ORIGINAL ARTICLE

IMAGE DE-NOISING USING MULTI RESOLUTION TRANSFORMS

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Abstract

In today's modem era the use and applications of image processing is increasing day by day. Image enhancement being the most crucial and very early step in image processing has its importance. Curvelet Transform (CT) offers a promising solution for representation, storage and processing of image curved features by means of Ridgelet analysis. So long as in the area of image processing, Wavelet Transform (Vv'T) has been an alternative for noise removal methodologies but since Wavelets shows their inefficiency while dealing with image edge and curved features, the term Curvelet Transform came into existence. Curvelet Transform in Image denoising is a well-established technique in today's era where we face a lot of challenges while dealing with huge amount of data relating to image processing applications. Curvelet Transform has the capability to deal with higher dimensional images having typical curved features and smooth areas along those curves, to do so curvelet makes use of ridgelet analysis after decomposing image into different subbands followed by smooth partitioning so that a curve may become nearly approximate to a straight line. An efficient image denoising technique must remove the noise thereby maintaining the important image features, so the main issue remains the selection and application of appropriate threshold. . While the technologies for acquiring images continue to improve, resulting images of higher and higher resolution and quality are expected, Rician noise still remains. The main trouble detoriating the quality while removing this noise from images remains one of the main approach inside the examination of imaging. Thus, extending the application of curvelet transform, aiming to filter the noisy image and restorating the losses in images. In particular, the aim is to develop an efficient artifact, free edge preserving vhr image denoising method using curvelet transform, assess and compare their performance in such a way to improve the reconstructed image quality.

Key Words:- *Image enhancement, denoising, curvelet, ridgelet, wavelet, noise*

1. Introduction

The aim of different denoising method based upon multiresolution transform that can be applied successfully to the biomedical images corrupted with noise. Wavelet Transform is one of the most recent areas of mathematics in the field of signal and image processing and its foremost use is in compression and denoising. In the perspective of denoising, the accomplishment of techniques established on the Wavelet Transform is confirmed by the ability to décorrelate noise and useful signal. Since the signal is restricted in a lesser number of coefficients of such a transform, all other coefficients basically comprise noise. By filtering these coefficients, most of the noise is eradicated. Thus, image denoising method built on wavelets adheres to the standard technique, in three steps: calculating a Discrete Wavelet Transform of the image to be denoised, filtering in the wavelet domain and the computation of the equivalent inverse Wavelet Transform. During the recent years, Wavelet Transforms (WT) have been used to work on denoising and the Discrete Wavelet Transform was the first among them. But it has three main drawback lack of shift invariance, absence of uniformity of the mother wavelet and decreased directional selectivity. These disadvantages can be brought down using a Complex Wavelet Transform. The Complex Wavelet Transform has remained a important tool in signal and image analysis and is a complex-valued extension to the usual Discrete Wavelet Transform (DWT).

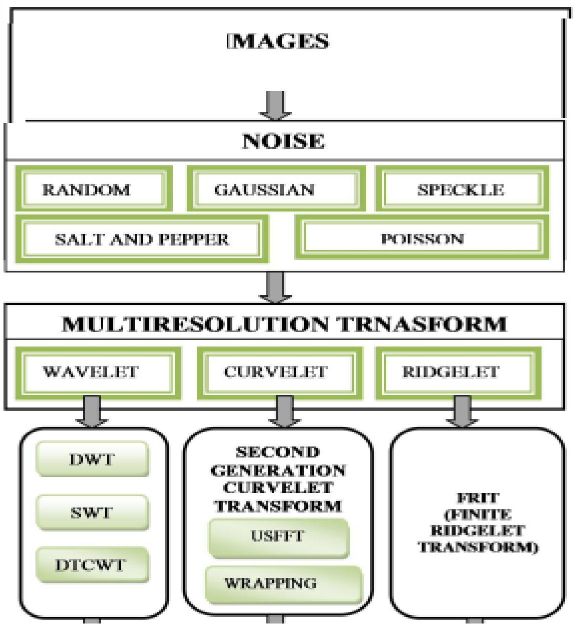

Figure 1 Block diagram of Multiresolution Transform-based Denoising

The limits of the Wavelet Transform are overcome due to the development of the Ridgelet Transform. Enormous wavelet coefficients are produced by the 2D Wavelet Transform of images at each scale of the decomposition. For enhancement of noisy images there lot of problem with so many large coefficients. As opposed to the Wavelet Transform, the Ridgelet Transform handles information by first computing integrals over various directions and areas. The Ridgelet Transform successfully signifies line singularities of 2-D signals. Line singularities are mapped onto point singularities in the Radon domain by using the Radon Transform. Subsequently the Wavelet Transform can adequately be utilized to decide the point singularities in this new zone. The Curvelet Transform technique initially as a result of the growing requirement of the existence of real multiresolution analysis has the capacity to overcome the downsides of wavelet investigation. The change was intended to speak to edges and different singularities along bends, for example utilizing impressively less coefficients for a predetermined accuracy of remaking. The same authors later proposed a much easier second-generation Curvelet Transform built on a frequency partition technique. It is as well faster and less redundant in contrast to its first generation form. In the new version of curvelet, the Ridgelet Transform was not needed, thus decreasing the extent of redundancy in the transform and improving the speed significantly

3. LITERATURE REVIEW

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Ming Jun Lai et al (2009) established the connection between the minimizers of the discrete and continuous ROF model. A central difference total variation term of the discrete ROF model is used and the discrete input data is treated as a projection of the continuous input data into the discrete space. The total variation model proposed by Rudin, Osher and Fatemi is the most powerful model for image denoising.

Hong Qiao Li et al (2009) have combined Wavelet Transform and Curvelet Transform and the method was implemented on natural images degraded by Gaussian noise. The images are denoised separately using Wavelet Transform with soft thresholding and Curvelet Transform with wrapping algorithm. Then different weight coefficients are given to the denoised image and added. The proposed method shows higher PSNR when compared with stand-alone wavelet and curvelet methods.

Fulvio Moscheti et al (2004) employed a hybrid structure that merges wavelet and ridgelet pointing at an effective illustration for natural images with edges. The authors have shown that this hybrid structure displays considerable progress when related with wavelets. The HL1 and LH1 subbands of the wavelet decomposition offer the high frequency information in the horizontal and vertical directions. When extracted, the edges are split into blocks 32 x32 and the Ridgelet Transform is employed

Latha Parthiban & Subramanian (2006) denoised Speckle noise in Ultrasound images using contourlets. The Contourlet Transform provides a multiscale and multidirectional representation of an image and the authors have concluded that they perform better than wavelets. The experiments are performed for different values of noise variance and for all values of ı, contourlets do better than wavelets in terms of PSNR.

Isabel Rodrigues et al (2008) have stated that medical images are degraded by Poisson noise appropriate for demonstrating the counting procedure related to several imaging modalities such as PET, SPECT and fluorescent confocal microscopy imaging. Algorithms for Poisson noise removal used are platelets, wavelets and minimum description length. Algorithms considered for Gaussian noise like total variation and non-local means surpass the methods designed for Poisson noise. The authors have concluded that the Total Variation denoising designed for Gaussian noise offers better results in terms of PSNR.

Sandep Palakkal & Prabhu (2011) developed a strategy to combine Variance Stabilizing Transform (VST) for Poisson image denoising with FDCT. The VST transforms the Poisson image to roughly Gaussian distributed and the ensuing denoising has been achieved in the Gaussian domain. Low intensity Poisson degraded images are denoised better by combining the VST with FDCT.

Yuan Guo & Zhengyao (2008) have proposed speckle reduction in Synthetic Aperture Radar (SAR) images in the cuvelet domain. Soft, hard and block complex thresholding of curvelet coefficients is used. The performance of the algorithm is evaluated in terms of PSNR. The PSNR using different threshold rule are higher and the denoised images are clearer and without scratches and the authors have concluded that it enables image segmentation, detection and recognition.

Jiang Tao & Zhao Xin (2008) have implemented wrapping-based curvelet to denoise natural images like Lena and Barbara degraded by Random noise and Synthetic Aperture Radar (SAR) images corrupted by Speckle noise . The Curvelet Transform method is compared with other filtering methods like Average, Median, Lee Filter and wavelets and shows superior results in terms of PSNR.

Shadi AlZubi et al(2011) intended to develop an Automatic Image Segmentation system for categorizing regions of interest in medical images which are obtained from different medical scanners such as PET,CT or MRI. Experimental results reveal that curvelet considerably improves the classification of abnormal tissues and decreases the surrounding noise.

Naga Sravanthi Kota & Umamaheswara Reddy (2011) denoised MRI images and natural images corrupted by Gaussian noise using Gaussian filters, Wavelet Transform using Bayes shrink and first generation Curvelet Transform for different noise variance. The denoised images obtained from these methods are fused and the results confirm that fusion technique offers better results in terms of PSNR.

Anil & Jyoti Singhai (2010) implemented a 2D Fast Discrete Curvelet Transform (FDCT) on three different grey scale images like Lena, Barbara and Cameraman with Gaussian noise level. Curvelet Transform with subband dependent threshold outperforms Wavelet Transform in terms of PSNR. Haar wavelet, db4 is used.

An adaptive threshold algorithm for image denoising based on Curvelet Transform and implemented on natural images degraded by Random, Salt-and-pepper and Gaussian noise was suggested by Aliaa et al (2010). The performance of the algorithm is compared with other state-of-the art methods like Wiener filter, Total Variation filter and adaptive threshold algorithm offers better results

Starck et al (2003) have used the Curvelet Transform for contrast enhancement and is compared with enhancement established on Wavelet Transform. Curvelet Transform outdoes Wavelet Transform in terms of enhancement on noisy images. Additive White Gaussian Noise is used and the algorithm is operated on natural images like Lena. However, first generation Curvelet Transform is used. Curvelet Transform is well reformed to characterize images encompassing edges; it is a good entrant for edge enhancement

Wen Chin Yen & Shen Chuan Tai (2010) have suggested an algorithm for speckle reduction which is an imperious pre-processing step in Ultrasound image for feature extraction, analysis and recognition. Dual tree Wavelet Transform is used for the segmentation of the ultrasound images

3. Image de-noising using curve-lets

Image De-noising is implemented to produce good estimates of the original image from noisy observations. The restored images hould contain less noise than the observations while still keep sharp transitions (i.e edges). Suppose an image f(m,n) is corrupted by the additive noise

$$g(m,n) = f(m,n) + \eta(m,n) \quad \ldots\ldots\ldots\ldots\ldots(1)$$

where η(m, n) are independent identically distributed Gaussian random variable with zero mean and variance σ2. Image de-noising algorithms vary from simple thresholding to complicate model based methods. However simple thresholding methods can remove most of the noise.

Algorithms :1. Apply the Forward Curvelet transform to the noisy image.

2.Threshold the Curvelet co-efficients to remove some insignificant curve-let

co-efficients by using a thresholding function in the curve-let domain.

3. Inverse Curvelet transform of the thresholded co-efficients to reconstruct a function.

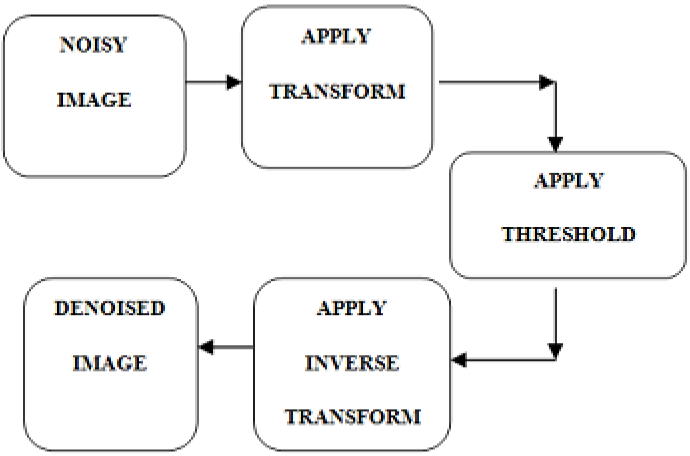

Figure 2 Block diagram of Curvelet - based Denoising

Shrinkage/thresholding plays an important role in curve-let application. Various thresholding techniques have been applied on the curve-let co-efficient of the observed image. The small coefficients are dominated by noise, while co-efficient with large absolute value carry more signal information than noise. As a result noisy co-efficients (small co-efficients below acertain threshold value) are replaced by zero.

The curve-let shrinkage is taken as

$P\sigma\, u = T^{-1}\, S\sigma\, T\,(u)$ ----------------(2)

T denotes the Curve-let transform, T^{-1} the inverse transform and Sσ is the thresholding function.

4. Result

Fig. 3 Visual results of different denoising algorithms for *Barbara* image (**a)** Noise free image (**b)** Noisy image (σN = 20, PSNR = 22.13 dB) **(c)** Wavelet result, PSNR = 27.08 dB (**d)** Ridgelet result, PSNR = 28.24 dB **(e)** Curvelet result, PNSR =28.11 dB

5. Conclusion

The need for noise suppression without significantly degrading the edges and other high frequency components of high resolution images has motivated the development of an edge preserving noise smoothing techniques on curvelet approximation, which preserves the important high frequency components like edges. In wavelet based denoising method the edge and detailed information are lost appreciably. But in our proposed curvelet based algorithm, edge details are retained better than wavelet based denoising method. From the analysis of PSNR values for different noise level, it is evident that for the high resolution image in the situation of noise level, PSNR values of curvelet transform improved denoising method, is relatively high. With the increase of noise size, PSNR value is gradually consistent with curvelet transform, but still surpassed the wavelet transform.

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