Medical Image Fusion Based on Wavelet Transform and Fast Curvelet Transform

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***Abstract*—Image Fusion is a data fusion technique which combines information of the two images which has varied information to form a new single image. The objective is to fuse an MR image and CT image of the same organ to obtain a single image containing as much information as possible. In this paper Wavelet Transform and Fast Curvelet Transform are highlighted to perform the image fusion of MR image and CT images. Wavelet Transform has good time-frequency characteristics in one-dimension, but this can't be extended to two-dimensions or multi-dimensions as wavelet has very poor directivity. Since medical images have several more objects and curved shapes, it is expected that the Fast Curvelet Transform will do better in their fusion. In this project image fusion based on Wavelet Transform and Fast Curvelet Transform was implemented. The experiment results show the superiority of Fast Curvelet Transform to the Wavelet Transform in the fusion of MR and CT images from both the visual quality and peak signal to noise ratio(PSNR) points of view.**

***Key Words*—Image Fusion, Wavelet Transform, Curvelet Transform.**

I. INTRODUCTION

Image fusion is the process of integrating two images of the same organ to obtain a single image which has as much more information as possible[1]. Nowadays image fusion has many applications in the field of satellite imaging, remote sensing and medical imaging.

There are many algorithms have been proposed for the fusion of images. In this paper wavelet transform and Fast Curvelet Transform were discussed for fusion purpose. Wavelet Transform[5] is having very good time-frequency characteristics. Hence it was applied in many image processing scenarios. But its properties in one-dimension can't apply into two-dimension or multi-dimension as such. In these case, Wavelet Transform shows very poor directivity[1]. Also there is another limitation in case of representation of curved edges. If there is any discontinuity along the curved edge that will affect all the wavelet coefficients. So there needs a better algorithm to represent the curved shapes efficiently. So in this situation Curvelet Transform is used[2].

Curvelet Transform is used to overcome these drawbacks of Wavelet Transform. There are mainly two types of Curvelet Transforms, First Generation and Second Generation Curvelet Transforms. Out of these two, Second Generation[6] is known as Fast Curvelet Transform. As First Generation Curvelet Transform had complicated digital realization, includes sub-band division, smoothing block, normalization, Ridgelet analysis and so on. The Ridgelet analysis is so complicated to implement, so there is another transform which is Second Generation Curvelet Transform also known as Fast Curvelet Transform. This uses wrapping algorithm. The whole image is divided into a collection of overlapping tiles and the transform is applied on it. As it will represents curves really good as compared to Wavelets, Curvelets will give better results.

Generally Image Fusion[4] can be perform by different methods like Simple averaging method, maximum pixel selection rule, Laplacian Pyramid method etc. Out of these in pixel level image fusion the fused image contains all relevant information that present in the original input images withoust any inconsistencies.

II. METHOD

This paper put forwards two methods of image fusion.They are,

i. Discrete Wavelet Transform
ii. Curvelet Transform

2.1 Discrete Wavelet Transform

Wavelet Transform is the method in which a signal is decomposed into two levels, one higher level and the other lower level. The coefficients of these two filters is calculated by mathematical formula and again this can be decomposed. The depth or level of decomposition performed is chosen according to the application purpose only. High level decompositions doesn't mean higher accuracy. If level of decomposition is higher there is a chance for lower band overlapping. The low-frequency component usually contains most of the contents of the signal i.e lower frequency contains most of the valuable information, so it is called the approximation frequency band. The high-frequency component contains the details of the signal, it contains only very less amount of information about the particular image. Hence by performing Wavelet Transform one can compress or de-noise the information[7]. This paper analysis the use of Haar Transform for Wavelet processing. The algorithm for Haar Transform is explained as below.

2.1.1 Haar Transform

Haar Transform is the one of the algorithms which is used for Wavelet Analysis. The one of the most advantage of Haar Transform is it's higher value of Peak Signal to Noise ratio(PSNR) can achieved by using Haar Transform[5]. Using Haar lower frequency components are obtained by taking the average of the two pixel values and the lower frequency one is obtained by taking half of the difference of the two pixels. After the first level of decomposition we will get four bands viz LL,LH,HL,HH. Out of these four bands the LL band, the lower frequency band contains most of the information. The other three higher frequency bands are having only less information like edge details of the image. The four bands of first level decomposition is as shown in Fig 1.

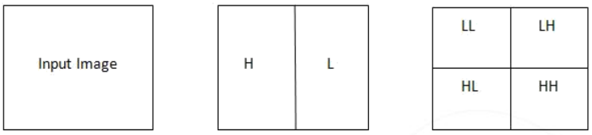

Fig 1 : Wavelet Bands after First Level Decomposition

The algorithm steps for performing Haar Transform is described as follows.

Step1: Process the input image to get H and L components using equation set (1).

$$H = (C_o - C_e)$$
$$L = (C_e + (H/2)) \quad (1)$$

Where C_o and C_e is the odd column and even column wisepixel values.

Step 2: Perform row wise processing of H & L components to get LL, LH, HL and HH using equation set (2).

$$\text{So, } LH = L_{odd} - L_{even}$$
$$LL = L_{even} + (LH/2)$$
$$HL = H_{odd} - H_{even}$$
$$HH = H_{even} + (HL/2) \quad (2)$$

Where, H_{odd} = Odd row of H
L_{odd} = Odd row of L
H_{even} = Even row of H
L_{even} = Even row of L

After performing the Haar Wavelet decomposition to get back the original image reverse procedure is followed.

2.1.2 Wavelet Based Fusion

In this method Discerete Wavelet Transform(DWT) is used for fusion purpose.In wavelet based fusion method first take the wavelet coefficients of the two input images i.e CT and MRI images. Then apply the fusion rule on the corresponding bands. Then take the inverse of the transform to get the fused output. The schematic diagram is as showm in Fig 2.

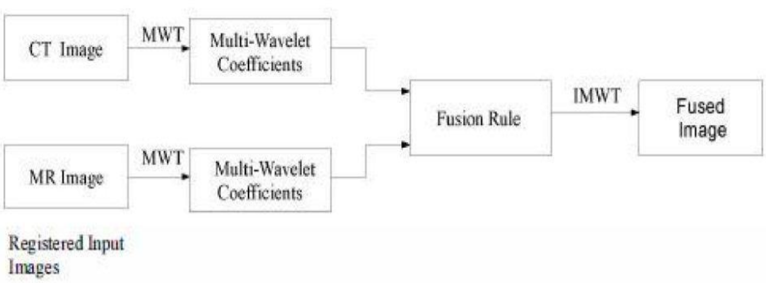

Fig 2: Wavelet Fusion

2.2 Curvelet Transform

Curvelet Transform is another one transform which is used in image processing field. This transform will overcome the drawbacks of Wavelet Transform, while representing curved shapes. There are mainly two types of Curvelet Transform[2]. First Generation and Second Generation Curvelet Transforms. As the implementation steps are most complex in First Generation, Second Generation Curvelet Transform is mostly used. This is more simple as compared to First Generation Curvelet. So it is known to be Fast Curvelet Transform.

2.2.1 Fast Curvelet Transform

This is also known as Second Generation Curvelet Transform. This does not uses Ridgelet analysis, hence it will reduce the complexity of the calculations and mostly preferred one. In this transform the whole image is divided into 30 or 45 or any convenient digrees of tiles. Then uses wrapping technique. Each of these tiles are translate into the origin and then wrapped across the center axis.The wrapping algorithm is given below.

1.Wrapping Algorithm
  a. Apply FFT on the original image.
  b. Divide FFT into tiles of particular dimension.
  c. On each tile,
    i. Translate one tile at a time to origin and wrap across the center as shown in Fig 3.
    ii. Then take inverse FFT of the wrapped one and add coefficients to the curvelet array.

Fig 3: a. Tile(Before Wrapping) b. Tile(After Wrapping)

2. Inverse Wrapping Algorithm
  a. In each curvelet coefficient array,
    i. Take FFT of the array.
    ii. Unwrap each tile and translate back to the original position and store the translated array.
  b. Add all the translated curvelet arrays
  c. Take inverse FFT to reconstruct the original image.

By applying the above mentioned steps the curvelet coefficients can be obtained. Second Generation is much simpler and faster as compared to First Generation Curvelets.

2.2.2 Curvelet Based Fusion

In Curvelet based fusion also procedure is same as that of wavelet based one, but instead of wavelet transform here used Fast Curvelet Transform(FCT). First take the curvelet coefficients of two registered input images viz CT and MRI. Then apply the fusion rule on it. Then take the inverse curvelet transform to get the fused output. The schematic representation of fusion is shown in Fig 4.

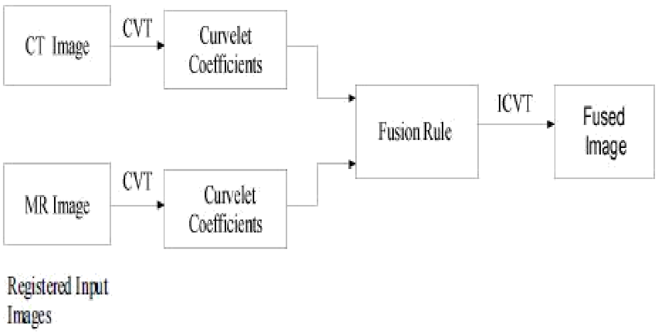

Fig 4: Curvelet Fusion

2.3 IMAGE FUSION

The term image fusion means combining of two images to form a new image which is having all the information which is present in the input ones. That means the output image should be of more information enriched one as compared to the input images. Hence all the redundant information should be retained in the output image. The above mentioned both transforms can be used for image fusion. There are many methods of image fusion like maximum selection method, simple average method, pyramid transform method etc.[7]. Out of these pyramid transform method will avoid the distortions, so it is mostly preferred one. In this paper a combined fusion method of both the transforms together are used for this fusion type. This fusion is known as Discrete Fast Curvelet Transform(DFCT). By adopting this combined method a better fusion result can be achieved. First wavelet Transform is applied on the image followed by Fast Curvelet Transform. Then find out the variance of the pixel values from the neighborhood on the corresponding to images which are to be fused. While choosing lower frequency coefficients local area variance is chosen for the better fusion result and for the higher pixel frequency ones window property is used.The schematic diagram of the fusion is given in Fig 5.

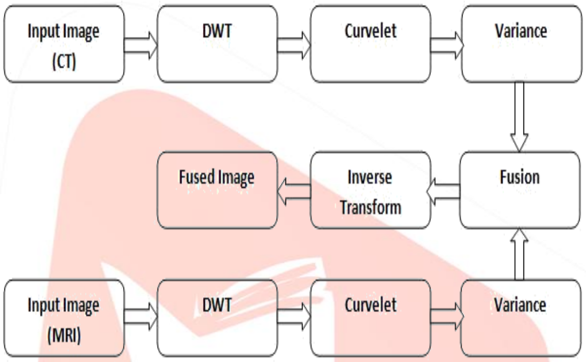

Fig 5 : Combined Fusion

III. RESULTS AND ANALYSIS

This paper put forward the fusion of CT and MRI images which have a valuable application in the medical field. Both of the images having different information i.e CT image will have only the information about harder parts of our body while MRI having information about the softer parts only.

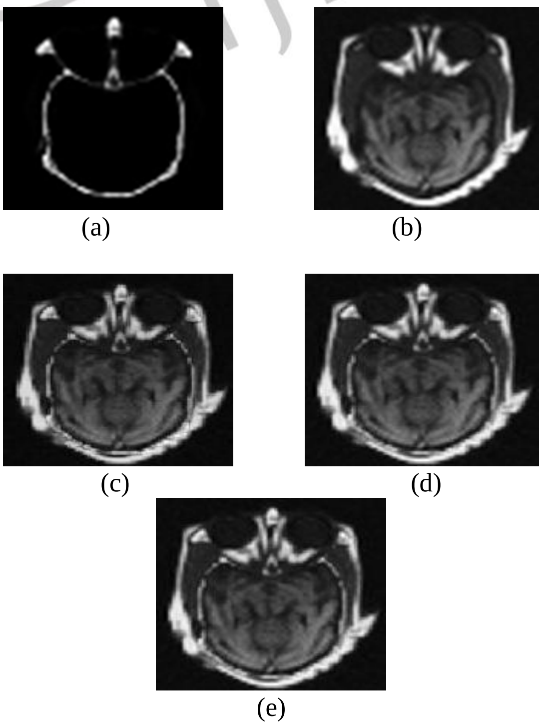

Fig 7 : Fusion Results (a) CT Image (b) MRI Image (c) Fused Image DWT (d) Fused Image FCT (e) Fused Image DFCT

For the better diagnosis purpose fusion of both the images are required. Fusion is done based on the above mentioned three methods and the results are obtained as shown in Fig 7. A comparative study of the three methods is given in Table I. For the better results of the fusion the Entropy should be minimum as possible, but in the case of Peak Signal to Noise ratio(PSNR) should be as higher as possible. The minimum value of PSNR is around 26 dB. Correlation Coefficient is the measure of the closeness of the result to that of the input one. It vary between -1 and +1 If the value is more close to the value 1 means it has maximum similarity.

Table I : EVALUATION OF PARAMETERS

Fusion Rule	Evaluation of Parameters		
	Entropy(bit/pixel)	PSNR(dB)	Cc
DWT	6.72737	34.3313	0.918839
FCT	6.75950	34.5011	0.925118
DFCT	6.75037	43.5040	0.923673

IV. CONCLUSION

In this paper image fusion based on three transforms namely Discrete Wavelet Transform, Fast Curevelet Transform and Discrete Fast Curevelet Transform were analyzed. Out of these three Discrete Fast Curvelet Transform was found to be more efficient in image fusion. From the above mentioned Table I it is clear from the values that Discrete Fast Curvelet Transform gives better efficiency in fusion. This will give a better fusion result while representing the edges of images.

REFERENCES

[1] Yan Sun, Chunhui Zhao, Ling Jiang,"***A New Image Fusion Algorithm Based on Wavelet Transform and the Second Generation Curvelet Transform***", IEEE transactions on image processing ,vol.44, no.10, June 2010.

[2] Swetha Metha, Bijith Marakarkandy, "***CT and MRI Image Fusion Using Curvelet Transform***",Journal of Information,Knowledge and Research in Electronics and Communication Engineering,Vol.2,Nov 2012.

[3] P.Phanindra, J.Chinna Babu, V. Usha Shree, "***VLSI Implementation of Medical Image Fusion Using Haar Transform***",International Journal of Scientific & Engineering Research,Volume 4,Issue 9,September 2013.

[4] Y.KiranKumar,"***Comparison of Fusion Techniques Applied To Preclinical Images:Fast Discrete Curvelet Transform Using Wrapping Technique & Wavelet Transform***",Journal of Theoretical and applied information Technology-JATIT,2005-2009.

[5] Thanikaiselvan.V,Arulmozhivarman.P,Rengarajan Amirtharajan,John Bosco Balaguru Rayappan, "***Wave(Let) Decide Choosy Pixel Embedding for Stego***",International Conferenceon Computer, Communication and Electrical Technology-ICCCET2011,March 18th,19th,2011.

[6] Sruthy S,Latha Parameswaran,"***Image Fusion Technique usin Curvelet Transform***",International Conference on Advances in Computer Engineering,2011.

[7] CYN Dwith,Vivek Angoth,Amarjot Singh,"***Wavelet Based Image Fusion for Detection of Brain Tumor***",International Journal on Image,Graphics and Signal Processing,January 2013.

[8] Ahmed Abd-el-kader, Hossam El-Din Moustafa,Sameh Rehan," ***Performance Measures for Imag Fusion Based on Wavelet Transform and Curvelet Transform***,"National Radio Science Conference,Egypt, April 2011.

[9] T.S.Anand ;K.Narasimhan, P.Saravanan,"***Performance evaluation of Image Fusion Using the Multi-Wavelet and CurveletTransforms***",IEEE Int. Conf. on Advances In Engineering, Science And Management(ICAESM-2012),March 30,31,2012.

[10] Y.KiranKumar,"***Comparison of Fusion Techniques Applied To Preclinical Images:Fast Discrete Curvelet Transform Using Wrapping Technique & Wavelet Transform***",Journal of Theoretical and applied information Technology-JATIT,2005-2009.