ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

FINGERPRINT IMAGE DENOISING USING CURVELET TRANSFORM

G. Jagadeeswar Reddy[1], T. Jaya Chandra Prasad[2] and M. N. Giri Prasad[3]
[1]ECE Department, VITS, Proddatur, Kadapa, AP, India
[2]ECE Department, RGMCET, Nandyal, Kurnool, AP, India
[3]ECE Department, JNTUCE, Pulivendula, Kadapa, AP, India
E-Mail: jagsuni@yahoo.com

ABSTRACT

Curvelet transform is the new member of the evolving family of multiscale geometric transforms. It offers an effective solution to the problems associated with image denoising using wavelets. Finger prints possess the unique properties of distinctiveness and persistence. However, their image contrast is poor due to mixing of complex type of noise. In this paper an attempt has been made to present the results of denoising of such images using both wavelet and curvelet transforms. The results obtained demonstrate that the curvelet transform based reconstructions are visually sharper than the wavelet reconstructions. The recovery of edges and of the faint linear and curvilinear features is of particularly superior quality. The results obtained are in accordance with the expected predictions of the existing theory of curvelet transforms.

Keywords: curvelet, wavelet, transform, finger prints, denoising.

1. INTRODUCTION

Finger prints have distinctiveness and persistence, which are highly desirable qualities for biometric applications. However, finger print images are generally of low contrast, due to skin conditions and application of incorrect finger pressure. Also, they inherently contain complex type of noise, originating from two distinct sources, such as the set of assorted devices involved in the acquisition, transmission, storage and display of the image and noise arising from the application of different types of quantization, reconstruction and enhancement algorithms. It is certain that every imaging method inherently involves noise. However different imaging methods involve noise of different extents. The presence of noise gives an image a mottled, grainy, textured or snowy appearance. The finger print images, with such an appearance, are often mistaken for the terminations. Hence it is essential to investigate for methods offering superior denoising of finger print images.

2. IMAGE DENOISING -- TRANSFORMS

In the past, wavelet based methods [1, 2] were applied for noise removal in images and signals. These methods have considered aspects like thresholding of the orthogonal wavelet coefficients of the noisy data followed by reconstruction. In the recent past, considerable improvements in visual quality were obtained; by applying methods based on thresholding of an undecimated wavelet transform [2, 4, and 5]. Still recently, tree-based methods have appeared for image denoising, which make use of the tree structure of the wavelet coefficients [3]. Subsequently, several investigators have applied variants of the basic schemes for image denoising.

Curvelet transform is the latest member of the evolving family of multiscale geometric transforms [6, 7, 8 and 9]. In this transform, the frame elements are indexed by scale, orientation and location parameters. It is designed to represent edges and the singularities along curved paths more efficiently than the wavelet methods. For example, to represent an edge to squared error 1/N, one needs 1/N wavelets but only 1/√N curvelets. [8]

3. ALGORITHM STEPS TO DENOISE THE FINGER PRINTS

Following steps are involved in the denoising algorithm of Curvelet Transform:

1. Compute all thresholds for cuvelets;
2. Compute norm of curvelets;
3. Apply curvelet transform to noisy image;
4. Apply hard thresholding to the curvelet coefficients; and
5. Apply inverse cuvrelet transform to the result of step 4.

Denoising of the images using curvelet transform [10, 11] was carried out with inverse wrapping function, involving a decomposition level of 8. Hard thresholding [2] was applied to the coefficients after decomposition. A value of thrice the standard deviation was used as the threshold. Coefficients exceeding the chosen threshold were discarded. The image was reconstructed from the remaining coefficients. Denoising of the images using wavelet transform was carried out with symlet 4 wavelet, which is an integral part of the wavelet tool box. Four types of noise, viz. Random noise, Gaussian noise, Salt and Pepper noise and Speckle noise, were chosen for mixing with the finger print image. For each type of noise, the extent of mixing corresponded to the standard deviations of 0.1, 0.15, 0.2, 0.25, 0.3 and 0.35.

The quality of reconstructed image is usually specified in terms of peak signal to noise ratio (PSNR). The PSNR values were calculated using the following expression:

VOL. 3, NO. 3, JUNE 2008 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

$$PSNR = 10\log 10 \frac{M_1 \times M_2 \times \max\left(f(i,j)\right)^2}{\sum_{i=1}^{M_1}\sum_{j=1}^{M_2}\left(f(i,j) - f'(i,j)\right)^2} \text{ dB}$$

Where M_1 and M_2 are the size of the image. *f*(i, j) is the original image, *f′*(i, j) is the denoised image.

4. RESULTS AND DISCUSSIONS

The finger print images containing the four types of noise have been denoised using both the Curvelet transform (Ct) and Wavelet transform (Wt). The PSNR values for the reconstructed images corresponding to the 4 types of noise, and standard deviations of 0.1, 0.15, 0.2, 0.25, 0.30 and 0.35 for each type of noise, are summarized in Table-1. The reconstruction of finger prints after denoising wrt curvletes and wavelets are presented in Figures-1 and 2.

From Table-1, it is observed that for low standard deviations say 0.1 and 0.15, the difference in PSNR values of curvelet denoised and wavelet denoised images is around 3dB for Random, Gaussian and speckle noises, where as for Salt and Pepper noise it is only around 1dB. As standard deviation increases say for 0.3, this difference is around 4dB for all the noises considered.

The results presented in Figure-1 demonstrate that the curvelet transform out performs the wavelet transform, in generating the reconstructed images. From Figure-2 it is interesting to note that while the general trend of PSNR vs. SD is similar for the Random, Gaussian and Speckle noises, it is different for the Salt and Pepper noise. This trend is because Salt and Pepper noise is randomly distributed as black and white pixels when it is added to the original image, where as the distribution of other noises will be uniform.

From the analysis done it was found that denoising using the Curvelet transform reconstructs the original image from the noisy one using lesser coefficients than denoising using the wavelet transforms. The Wrapping based Curvelet transform technique was found to be conceptually simpler, faster and far less redundant than the existing techniques.

In all cases it was found that the Curvelet transform dominates the Wavelet transform in terms of PSNR .The Curvelet denoised images appear closer to the original image than the Wavelet denoised images. The Curvelet transform provides high PSNR values, irrespective of standard deviation, than the Wavelet transform in case of Random, Gaussian and Speckle noises. In case of Salt and Pepper noise, for low standard deviations the performance of both the Curvelet and Wavelet transforms is almost similar but for high standard deviations Curvelet transform outperforms the Wavelet transform.

Table-1

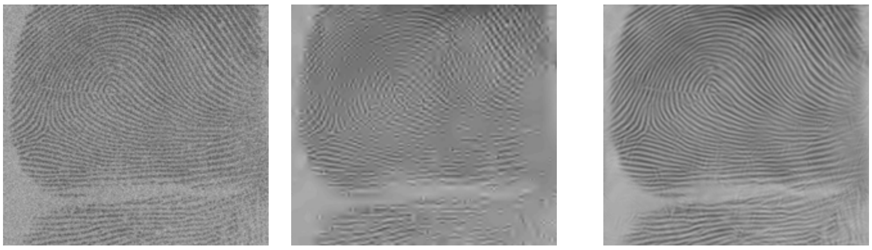
S. No.	S.D	PSNR Values in dB							
		Random Noise		Gaussian Noise		S and P Noise		Speckle Noise	
		Wt	Ct	Wt	Ct	Wt	Ct	Wt	Ct
1	0.1	22.08	25.61	22.08	25.59	19.6	20.2	21.25	24.462
2	0.15	20.24	23.84	20.35	23.89	19.8	20.8	20.12	23.56
3	0.2	19.14	22.7	19.3	22.7	19	22.2	19.14	22.503
4	0.25	18.28	21.96	18.48	21.92	18.3	21.7	18.34	21.722
5	0.3	17.55	21.32	17.71	21.37	17.5	21.1	17.58	21.184
6	0.35	16.95	20.79	17.05	20.96	16.9	20.7	16.96	20.763

Figure-1 shows the images for different noise types, corresponding to standard deviation (S.D.) value of 0.3.

ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

A. Original Fingerprint image.



(a) (b) (c)

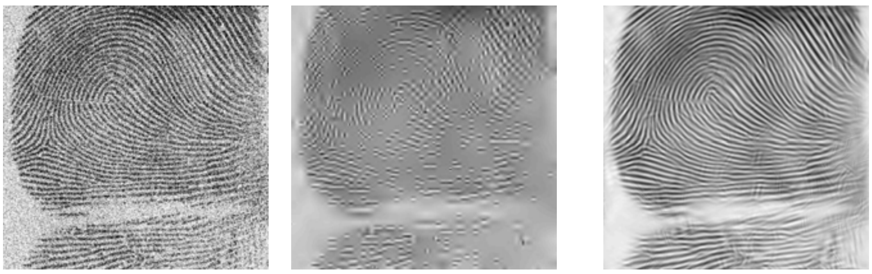
B. For Random Noise.

(a) (b) (c)

C. For Gaussian Noise.

(a) (b) (c)

D. For Salt and Pepper Noise.

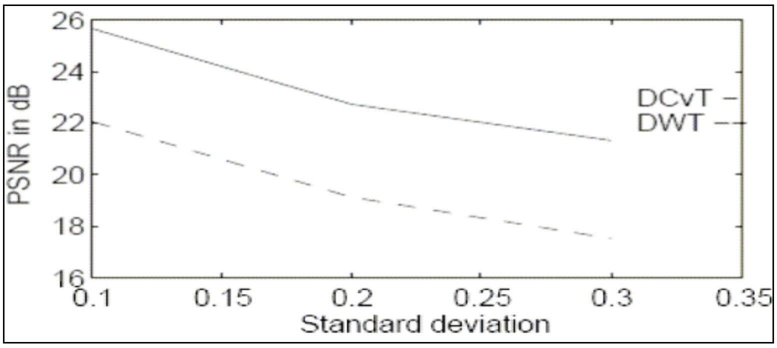


(a) (b) (c)

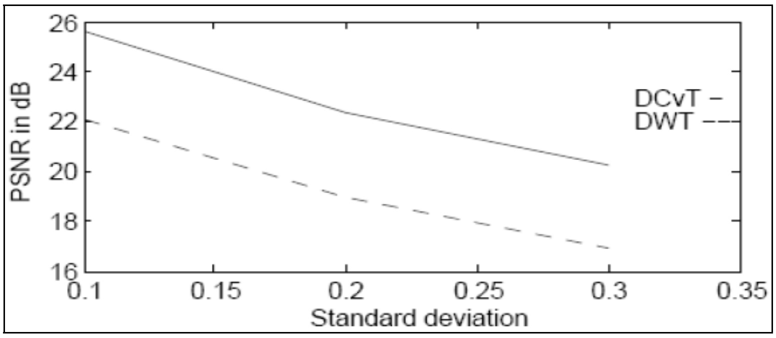
E. For Speckle Noise.

Figure-1. Images corresponding to S.D. of 0.3: (a) Noisy (b) Wavelet reconstruction (c) Curvelet reconstruction.

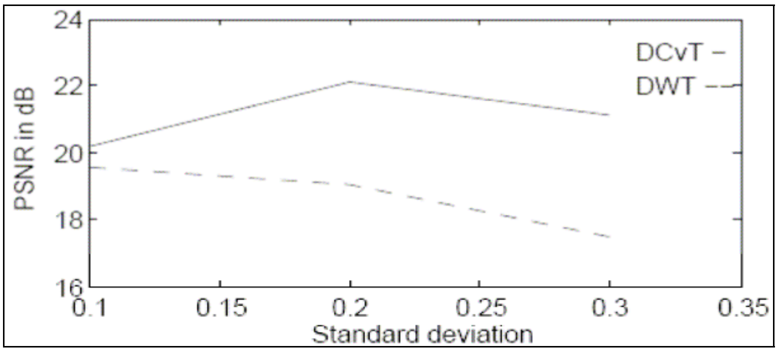
Figure-2 shows plots of PSNR vs. SD corresponding to the Curvelet and Wavelet transforms, for the four types of noise.



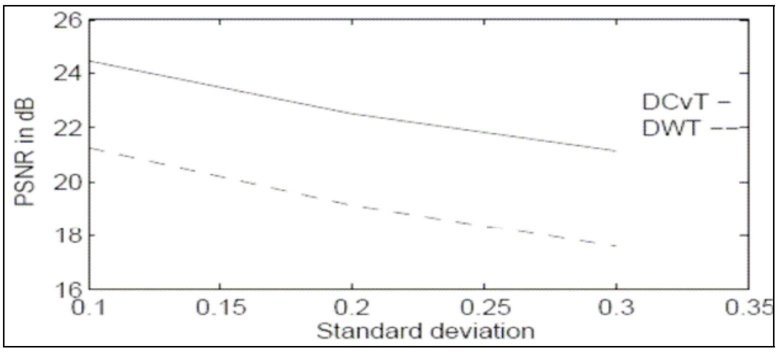
A. For Random Noise.



B. For Gaussian Noise.



C. For Salt and Pepper Noise.



D. For Speckle Noise.

Figure-2. Comparative plots of PSNR vs SD for Digital Curvelet (DCvT) and Digital Wavelet (DWT) Transforms.

ACKNOWLEDGMENTS

The authors would like to thank Dr. K.V. Reddy, Dean (Academic), VITS, Proddatur, for his constant encouragement during the course of the present work.

REFERENCES

[1] R.C. Gonzalez and R.E. Woods. Digital Image Processing.

[2] Raghuveer M. Rao and Ajit S. Bopardikar. Wavelet Transforms, Introduction to Theory and Applications.

[3] Shapiro J. 1993. Embedded image coding using zerotrees of wavelet coefficients. IEEE Transactions on Signal Processing. 41(12): 3445-3462.

[4] Fodor I.K. and C. Kamath. 2003. Denoising through Wavelet Shrinkage: An Empirical Study. SPIE Journal on Electronic Imaging. 2(1): 151-160.

[5] Malfaint M. and Roose D. 1997. Wavelet-based image denoising using a Markov random field a priorimodel. IEEE Transactions on Image Processing. 6(4): 549-565.

[6] E.J. Candes and D.L. Donoho. 1999. Curvelets [online] available. http://www.stat.stanford.edu/~donoho/Reports//curvelets.pdf

[7] E.J. Candes and D.L. Donoho. Curvelets-A Surprisingly Effective Nonadaptive Representation For Objects with Edges. In: Saint-Malo Proceedings.

[8] D.L. Donoho and M.R. Duncan. 2000. Digital Curvelet Transform: strategy, Implementation and Experiments. [online] available. http://www.stat.Stanford.edu/~donoho/Reports/curvesoft.pdf

[9] Jagadeeswar Reddy G., Jayachandra Prasad T. and Giriprasad M.N. 2007. In: Proceedings of icon DELCO. February.

[10] Jean-Luc Starck, Emmanuel J. Candes and David L. Donohoo. 2002. The Curvelet Transform for Image Denoising. IEEE Transactions on Image Processing. June.

[11] R. Sivakumar. 2007. Denoising of Computer Tomography Images using Curvelet Transform. ARPN Journal of Engineering and Applied Sciences. February.