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An Image Fusion using DWT and Fast Discrete Curve let Transform

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Abstract

This paper describes two digital implementations of a new mathematical transform, namely, the second generation curve let transform in two and three dimensions. The first digital transformation is based on unequally-spaced fast Fourier transforms (USFFT) while the second is based on the wrapping of specially selected Fourier samples. The two implementations essentially differ by the choice of spatial grid used to translate curve lets at each scale and angle. Both digital transformations return a table of digital curve let coefficients indexed by a scale parameter, an orientation parameter, and a spatial location parameter. And both implementations are fast in the sense that they run in O (n2 log n) flops for n by n Cartesian arrays; in addition, they are also invertible, with rapid inversion algorithms of about the same complexity.

Keywords *IMAGE, DWT, DFCT, WRAPPING AND SNAPPING, RMSE, PSNR, ENTROPHY*

1. Introduction

Image fusion is a data fusion technology which keeps images as main research contents. It refers to the techniques that integrate multi-images of the same scene from multiple image sensor data or integrate multi-images of the same scene at different times from one image sensor. The image fusion algorithm based on Wavelet Transform which faster developed was a multi resolution analysis image fusion method in recent decade.

Wavelet Transform has good time-frequency characteristics. It was applied successfully in image processing field. Nevertheless, its excellent characteristic in one-dimension can't be extended to two dimensions or multi-dimension simply. Separable wavelet which was spanning by one-dimensional wavelet has limited directivity.

Aiming at this limitation, E. J. Candes and D. L. Donoho put forward Curve let Transform theory in 2000. Curve let Transform consisted of special filtering process and multi-scale Ridge let Transform. It could fit image properties well. However, Curve let Transform had Complicated digital realization, includes sub-band division, smoothing block, normalization, Ridge let Analysis and so on. Curve let's pyramid decomposition brought immense data redundancy. Then E. J. Candes put Forward Fast Curve let Transform (FCT) that was the Second Generation Curve let Transform which was simpler and easily understanding in 2005. Its fast algorithm was easily under stood. Li Huihui's researched multi-focus image fusion based on the Second Generation Curve let Transform. This paper introduces the Second Generation Curve let Transform and uses it to fuse images, different kinds of fusion methods are compared at last. The experiments show that the method could extract useful information from source images to fused images so that clear images are obtained.

1.1. Image:

An image is a two-dimensional picture, which has a similar appearance to some subject usually a physical object or a person.

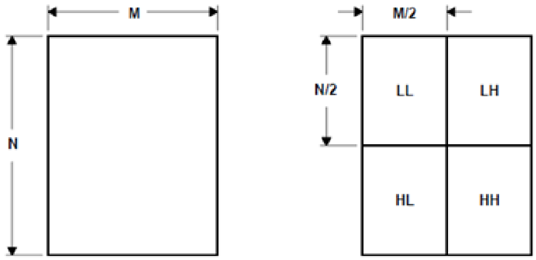
Image is a two-dimensional, such as a photograph, screen display, and as well as a three-dimensional, such as a statue. They may be captured by optical devices—such as cameras, mirrors, lenses, telescopes, microscopes, etc. and natural objects and phenomena, such as the human eye or water surfaces.

2. Wavelet:-

Over the past several years, the wavelet transform has gained widespread acceptance in signal processing in general and in image compression research in particular. In applications such as still image compression, discrete wavelets transform (DWT) based schemes have outperformed other coding schemes like the ones based on DCT. Since there is no need to divide the input image into non-overlapping 2-D blocks and its basis functions have variable length, wavelet-coding schemes at higher compression ratios avoid blocking artifacts.

2.1. Wavelet Decomposition of Images

In wavelet decomposing of an image, the decomposition is done row by row and then column by column. For instance, here is the procedure for an N x M image. You filter each row and then down-sample to obtain two N x (M/2) images. Then filter each column and subsample the filter output to obtain four (N/2) x (M/2)images.



Of the four sub images obtained as seen in Figure, the one obtained by low-pass filtering the rows and columns is referred to as the LL image.

The one obtained by low-pass filtering the rows and high-pass filtering the columns is referred to as the LH images. The one obtained by high-pass filtering the rows and low-pass filtering the columns is called the HL image. The sub image obtained by high-pass filtering the rows and columns is referred to as the HH image. Each of the sub images obtained in this fashion can then be filtered and sub sampled to obtain four more sub images. This process can be continued until the desired sub band structure is obtained.

3. CUREVE LET TRANSFORM:-

The curve let transform has evolved as a tool for the representation of curved shapes in graphical applications. Then, it was extended to the fields of edge detection and image de-noising. Recently, some authors have proposed the application of the curve let transform in image fusion.
1. Split the input image into 3 sub bands using additive wavelet transform.
2. Perform tiling on each of the three sub bands
3. Perform Discrete Ridge let Transform on each of tile on all the sub bands.
Sub band filtering decomposes image into additive components which are the sub bands of the image.

3.1. Wrapping Algorithm (In frequency domain):

- Perform FFT on the original image.
- Divide FFT into collection of tiles
- For each tile apply
- Translate tile to the origin.
- Wrap parallelogram shaped support of tile around the rectangle with centre as the origin as shown in Figure 2.
- Take inverse FFT of wrapped one
- Add curve let array to collection of curve let coefficients.

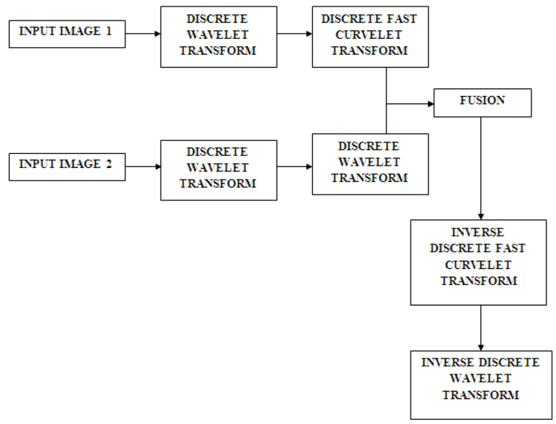


Figure2: BLOCK DIAGRAM

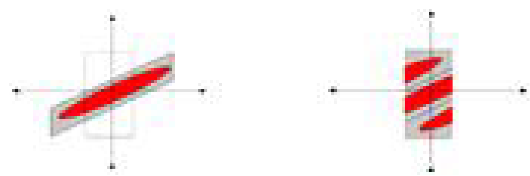


Figure3: Support of wedge before (left) wrapping and after wrapping

Curve let transform is a tool for representation of curved shapes in images. The concept of curve let transform is based on the segmentation of the whole image into small overlapping tiles and then applying ridge let transform on each tile. It is most suitable to work with medical images. Algorithm for first generation curve let is given below:

3.2. Inverse Wrapping Algorithm:

- For each curve let coefficient array
    1. Take FFT of the array.
    2. Unwrap rectangular support to original orientation shape.
    3. Translate it back to the original position
    4. Store the translated array
- Add all the translated curve let arrays
- Take inverse FFT to reconstruct the image.

4.DISCRETEFASTCURVELET TRANSFORM:-

Image fusion is the process of merging two images of the same scene to form a single image with as much information as possible. Image fusion is important in many different image processing fields such as satellite imaging, remote sensing and medical imaging. The study in the field of image fusion has evolved to serve the advance in satellite imaging and then, it has been extended to the field of medical imaging. Several fusion algorithms have been proposed extending from the simple averaging to the curve let transform. Algorithms such as the intensity, hue and saturation (IHS) algorithm and the wavelet fusion algorithm have proved to be successful in satellite image fusion. The IHS algorithm belongs to the family of colour image fusion algorithms. The wavelet fusion algorithm has also succeeded in both satellite and medical image fusion applications. The basic limitation of the wavelet fusion algorithm is in the fusion of curved shapes. Thus, there is a need for another algorithm that can handle curved shapes efficiently. So, the application of the curve let transform for curved object image fusion would result in a better fusion efficiency. A few attempts of curve let fusion have been made in the fusion of satellite images but no attempts have been made in the fusion of medical images.

The main objective of medical imaging is to obtain a high resolution image with as much details as possible for the sake of diagnosis. There are several medical imaging techniques such as the MR and the CT techniques. Both techniques give special sophisticated characteristics of the organ to be imaged. So, it is expected that the fusion of the MR and the CT images of the same organ would result in an integrated image of much more details. Researchers have made few attempts for the fusion of the MR and the CT images. Most of these attempts are directed towards the application of the wavelet transform for this purpose. Due to the limited ability of the wavelet transform to deal with images having curved shapes, the application of the curve let transform for MR and CT image fusion is presented in this paper.

4.1. RESULT ANALYSIS:-

In this simple case all attributes are uniform across the entire analysis domain, so attributes may be simply assigned. In more realistic applications, attributes are rarely uniform and some type of interpolation is usually required to properly assign attributes to the data points in the fused set.

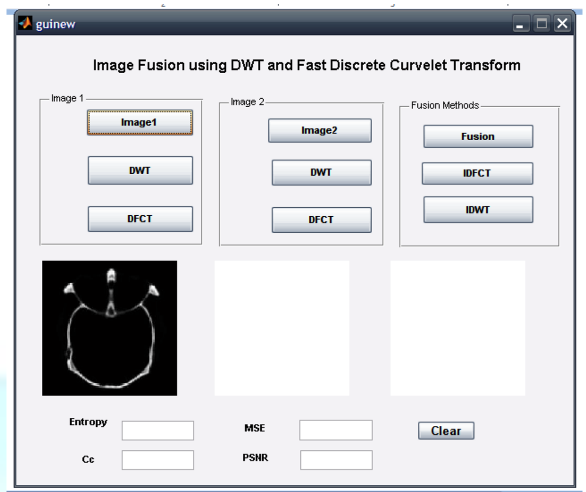


Figure: 4(a) INPUT IMAGE 1 (CT SCANE IMAGE)

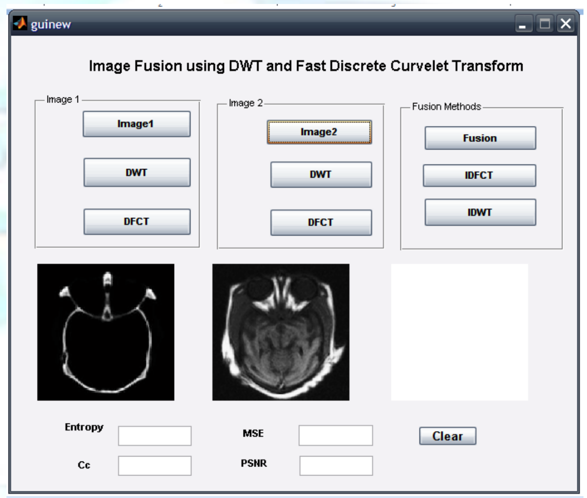


Figure: 4(b) INPUT IMAGE 2 (CT and MRI SCAN IMAGE)

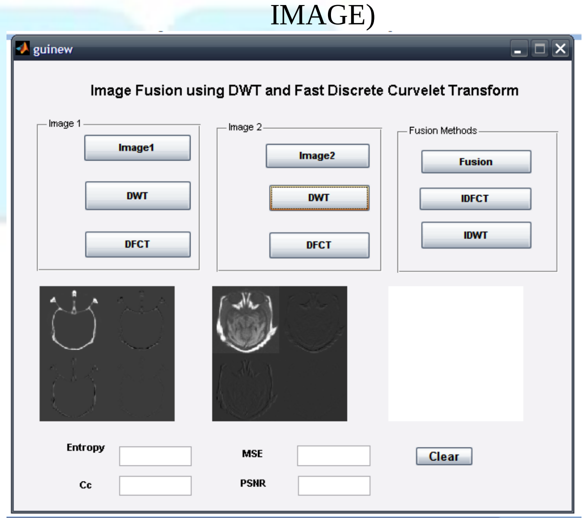


Figure: 4(c) DWT PROCESS OF BOTH CT AND MRI IMAGES

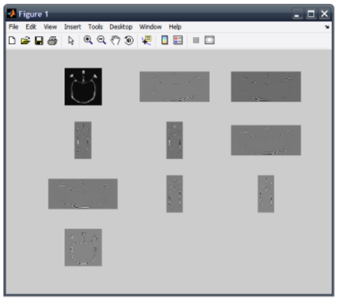


Figure: 4(d) (i) LL band for DFCT Process in CT Image

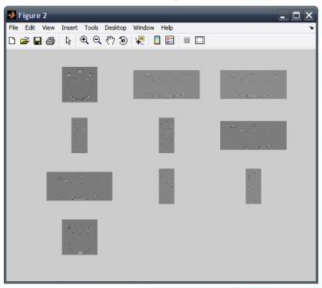


Figure: 4(d) (ii) LH band for DFCT Process in CT Image

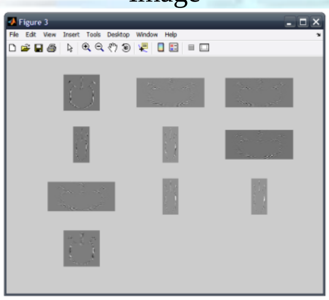


Figure: 4(d) (iii) HL band for DFCT Process in CT Image

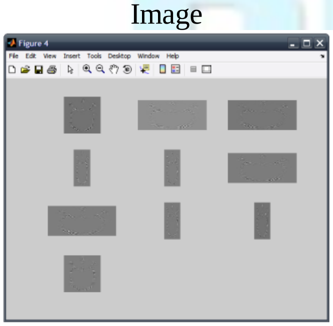


Figure: 4 (d) (iv) HH band for DFCT Process in CT Image

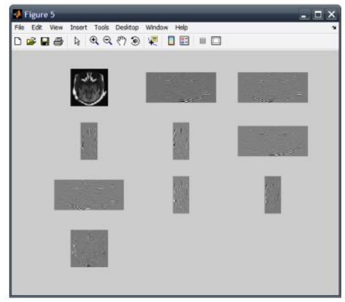


Figure: 4(e) (i) LL band for DFCT Process in MRI Image

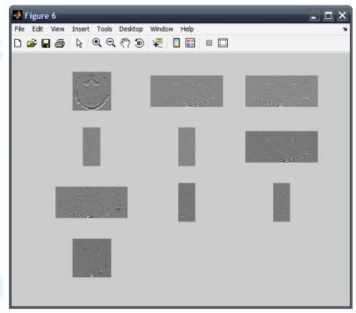


Figure: 4(e) (ii) LH band for DFCT Process in MRI Image

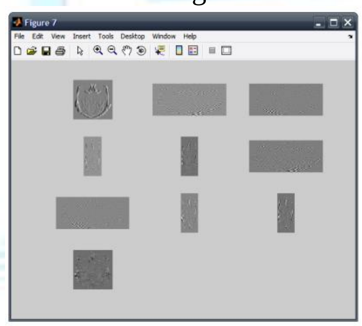


Figure: 4(e) (iii) HL band for DFCT Process in MRI Image

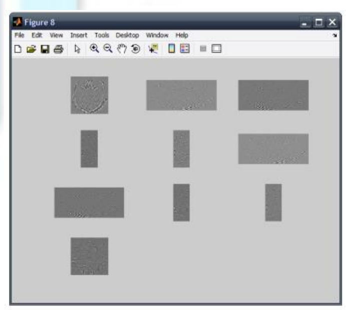


Figure: 4(e) (iv) HH band for DFCT Process in MRI Image

5. Medical Image Fusion:-

Image fusion has become a common term used within medical diagnostics and treatment. The term is used when multiple patient images are registered and overlaid or merged to provide additional information. Fused images may be created from multiple images from the same imaging modality, by combining information from multiple modalities, such MRI, CT, PET, and SPECT).

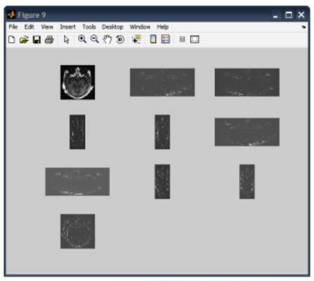


Figure: 5 (i) FUSION IMAGE IN CT AND MRI IMAGE IN LL BAND

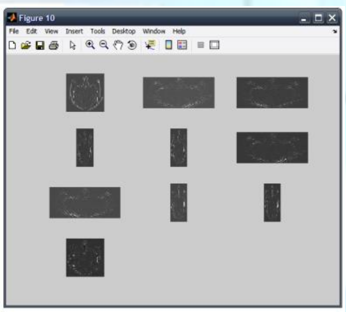


Figure: 5 (ii) FUSION IMAGE IN CT AND MRI IMAGE IN LH BAND

In radiology and radiation oncology, these images serve different purposes. For example, CT images are used more often to ascertain differences in tissue density while MRI images are typically used to diagnose brain tumors.

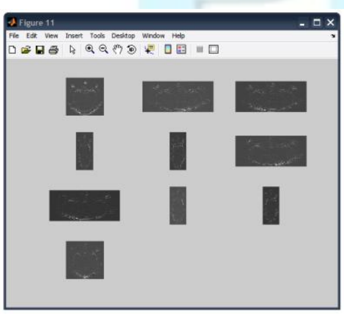


Figure: 5 (iii) FUSION IMAGE IN CT AND MRI IMAGE IN HL BAND

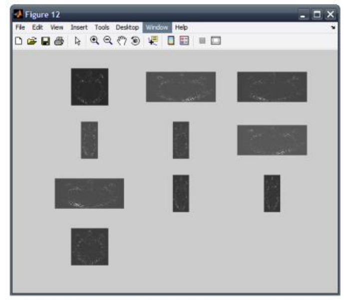


Figure: 5 (iv) FUSION IMAGE IN CT AND MRI IMAGE IN HH BAND

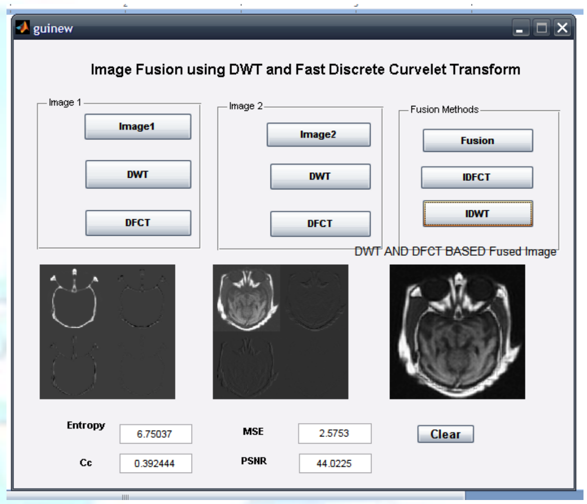


Figure: 5.1. FUSION IMAGE IN DWT AND DFCT IN FINAL IMAGE

6. CONCLUSION:-

The paper has presented a new trend in the fusion of digital image, MRI and a CT image which is based on the curve let transform. A comparison study has been made between the traditional wavelet fusion algorithms and the proposed curve let fusion algorithm. The experimental study shows that the application of the Curve let transform in the fusion of MR and CT images is superior to the application of the traditional wavelet transform. The obtained curve let fusion results have higher correlation coefficient and entropy values than in wavelet fusion results and minimum values of RMS error than in the wavelet transform. At last, these fusion methods are used in simulation experiments of multi-focus and complementary fusion images. In vision, the fusion algorithm proposed in this paper acquires better fusion result. In objective evaluation criteria, curve lets fusion characteristic are superior to traditional DWT.

	RMSE	PSNR	ENTROPHY
DWT	75.7620	29.3633	0.0014
CURVELET	75.6446	29.3430	6.7633
DFCT	2.5753	44.0225	6.7504

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