforms the other standard spatial domain filters. Spatial filters operate by smoothing over a fixed window and it produces artefacts around the object and sometimes causes over smoothing thus causing blurring of image. Besides, the complexity of the algorithms can be measured according to the CPU computing time flops. This can produce a time complexity standard for each algorithm. These two points would be considered as an extension to be further processed in present systems.

12. PROPOSED FUTURE WORK

In the review of various techniques, the problem of applying recovery to large set of images is the high computing time required for processing and the requirement for a large matrix data. In this research work, we propose a fast image recovery algorithm by dividing the image into block of pixels and applying to each block instead of the entire image. The key idea is that small matrix requires less computing time and less memory. In our experiment, the block based processing using Gaussian kernel filtering will be applied in segments to non standard test images with final efficiency compared with less computing time, PSNR, MSE, SSIM, Entropy, STD for the restored image data and also the original image under recovery processing.

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