A Comparative Study of Various Filters in Image Denosing with Curvelet Transformation

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Abstract— **In the diverse fields of life, Digital Imaging is the part and parcel, from education to medical such as clinical diagnosis or medical imaging. But it reckons with the difficulty due to Gaussian Noise, thus both the images and videos are devoured. Noisy images are not much to look at; therefore the image denoising process is needed. Images may be ill-defined with the noise so that it conceals the fine details in the image. Here, the idea behind this Denoising algorithm is to improve the pictorial information by enabling the noise-free modifications of an image. This paper is intent to accomplish the performance assessment of the noise depletion methods on the Brain Computed Tomography (CT) images with the combination curvelet transformation along with various filters. This work propounds a Curvelet Transformation founded image denoising which is composited with Gabor filter, median filter and wiener filter in the place of low pass filtering in the transform domain and results conclude that wiener filter gives better result.**

Index terms—Coefficient of Correlation (CoC), Computed Tomography, Curvelet Transform, Denoising, Gabor Filter, Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR).

I. INTRODUCTION

To bring forth the tomographic images (or virtual slices) of specific areas of the scanned object, a technology is used with the computer processed X-rays, known as Computed Tomography or Computed axial Tomography. It can be employed for the medical imaging and industrial imaging. Digital geometry processing is exploited to render a three dimensional image of the inside of an object from a large series of two-dimensional X-ray images taken around a single axis of rotation. It is an advanced scanning X-ray and computer system that makes detailed pictures of horizontal cross-sections of the body or the part of the body that is X-rayed. A CT scan is a diagnostic test that combines the use of X-ray with computer technology. A volume or measure of data, produced by CT that competently utilized via a mechanism named as "Windowing" with an eye to manifest the various bodily complexions founded on their potentiality or competency to interrupt the X-ray beam. Historically, the pictures rendered were in the axial plane, vertical to the long axis of the body. Volume or measure of data to be redesigned in many planes or even as three dimensional representations of complexions, admitted by modern scanners. Medical imaging is the most common application of CT. In the different fields, CT is also used such as non-destructive materials testing. Another example is archaeological uses such as imaging the contents of sarcophagi [17, 18]. Computed Tomography (CT) and magnetic resonance imaging (MRI) are the two techniques that are widely used in medical diagnosis. CT imaging has more prior than the MRI due to its lower price, short imaging times, provides good details about bony structures, widespread availability, ease of access, optimal detection of calcification and hemorrhage and excellent resolution of bony detail. A major advantage of CT is that it is able to image bone, soft tissue and blood vessels all at the same time. CT gives accurate information about the distribution of structures inside the body. CT introduces excessive transparency than conventional X-ray. However, the limitations for CT, compared to other diagnostic tests, CT scans deliver a relatively high dose of radiation to the patient which produces low brain tissue contrast [1]. The improved resolution of CT has permitted the development of radiography investigation method that renders a 3-D image of the inside of an object from a large series of 2-D images taken on a cross sectional plane of the same object. CT generates tenuous or thin slices of the body with a narrow x-ray beam, which float around the body of the stagnant patient [2].

In the ordinary way, CT images are of inferior contrast and due to various attainments, propagation storage and display devices they often has Gaussian noise [3], [4]. It is requisites to use a suitable noise depletion method in most of the image processing application, before any relevant details could be extracted from analyzed images. Herein, with the abstract based on statistical filtering in spatial domain, the initial exertion was started [5].

In the earlier days, wavelet methods based noise reduction in signals and images, has been on the big side attention. By adopting Discrete Wavelet Transform (DWT) of the image, the wavelet coefficients at different scales could be attained. In the sub-band, the small coefficients are run away with noise, whereas the more signal information occurs than the noise, in the coefficient with large absolute value. The noiseless reconstruction may lead by an inverse wavelet transform when the noisy coefficients are dislodging by zero. Normally, the two techniques used for the denoising process are hard thresholding (Hard WT) and soft thresholding. Although both techniques are used for denoising process on the big side but they include some disadvantages too. At the preset threshold, the wavelet coefficients are not continuous therefore it may lead to the oscillation of the reconstructed signal. The wavelet coefficients having good continuity in the

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case of soft thresholding but this may lead to constant deviations between the estimated wavelet coefficients and original wavelet coefficients. Thus the transparency of reconstructed image might suffer. A wide number of research on wavelet thresholding and threshold selection for the noise depletion from signal and images [6], [7], [8], [9]. Immoderately refinements in the transparency and accuracy of image were acquired by translation invariants method built on thresholding of an undecimated wavelet transform [10], [11], [12]. Even after that wavelet is as a tremendous tool for 1-D signals, and in 2-D images at edge points, wavelet is only good enough at appropriating the discontinuities but it cannot reveals the smoothness. Wavelet has poor directional information. Theory of multi-scale geometric analysis has been introduced to overcome the disadvantages of wavelet. To overcome the weakness of wavelets in higher dimensions, and to better capture the curve singularities of high dimensional signals, Donoho and others propounds curvelet transform in 1999.[13] Curvelets are localized not only in position and scale but also in orientation. The curvelet frame with excessive properties, provided by this localization; it is an optimally sparse representations supported on curves on 2-D and has become an assuring tool for various image processing applications [13], [14], [15], [16].

This paper is intent to denoise computed tomography images by using curvelet transform with log Gabor filters. This paper organized with the subsequent sections which are Curvelet transformation, Gabor filter, Methodology, Results, Conclusion and References.

II. CURVELET TRANSFORMATION

A multi-resolution geometry analysis (MGA), named Curvelet transform, was propounds in order to overcome the drawbacks of Wavelet transform. The curvelet transform is a multi-scale method, composed to bring forward the images at different scales and different angle. Curvelets relish two incomparable mathematical recommendations, namely:

A. Curve singularities; can be well approximated with few coefficients and in a non-adaptive manner. It is very well-organized in representing curve-like edges. This is why they are submitting to as curvelets. Most natural images or signal exhibit line-like edges, i.e., discontinuities across curves (so called curve singularities).

B. Sparse representation; curvelets has a sparse representation with geometrical structure and multi-scale pyramid: multi-scale image processing and multi-orientation.

   The Curvelet transform is a multi-scale directional transform that allows an almost optimal non-adaptive sparse representation of objects with edges. Multi-scale methods are deeply related with computer visualization. Wavelet does not bring in a good directional selectivity, which is also a vital response property. Therefore a directional multi-scale sparse is desirable in this field. Curvelet transform has been shown to be a very resourceful tool for many special applications in image processing.

Curvelet transform based denoising: Curvelets are based on multi-resolution, multi-scale ridgelets piled up with a spatial band-pass filtering operation. These band-pass filters are set so that the curvelet length and width at fine scale obey the scaling rule width and length. Even after that wavelet is as a tremendous tool for 1-D signals, and in 2-D images at edge points, wavelet is only good enough at appropriating the discontinuities at different scales and spatial partitioning is used to separate each scale into blocks. To partition the large scale wavelet transform components by using large size blocks and to partition the small scale components by using the small size block. Finally, the ridgelet transform is applied to each block. By the ridgelet transform, the image edges can be bring forward very excessively at a certain scale because the image edges are almost like straight lines at that scale. The curvelet transform can sparsely characterize the higher dimensional signals which have lines, curves or hyper plane singularities. Curvelet can provide a sparse representation of the objects that exhibits 'curve punctuated smoothness'.

The curvelet transform comprises four stages to improve the pictorial information or signal quality:

1. Sub-band Decomposition: Separating the picture into resolution levels. Every level have minutiae of different frequencies:

   P0 –Low-pass filter
   $\Delta 1, \Delta 2, ...$ Using log Gabor filter to estimate the frequencies.
   The sub-bands rebuild the Original image, so necessitate performing Sub-band decomposition.
2. Smooth Partitioning: Defines a collection of smooth windowing function w localized around dyadic square.
3. Renormalization: Each dyadic square resulting in the previous stage is renormalized to unit scale $[0,1] \times [0,1]$.
4. Ridgelet analysis: Each regularized square is examined in the ridgelet system. All ridge part has an aspect ratio of 2-2s $\times$ 2-s.

III. IMAGE DENOISING USING CURVELET TRANSFORMATION

Nowadays noise is the most general problem in image, because of that, image is imprecise and it conceals important details inside of the images. So, to extract all these problems there are various curvelet transformation methods, which explained below:

A. Log Gabor filter

To acquire frequency information locally, Log Gabor filter is accepted as a most excellent selection. This endowed the finest spatial and frequency information by dropping noise from signals. It has mainly two traits first is, log Gabor functions constantly comprise no DC component i.e. it throw in to get better the contrast ridges as well as edges of images. Second is, at the high frequency end, the transfer function of the Log-Gabor function has an elongated tail, with localized

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spatial extent and thus facilitates to maintain an accurate ridge formation of images so as to frequently enable one to attain extremely broad spectral information [19]. It is the best choice to find out the feature domain of an image to render the image. In the long run, to see all these aspect of Log Gabor filter, it is comprehensible that ordinary Gabor filters is less efficient than the Log Gabor filter.

B. Cycle spinning

Cycle spinning is another one technique used to eliminate noise from signal and deciphers this signal into different time shifts which is to be denoised or modified as noise free and this also exploits the periodic time invariance of curvelet transform. It is an uncomplicated and proficient technique to perform signal denoising on a shift variant transform as the shifting, denoising and unshifting process are processed on the data. [21]

C. Median filter

This filter substitutes the core pixels with the middle assessment in the set, within the define window which creates an orderly set by categorization of the neighboring pixels assessment in the window.

$$\hat{f}(x,y) = \underset{(s,t)\in S_{xy}}{\text{median}}\{g(s,t)\}$$

D. Wiener filter

To approximate the mean and standard deviation, this filter is used to filter the image l by using pixel wise adaptive method using neighborhoods of size m-by-n by using below method:
J= wiener2 (l, [m, n], noise)
Before doing the filtering it also approximates the additive noise power and returns noise by using below method:
[J, noise]= wiener2 (l, [m, n]).

IV. RESULTS

In this paper, noise-free modifications of an image are discussed to reduce the noise and improve the picture quality. There are various parameters composed include the Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE), Coefficient of Correlation (CoC).
An image is of high quality when it has the high value of Peak Signal to Noise Ratio (PSNR).
PSNR is defined as below:

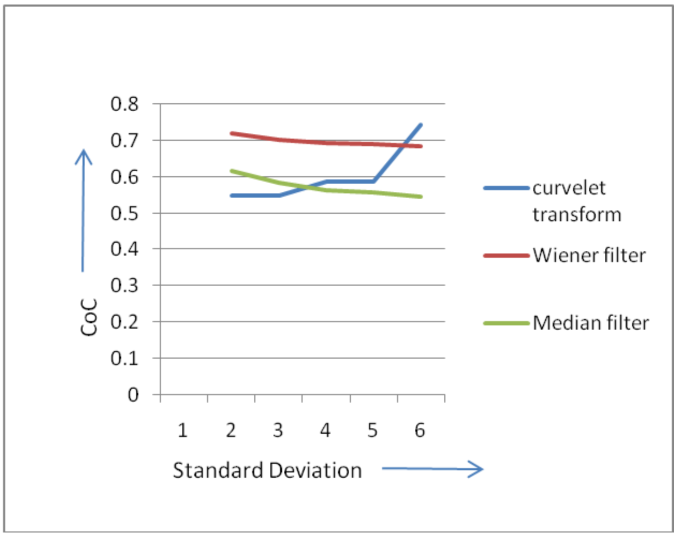
$$PSNR = [10\log\frac{255^2}{MSE}]$$

CoC (Coefficient of Correlation) is defined as below:

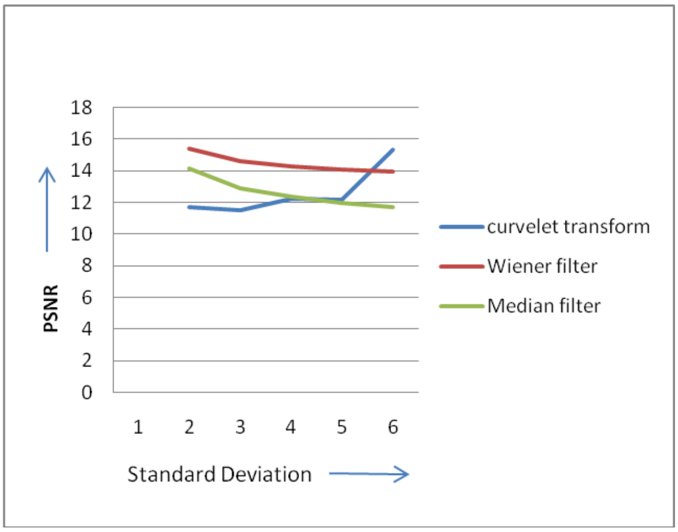
$$CoC = \frac{\varepsilon\left(g-\bar{g}\right)^2.\left(\hat{g}-\bar{\hat{g}}\right)}{\sqrt{\varepsilon\left(\Delta g-\Delta\bar{g}\right)^2.\varepsilon\left(\Delta\hat{g}-\Delta\bar{\hat{g}}\right)}}$$

Where $\bar{g}$ is mean of original image, $\bar{\hat{g}}$ is mean of denoised image.

PSNR result test for Curvelet transform, wiener filter and median filter are represented in below graph:



CoC result test for Curvelet transform, wiener filter and median filter are represented in below graph:



V. CONCLUSION

For the image denoising, the curvelet with log Gabor filter is more prevailing method than the other methods.
In this reasearch, an image denoising method has been executed which is trouble-free and skilled system build on curvelet using Gabor filtering approach and uses PSNR, CoC and MSE quality metrics to improve the image quality and pictorial information.

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There were various objectives, first was to propound an algorithm for denoising the image efficiently and unproblematic. Second was to compare this method with another existing techniques. Log Gabor filter gets better in performing the denoising an image and for future, curvelet transform with its other stages may be got better by using various quality metrics.

REFERENCES

[1] P. Gravel, G. Beaudoin, and J. A. De Guise, "A method formodeling noise in medical images," IEEE Trans. Med. Imag.,vol. 23, no. 10, pp. 1221–1232, Oct. 2004.

[2] C. J. Garvey and R. Hanlon, "Computed tomography in clinical practice," BMJ, vol. 324, no. 7345, pp. 1077–1080, May 2002.

[3] H. Lu, X. Li, I. T. Hsiao, and Z. Liang, "Analytical noise treatment for low-dose CT projection data by penalized weighted least-squares smoothing in the K-L domain," Proc. SPIE, Medical Imaging 2002, vol. 4682, pp. 146–152.

[4] H. Lu, I. T. Hsiao, X. Li, and Z. Liang, "Noise properties of low-dose CT projections and noise treatment by scale transformations," in Conf. Rec. IEEE Nuclear Science Symposium p., Nov. 2001, vol. 3, pp. 1662–1666.

[5] J.S. Lee, "Refined filtering of image noise using local statistics" Com-put. Graphics Image Process, vol.15, pp. 380–389, 1981.

[6] D.L. Donoho, "Denoising by soft thresholding," IEEE Trans. Inform. Theory, vol. 41, pp. 613–627, 1995.

[7] S. Grace Chang, Bin Yu and M. Vatterel, "Wavelet Thresholding for Multiple Noisy Image Copies" IEEE Transaction. Image Processing, vol. 9, pp.1631-1635, 2000.

[8] D.L. Donoho and I.M. Johnstone. "Adapting to unknown smoothness via wavelet shrinkage" Journal of American Statistical Association, Vol. 90, no. 432, pp1200-1224, 1995.

[9] A. M. Alsaidi, M. T. Ismail, "A comparison of some thresholding selection methods for wavelet regression" World Academy of Science, Engineering and Technology, Vol. 62, pp 119-125, 2010.

[10] R. R. Coifman and D. L. Donoho, "Translation-Invariant De-Noising," In Wavelets and Statistics, Springer Lecture Notes in Statistics 103. New York: Springer-Verlag, 1994, pp. 125-150.

[11] I.A.Ismail, and T.Nabil, "Applying Wavelet Recursive Translation-Invariant to Window Low-Pass Filtered Images," International Journal of Wavelets, Multiresolution and Information Processing, Vol.2, No.1, 2004, p.p.99-110.

[12] S. Qin, C. Yang, B. Tang and S. Tan, "The denoise based on translation invariance wavelet transform and its applications," A Conference on Structural Dynamics, Los Angeles, vol. 1, pp.783 -787, Feb. 2002.

[13] D. L. Donoho, and M. R.Duncan "Digital Curvelet Transform: Strat-egy, Implementation and experiments"Standford University. November 1999.

[14] J. L. Starck, F. Murtagh, E. J. Candes, and D. L. Donoho, "Gray and color image contrast enhancement by the curvelet transform" IEEE Trans. on Image Processing, 12(6):706–717, June 2003.

[15] J. L. Starck, E. J. Candes, and D. L. Donoho, " The curvelet transform for image denoising" IEEE Trans. on Image Processing, 11(6):670–684, June 2002.

[16] E. J. Candes, L. Demanet, D. L. Donoho and L Ying, "Fast Discrete Curvelet Transforms" 2005
http://www.curvelet.org.papers.FDCT.pdf

[17] Herman, G. T., Fundamentals of Computerized tomography: Image reconstruction from projection, 2nd edition, Springer, 2009

[18] "computed tomography—Definition from the Merriam-Webster Online Dictionary"

[19]
www.csse.uwa.edu.au/~pk/research/matlabfns/.../convexpl.html

[20] Mehrotra, H. Majhi, B and Gupta, P. (2009), "Multi-algorithmic Iris Authentication System", International Journal of Electrical and Computer Engineering, pp 78—82.W.-K. Chen, Linear Networks and Systems. Belmont, Calif.: Wadsworth, pp. 123-135, 1993. (Book style).

[21] Starck J L, Candµes E J, Donoho D L. The curvelet transform for image denoising. *IEEE Trans. Image Processing*, June 2002, 11(6): 670-684.

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