Performance Analysis of Non Linear Filtering for Image Denoising

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Abstract - *In Image processing, image analysis is done to make image noise free. The image segmentation is utilized in image analysis that uses edge detection methods. In image the points where image brightness changes are known as edges. These points can be created using shadows, texture and geometry. It originates discontinuities in image that changes the structure of image. To handle this problem edge detection mechanism is utilized. The various methods like Sobel, canny and Prewitt are utilized for edge detection but they have drawback like analysis of multi-resolution cannot be done and these are only works with high quality images .In case of noisy image the present methods does not detect proper edges and noise components that degrades image. So we proposed an approach that based on wavelet edge detection and also utilized non linear filtering for enhancing noisy image.*

KeyWords **-** Mean square error, thresholding, PSNR, Denoising, Non linear filter.

1. INTRODUCTION

In our day to day life as well as various fields of research, such as satellite TV etc, digital images play a vital role. Digital images are prone to Noise. The basic definition of noise can be stated as an unwanted signal which interferes with the original image and affects the quality by degrading it. There are various sources of noise, like, imperfect instruments, problems with data acquisition, transmission [1], etc. Image noise removal is a technique for removing noise from a digital image and it gets affected during acquisition or while maintaining the visual quality. Therefore, designing some effective techniques for image denoising is necessary.

Various schemes for Denoising are present and most of them are based on linear methods, most commonly used is Wiener filtering. Lately, many non-linear methods, especially based on wavelets are becoming very popular [2]. In Fig.1, it is shown in detail.

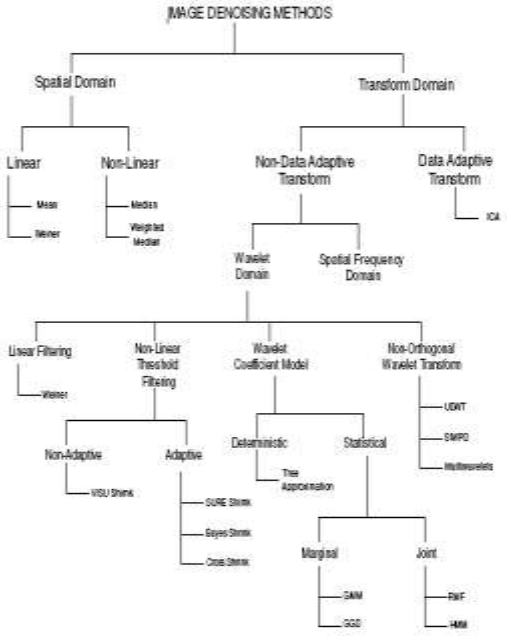


Figure-1: classification of image denoising methods

A New technique for filtering noise from a digital image is based on thresholding. Non Linear filtering using swarm filter can be used to reduce noise significantly without affecting the sharpness [3].Non Linear filtering has many great properties, such as better convergence rate near optimality in minimax sense.

Preserving the edges and other fine details of a digital image while removing the noise is the great challenge of image Denoising. It is still a challenge for many developers and researchers as removing of noise introduce artifacts and introduces blurring in an image. So, developing an effective and efficient Denoising technique is necessary to avoid or reduce corruption in data. In this paper, a new thresholding function is introduced to improve the denoised results of digital images. Results are shown and quantified in terms of various parameters like PSNR and MSE and the quality of image can be used to the advantage of the used method.

2. LITERATURE REVIEW

R Sujita et.al[2017] in his paper titled "wavelet based thresholding for image denoising in MRI images" Implemented various algorithms of image denoising torecuperate signal to be as close as conceivable to the

original signal. In this paper he proposed diverse methodologies of wave let based image denoising strategies. He also introduced wavelet based tgresholding of image denoising and noise minimization in MRI images. He evaluated the effectiveness on the basis of PSNR, MSE, MAE.

Mukesh E Motwani et.al[2016] in his paper titled "Survey of image denoising techniques" presented wavelet transform due to its properties of sparsity, multi resolution, multi scale nature. He also advocated the use of thresholding techniques in combination with discrete wavelet transform due toteir simple implementation .In this paper he also used non orthogonal wavelets like UDWT and multi wavelets toenhance the performance in their computation .His work of research was mainly concerned with guassiannoise associated with natural images.

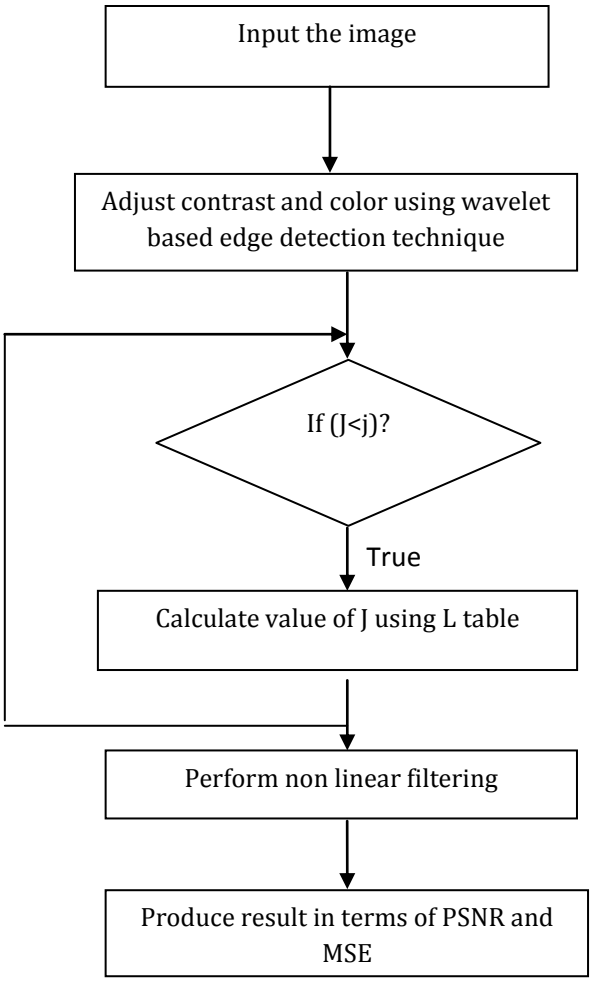
Pankaj Hedaoo et.al[2011] in his paper titled "Wavelet thresholding appliacations for image denoising" presented the work of his research in two parts.IN the first part threshold was driven in Bayesian technique while employing probabilistic model of image wavelet coefficients .Results depicted that the present model is called beyshrink which ranging in between 5% of MSE.This technique outperformed donoho and Johnson shrink. Second part of the paper was deliberated towards claiming lossy compression thereby achieving dual work of compression as well as denoising. The criteria for choosing parameters is based on Risanen's minimum description length principle.

Md. Foisal Hossain et al(2015), "Medical Image Denoising Using a Nonlinear Thresholding Function in Nonsubsampled Contourlet Transform" This paper proposes a new method of medical image denoising based on a new nonlinear thresholding function in Nonsubsampled Contourlet Transform (NSCT) domain. In medical images, noise suppression is a particularly delicate and difficult task. A tradeoff between noise reduction and the preservation of actual image features has to be made in a way that enhances the diagnostically relevant image content. The contourlet transform is a new extension of the wavelet transform that provides a multi-resolution and multidirection analysis for two dimension images

3. RESEARCH METHODOLOGY

Image processing requires identification of image boundaries for introducing clarity and reducing calculations complexity. To rectify the issue, edge detection is included to eliminate the area where critical section of the image is not present. In addition wavelet transformation is applied to identify the corrupted region within the required image. There are total of four bands LL,LH ,HL and HH. Every band is accompanied with the intensity level values. Intensity levels varied from 0 to 255. The values of the pixels lying outside this region are said to be corrupted. In order to resolve the problem, patches with highest uniformity with range 200 to 240 is identified and stored within the buffer. The particular band is checked for distortion where pixel intensity values violate the range of 0 to 255. The intensity levels then are scanned from the buffer and neighbourhood pixel values of the corrupted region is compared against the buffered values. The most appropriate values are replaced with the corrupted region to enhance the noised image. patched region within particular band with range between 200 to 240 is known as swarm and filter of such sort in proposed methodology is termed as swarm filter.

The flow chart is as given



4. RESULTS

Mostly utilized image quality measure is known as **Root Mean Square Error (RMSE).** It is the difference between original image and denoised image as shown in the equation 4.1 and 4.2. In spite of the fact that it doesn't constantly relate with human observation it is considered as great measure of the fidelity of an image estimate. Another related image quality measure is **Peak Signal-Noise Ratio (PSNR)** which is inversely proportional to RMSE. Its units are in decibels (dB). It is defined as the Ratio between the maximum possible power of a signal and the power of the corrupting noise as shown in the equation 4.3 and 4.4. It defines the purity of output signal.

$$MSE = \sum_{x=1}^{M} \sum_{y=1}^{N} \frac{[f(x,y) - f(x,y)]2}{M * N} \quad \text{.....4.1}$$

$$RMSE = \sqrt{MSE} \quad \text{.....4.2}$$

$$PSNR = 20 \log_{10}\left(\frac{MAX}{MSE}\right) \quad \text{.....4.3}$$

$$PSNR = 20 \log_{10}\left(\frac{255}{RMSE}\right) \quad 4.4$$

The basic motive behind PSNR is to compute a single no. that gives the perfect quality of reconstructed image. Reconstructed images having lower MSE and higher PSNR are judged better.

We used MatLab to implement the procedure of denoising. A usual way to denoise is to find a processed image such that it minimize mean square error (MSE) and increases the value of PSNR.

Figure 4.1 Image restoration of Brain MRI using existing edge and wavelet transform technique.

Figure 4.2 Image restoration of Brain MRI using proposed method

Figure 4.3 Image restoration of Arachnoid cyst using existing edge and wavelet transform technique.

Figure 4.4 Image restoration of Arachnoid cyst in Brain using proposed method

5. CONCLUSIONS

The use of Nonlinear filters have been widely used for the purpose of noise reduction and smoothing of grayscale images. The research work proposes an image denoising algorithm which retains basic features and properties of an image. The proposed method works by splitting a noisy image into basic image features and noise. The proposed method outperformed the existing edge and wavelet transforms by improving the subjective appearance of grayscale images corrupted by noises like impulse noise and in producing higher PSNR and lower MSE

In this paper, a New Nonlinear Filtering Technique (NNFT) using swarm filter has been developed. The filter has been shown to be quite effective in eliminating the noise. Further, since the filtering is performed only on corrupted pixels, the essential features of the images, namely, edges and fine details are preserved satisfactorily. The proposed NNFT using swarm filter has been shown to outperform the edge and wavelet transform other in terms of noise elimination and feature preservation properties.

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