A Survey on Performance Analysis of Image Denoising in Wavelet Domain

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Abstract- *An important part of digital image processing and computer vision based problems is Image Denoising. So Image Denoising should possess some crucial qualities. An important property of image denoising based model is that it should remove the unwanted amount of information present in the image. The image should not contain the noisy pixels. The extent of noise present in the image should be as much as possible. Another Crucial property of image denoising is that is should preserve the edges contained in the image. One of the powerful approach used in image denoising using discrete wavelet transform(DWT). In this paper, a comparison study of some filters is carried out. The filters included are mean filters and median filters. Also a brief study of various operations in wavelet domain is carried out. The analysis results shows that wavelet domain based methods outperforms the other existing methods of image denoising methods.*

Keywords- Denoising, Mean and Median filters, Noisy pixels, Wavelet domain.

I. INTRODUCTION

The area of digital image processing is increasing day by day. The digital world generally consists Digital cameras, MRI(Magnetic Resonance Imaging), Satellite Television etc. Thus the noise can be easily available in the images during the acquisition process from the source. The main type of noises that can be there in the images can be Gaussian noise, Salt and pepper noise, Uniform noise etc. The function of image denoising is to prevent from these various types of noises. The main fundamental goal of image denoising process is preservation of crucial information that may be present in the image. Preservation of edges is another critical goal of image denoising. The commonly used filters in spatial domain are mean and median filters. The major drawback of using these spatial domain based filters is that these filters can cause blurness in the images. Although these filters smooth the data present in the image, but the advantage of these filters can be seen in terms of noise removal feature. The major reason for using wavelet domain is therefore lies in the area of edge preservation. The wavelet domain can be localized in space but the Fourier sine and cosine functions can not be localized in the space. But the mathematical properties of both are same. Image denoising in wavelet domain involves the decomposition of the image. The decomposition process defines the various levels. The various levels of decomposition divides the image into specified sub bands. The first level of decomposition is further decomposed. The decomposition criteria using DWT follows proper steps.

II. LITERATURE SURVEY

Thakur et.al.[1] proposed a method in which X-rays along with the photon are used to generate X-ray images. The X-rays used for this purpose should have wavelength below 0.2 to 0.1nm. These X-rays have the high penetration ability. But these rays generally consists of photon i.e. these rays obeys the distribution of Poisson noise. This Poisson noise effects the quality of medical images. In this paper, Harris operator in modified form as well as wavelet domain based thresholding is suggested to do de-noising. Harris Operator has the advantage that it finds the pixels in the image where intensity is high to give the better results.

Zhang et.al.[2] proposed a system which uses the linear minimum mean square error calculation for the process of de-noising. It assures good output of the image. During the acquisition of the image, noise may present system. When de-noising gets completed, this image is required for the interpolation process. During the application of interpolation scheme of de-noising, sometimes image's detail along the edges gets effected. Thus the interpolation scheme may introduce artifacts in the image. The crucial issue in the interpolation scheme is thus preservation of edges. To remove these problems, a scheme named as Directional Interpolation Scheme is introduced. Therefore a directional de-noising algorithm is suggested. It includes a scheme named directional interpolation . The calculation of noiseless and missing samples is conducted using the optimal calculation for the same framework. This estimation process is carried out by using adaptive calculation of various local statistics. By using this calculation a better or accurate output is obtained in many directions. This method not only preserves the image edge structures but also decreases the artifacts introduced in the image.

Jung *et.al.*[3] proposed that two complementary discontinuity measures are used in the scheme of Bayesian Image De-noising. But the spatial discontinuity has a special characteristics of over-locality. Due to this over locality characteristic, many crucial discontinuities can not be detected during the process of de-noising. However spatial discontinuity has a feature that it preserves the image's edge components in a better way. Therefore, there is great need of finding new discontinuity measures for the purpose of preservation of features by following the detection process of contextual discontinuities. discontinuities. The main advantage of this scheme is that in the small regions there is degree of uniformity. Also there is effective detection of crucial discontinuities in this method. The prior probabilities of de-noising scheme of Bayesian framework are created by using the combined complementary discontinuity measures. This method achieves high PSNR, also the edge components are preserved well.

Chen et.al.[4] proposed that for the de-noising process , three scales of dual tree complex wavelet coefficients are used. This is done for the removal of a specific noise. This noise is known as White Gaussian Noise. Dual tree complex wavelet transform have special characteristic of approximate shift invariance and better directional selectivity. Due to these two special qualities it provides high competitive outputs. In case of 3D MRI(magnetic resonance images), there exists other useful methods. This technique is based on the idea of block wise non-local(NL) means scheme. This NL means scheme is used along with adaptive multi resolution. In the adaptive soft wavelet coefficient mixing, the content of de-noising is implicitly adapted with respect to the spatial and frequency based contents.

Coupe *et.al.*[5] proposed a filter which is suitable for mainly two types of noises. These noises are basically Gaussian Noise and Rician Noise. When this technique is compared to the other latest techniques like Rician NL means filter technique produces high competitive measure results with the help of several quality metrices on brain web databases in the quantitative validation. This type of filter not only preserves the fine details but also removes the noise. This filter actually does experiments on the images like anatomical and diffusion weighted MR images. This is generally used in the area of fiber tracking. Authors have proposed an improved decision based detail preserving variational method to remove a special type of noise. This Type of noise is basically random valued impulse noise. A great care is needed if the images are highly corrupted. So in case of highly corrupted images, it is very important to improve the detection process. To achieve this, a variable window scheme is introduced which is employed by adaptive centre weighted median filter. While the classification of noisy parts of the image is carried out then various noise marks are labeled. This is carried out by fast iterative strategy given by improved ACWMF. To store all the noisy parts of the image a weight adjustable detail-preserving variational method is purposed. Also all these noisy parts of the image are stored as one time event. The function of these noise marks is that it decides the weights of DPVM's convex cost function. This_decision is done on the basis of data fidelity term and smooth regularization term. After the minimization process, this restored image is fetched. The quantitative measurements and version done by the proposed filter outperforms all other existing algorithms. It is quite fast and easily it can be used for practical applications or can say in real time applications.

Zhou *et.al.*[6] discussed many noise models according to the form of images. Mostly the images can be of the form real, satellite, medical images etc. The decomposition process is presented in form of new model. In the new proposed algorithm a non-convex, non-smooth regularization and also Hilter Sobolev spaces whose degree is negative in differentiability are applied. This captures the oscillatory patterns. A pseudo solution which is already proven exists for the proposed model. To solve the minimization problem, variable splitting and penalty schemes are used. This problem is solved by using different numerical algorithm. Many experiments are carried out for the de-noising, de-blurring and decomposition for the real and synthetic images.

Lu. C.W[7] discussed the main issue in digital image processing is to reduce the noise in the various images. With respect to the various experiments, assumptions, applications, limitations, various image de-noising algorithms have been proposed.

III. TECHNIQUES USED FOR IMAGE DENOISING IN WAVELET DOMAIN

3.1 NOISE MODEL:

3.1.1 Gaussian Noise

The standard model of amplifier noise is additive, Gaussian, which is independent at each pixel and independent of the signal intensity. In color cameras, blue colour channels are more amplified than red or green channel. Therefore, blue channel generates more noise. Gaussian noise is also known by the name electronic noise. Its main source is that it can arise from the natural sources.

3.1.2. Impulsive Noise

Impulsive noise is also called as salt-and- pepper noise or spike noise. This kind of noise is usually seen on images. It consists of white and black pixels. An image containing salt and pepper noise consists of two regions i.e. bright and dark regions. Bright regions consist of dark pixels whereas dark regions consist of bright pixels. Transmitted bit errors, analog-to-digital converter errors and dead pixels contain this type of noise.

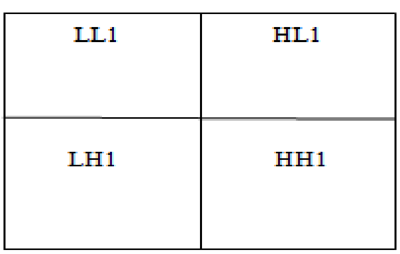
3.1.3 Mean Filtering technique

The advantage of using this filter is that it provides smoothness to an image by reducing the intensity variations between the adjacent pixels. Mean filter is essentially an averaging filter. It applies mask over each pixel in signal. Therefore, to make a single pixel each of the components of pixel which falls under the mask are average filter. The main disadvantage of Mean filter is that it cannot preserve edges.

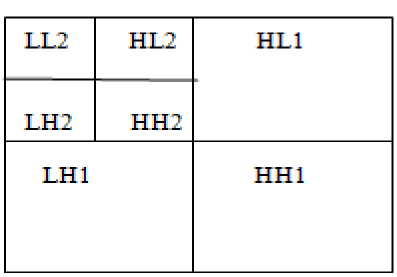
3.1.4 Median Filtering technique

One type of non linear filter is Median filter. By firstly finding the median value and then replacing each entry in the window with the pixel's median value, median filtering is done . Median is just the middle value after all the entries made in window are sorted numerically, if window has an odd number of entries. There is more than one median when window has an even number of entries. It is a robust filter. To provide smoothness in image processing and time series processing, median filters are used.

3.2 DWT TECHNIQUE OF IMAGE DECOMPOSITION



(a) One level



(b) Two level

Figure1: DWT decomposition of image.

Wavelet domain is advantageous because DWT make the signal energy concentrate in a small number of coefficients, hence, the DWT of a noisy image consists of 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, the image is reconstructed using inverse DWT. Time and frequency localization is simultaneously provided by Wavelet transform. Moreover, wavelet methods represent such signals much more efficiently than either the original domain or fourier transform. The DWT is same as hierarchical sub band system where the sub bands are logarithmically spaced in frequency and represent octave-band decomposition. Image is decomposed into four sub-bands and critically sampled by applying DWT as shown in Fig. 1(a). These sub bands are formed by separable applications of horizontal and vertical filters. Sub-bands with label LH1, HL1 and HH1 correspond to finest scale coefficient while sub-band LL1 represent coarse level coefficients. The LL1 sub band is further decomposed and critically sampled to find out the next coarse level of wavelet coefficients as shown in Fig. 1(b). It results in two level wavelet decomposition.

3.3WAVELET THRESHOLDING TECHNIQUE USING HARD AND SOFT THRESHOLD

Hard and soft thresholding techniques are used for purpose of image denoising. Keep and kill rule which is not only instinctively appealing but also introduces artifacts in the recovered images is the basis of hard thresholding whereas shrink and kill rule which shrinks the coefficients above the threshold in absolute value is the basis of soft thresholding. As soft thresholding gives more visually pleasant image and reduces the abrupt sharp changes that occur in hard thresholding, therefore hard thresholding is preferred.

Hard thresholding : $y = \begin{cases} x, & if\ |x| > T \\ 0, & if\ |x| < T \end{cases}$ (1)

Soft thresholding: $y = sign(x)(|x| - T)$ (2)

Here, x is the input signal, y is the output signal and T is the Threshold.

Advantages of using wavelet domain based de-noising

- Works Well efficiently
- Can be lacalized in space as well.

Disadvantages

- Does not consist set of basis function like Fourier Transform.

IV. ALGORITHMIC PROCEDURE USED

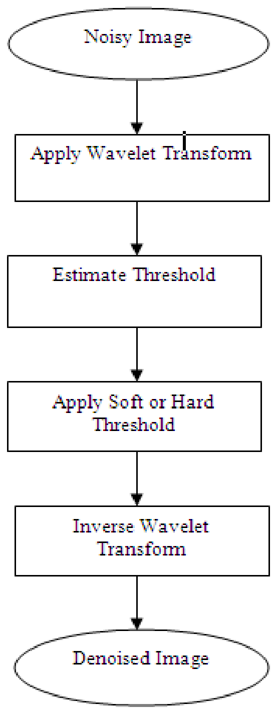


Figure 2: Denoising algorithm

4.1.2. Threshold Selection Rules:

- Universal Threshold
- Sub band Adaptive Threshold
- Spatially Adaptive Threshold

V. CONCLUSION

In this paper, survey on de-noising in the digital images have been conducted. This survey is conducted with the help of different techniques that are used for image de-noising. In these techniques various methods of de-noising are well stated. Performance results shows that wavelet domain based de-noising scheme well efficiently performs the denoising procedure.. On the other hand, Spatial filtering methods Scheme does not efficiently perform the denoising process. Spatial methods does not preserve the egdes efficiently. While the DWT decomposition of wavelet domain not only achieves the high PSNR but also preserve the edge components of the image.

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