Series Filtering Approach for Optimal Image Denoising using Wavelets

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Abstract*-The denoising of digital Image is a process of image restoration, where an image that has been degraded by prior knowledge of the degradation process is attempts to recover. A digital image can mathematically represented as a two dimensional function of u, in the spatial coordinat vectors x and y. Intensity is the amplitude of u at any coordinat pairs. A digital image is made out of limited number of components called pixels. A picture might be debased with commotion during processing, transmission, acquitition or transformation. Image denoising has dependably been an essential segment of signal processing, particularly in the digitized universe of present day society. Local filters are one of the most punctual strategies for denoising which utilized data from neighboring pixels with the possibility that area implied comparability. Anyway what nearby filters neglects to consider is the nonlinear structure inside the image, where pixels spatially far separated in an image can share similarities. To overcome denoising issue of image denoising using local filtering approach this work presents a Series filtering approach for optimal image denoising using wavelets Thresholding.

***Keywords* - PSNR, MAE, Image Denoising, Wavelets, Series Filtering.**

I. INTRODUCTION

Image processing is a field that continues to grow, with new applications being developed at an ever increasing pace. It is a fascinating and exciting area with many applications ranging from the entertainment industry to the space program. One of the most interesting aspects of this information revolution is the ability to send and receive complex data that transcends ordinary written text. Visual information, transmitted in the form of digital images, has become a major method of communication for the 21st century. Image processing is any form of signal processing for which the input is an image, such as photographs or frames of video and the output of image processing can be either an image or a set of characteristics or parameters related to the image. Most image processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it. There are applications in image processing that require the analysis to be localized in the spatial domain which can be done through Windowed Fourier Transform (WFT). Central idea of windowing is reflected in Short Time Fourier Transform (STFT). The STFT conveys the localized frequency component present in the signal during the short window of time.

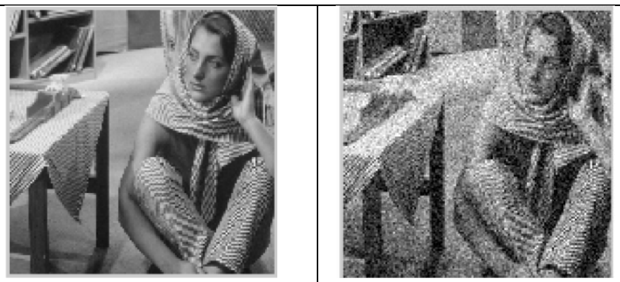
Images are often corrupted with noise during acquisition, transmission, and retrieval from storage media. Many dots can be spotted in a Photograph taken with a digital camera under low lighting conditions. Appereance of dots is due to the real signals getting corrupted by noise (unwanted signals). On loss of reception, random black and white snow-like patterns can be seen on television screens, examples of noise picked up by the television. Noise corrupts both images and videos. The purpose of the denoising algorithm is to remove such noise.

Image denoising is needed because a noisy image is not pleasant to view. In addition, some fine details in the image may be confused with the noise or vice-versa. Many image-processing algorithms such as pattern recognition need a clean image to work effectively. Random and uncorrelated noise samples are not compressible. Such concerns underline the importance of denoising in image and video processing.

Image denoising is a restoration process, where attempts are made to recover an image that has been degraded by using prior knowledge of the degradation process".

It is well known that while receiving the input image some aberrations get introduced along with it and hence a noisy image is left with for future processing. The image denoising naturally corrupted by noise is a classical problem in the field of signal or image processing. Images are often corrupted with noise during acquisition, transmission, and retrieval from storage media. For example, many dots can be spotted in a photograph taken with a digital camera under low lighting conditions as shown in Fig. 1.1.

Appearance of dots is due to the real signals getting corrupted by noise (unwanted signals). Whereas in television, random black and white snow-like patterns can be seen on the television screens due to loss of reception. Hence noise corrupts both images and videos. In addition, some fine details in the image may be confused with the noise or vice- versa. Many image processing algorithms such as an improved non local denoising algorithm, pattern recognition etc. need a clean image to work effectively.



(a) Clean Barbara Image (b) Noisy Barbara Image

Figure 1.1 Illustration of Noise in the Image.

The work presented herein focuses on a zero mean additive white Gaussian noise (AWGN). Zero mean does not lose generality, as a non-zero mean can be subtracted to get to a zero mean model. In the case of noise being correlated with the signal, it can be de-correlated prior to using this method to mitigate it. The problem of denoising can be mathematically presented as follows,

$$Y = X + N \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1.1)$$

where Y is the observed noisy image, X is the original image and N is the AWGN noise with variance σ^2.

The objective is to estimate X given Y. A best estimate can be written as the conditional mean X = E[X | Y]. The difficulty lies in determining the probability density function ρ(x | y). The purpose of an image-denoising algorithm is to find a best estimate of X. Though many denoising algorithms have been published, there is scope for improvement.

II. NOISE SOURCES

The block diagram of a digital camera is shown in Figure 2.1. A lens focuses the light from regions of interest onto a sensor. The sensor measures the color and light intensity.

An analog-to-digital converter (ADC) converts the image to the digital signal. An Image-processing block enhances the image and compensates for some of the deficiencies of the other camera blocks. Memory is present to store the image, while a display may be used to preview it. Some blocks exist for the purpose of user control. Noise is added to the image in the lens, sensor, and ADC as well as in the image processing block itself.

The sensor is made of millions of tiny light-sensitive components. They differ in their physical, electrical, and optical properties, which add a signal-independent noise (termed as dark current shot noise) to the acquired image. Another component of shot noise is the photon shot noise. This occurs because the number of photons detected varies across different parts of the sensor. Amplification of sensor signals adds amplification noise, which is Gaussian in nature. The ADC adds thermal as well as quantization noise in the digitization process. The image-processing block amplifies part of the noise and adds its own rounding noise. Rounding noise occurs because there are only a finite number of bits to represent the intermediate floating point results during computations [2].

Most denoising algorithms assume zero mean additive white Gaussian noise (AWGN) because it is symmetric, continuous, and has a smooth density distribution. However, many other types of noise exist in practice. Correlated noise with a Guassian distribution is an example. Noise can also have different distributions such as Poisson, Laplacian, or non-additive Salt-and-Pepper noise. Salt-and-Pepper noise is caused by bit errors in image transmission and retrieval as well as in analog-to-digital converters. A scratch in a picture is also a type of noise. Noise can be signal dependent or signal independent.

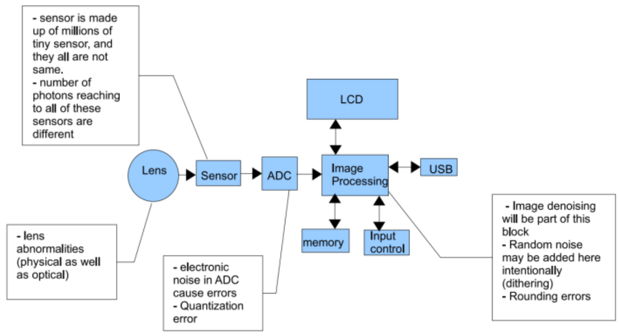


Figure 2.1 Basic blocks of a digital camera and possible noise sources.

III. PROPOSED METHODOLOGY

To achieve optimal image denoising in this work presents a series filtering approach using wavelets soft and hard thresholding. The main objective to develop an image denoising algorithm is to remove noise by differentiating it from the signal.

The wavelet transforms's energy conservativeness helps enormously in denoising. Energy conservativeness alludes to the way that the greater part of the signal energy is contained in a couple of huge wavelet coefficients, though a little segment of the energy is spread over an extensive number of little wavelet coefficients. These coefficients represents to points of interest and also high frequency noise in the image. By suitably thresholding these wavelet coefficients, image denoising is accomplished while saving fine structures in the image.

The Other useful properties of the wavelet transform that used in the image denoising approach are sparseness, clustering, and relationship between's neighboring wavelet coefficients. The wavelet coefficients of characteristic images are sparse. The histogram of the wavelet coefficients of characteristic images tends to peak at zero.

A wave is typically characterized as a oscillating function in time or space. Sinusoids are a case. Fourier investigation is a wave examination. A wavelet is a "little wave" that has its energy amassed in time and frequency. It gives a tool to the examination of transient, non-stationary, and time-varying phenomena. It permits simultaneous time and frequency investigation with an adaptable numerical establishment while holding the oscillating wave-like characteristic.

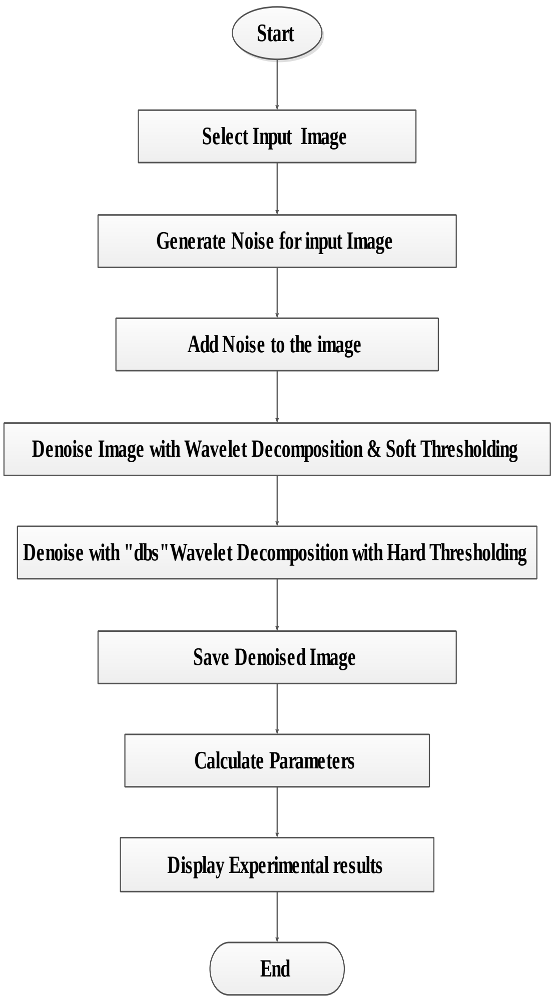


Figure 3.1 Flow chart of proposed work.

The two dimensional (2D) wavelet transform is an augmentation of the one dimensional (1D) wavelet transform. To acquire a 2D transform, the 1D transform is first connected over every one of the rows and afterward over every one of the columns at every decomposition level. Four arrangements of coefficients are produced at every disintegration level: LL as the average, LH as the details across the horizontal direction, HL as the details across the vertical direction and HH as the details across the diagonal direction.

A wavelet based Thresholding is one of the most effective technique used in this work for image segmentation. It is a non-linear operation utilized to converts a gray-scale image in to binary image format. In this process two levels pixels above or below specified threshold value are assigned. In many applications, it is useful to separate out the regions of the image corresponding to objects and background in which is to be analyze.

A global Hard-thresholding is utilized as a part of proposed algorithm, in this thresholding strategy thresholds the total image with a solitary threshold esteem. So utilizing that technique for image denoising select one threshold esteem for entire image.

Steps of Simulation

1. Start Matlab Program
2. Select Input Test image
3. Generate Noise for input image
4. Add noise to the image
5. Denoise image with wavelet decomposition & Soft Thresholding
6. Denoise image with "dbs" wavelet decomposition with Hard Thresholding.
7. Save achieved denoised image.
8. Calculate Parameters
9. Display experimental results.
10. End simulation process.

IV. SIMULATION RESULTS

The implementation and simulation of proposed work is done on MATLAB. Proposed image denoising algorithm has been tested on a standard image set with noise standard deviation σ for additive white Gaussian noise. The proposed strategy has been contrasted and the current image denoising algorithm and its variations. The correlation and examination of results has done based on the PSNR and the MAE measures.

To assess the execution of proposed denoising approach Peak Signal to Noise Ratio (PSNR) and Mean Absolute Error(MAE) measure has utilized the. These are broadly utilized target measures for assessing the execution of image denoising algorithms. Fig. 4.1 shows the Simulation outcomes of PSNR and MAE for Barbara image (a) Original Image (b) Noisy Image and (c) Denoised Image on noise levels $\sigma = 10, 30, 50, 70$ and 90 respectively.

The peak signal to noise proportion (PSNR) refers to the ratio between the greatest power of a signal to the noise which debases the first image. This measure is based on the Mean Squared Error (MSE) which evaluates the contrast between the first image information and the corrupted image information.

The basic similarity index is utilized to discover similitude between two images. Comparable pixels have solid between functions when they are nearer. The accompanying equation measures MAE.

Table 1 has given performance analysis of proposed work based on PSNR and MAE. Fig. 4.2 shows the comparison of PSNR for All Images on Noise Standard Deviation σ = 30. Fig. 4.2 shows the Comparison of MAE for Man on σ = 10 to 90 among previous and proposed system

Original Image Noisy Image Denoised Image

(a) (b) (c)

Figure 4.1 Man Image is Simulated with Proposed Methodology on Noise Levels σ = 10, 30, 50, 70 and 90 respectively.

Table 1: Performance Comparison of PSNR and MAE for Noise Standard Deviation σ = 50

Images	*Peak Signal to Noise Ratio (PSNR) in dB*		*Mean Absolute Error(MAE)*	
	Previous	*Proposed*	*Previous*	*Proposed*
Lena	27.24	*34.02*	9.47	*8.23*
Peppers	22.58	*34.11*	9.32	*8.12*
Columbia	26.40	*33.48*	10.71	*10.18*

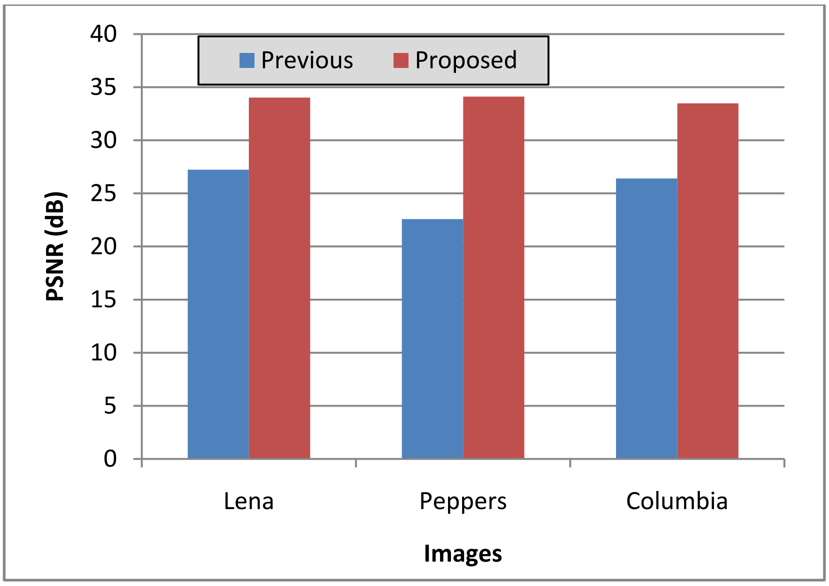


Figure 4.2 Bar Chart Comparison of Peak Signal To Noise Ratio (PSNR)

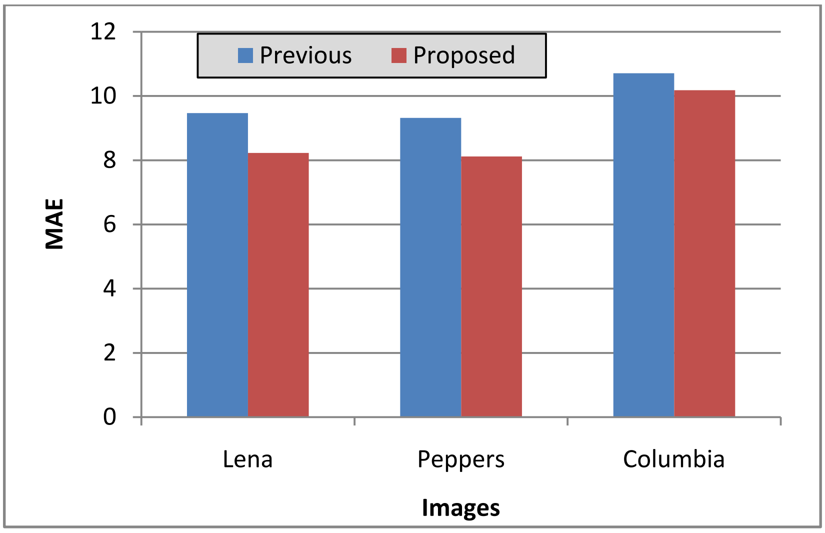


Figure 4.3 Bar Chart Comparison of Mean Absolute Error (MAE)

V. CONCLUSION AND FUTURE SCOPES

The key of this enhancement is to reduce the noise, which diminishes the patch similarity measurement time and expands the general denoising execution. The optimized parameters are used in our proposed method to improve the performance of the denoising scheme. Proposed image denoising approach shown in this work proves the efficiency of algorithm for various images and also for various noise densities of Noise Standard Deviation. The Effectiveness of the proposed approach is contrasted and the current work as far as Peak Signal to Noise Ratio (PSNR) and Mean Absolute Error (MAE). Experimental results are compared and shown in previous section in different visual aspects. The reverse bi orthogonal approach can be improved by integrating with or replacing with multiple structures of wavelet decomposition filters and levels to achieve optimum outcomes along with that adjustive filter can be modified with the integration of other filters for future perspectives. The following algorithms can be extended for color image denoising or video denoising applications which can also be considered as a future work.

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