Comparative Analyses of Multilevel and Geometric Image Fusion Techniques

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Abstract—Image fusion which is a technique to provide the resultant and complete information when two images are combined at a single image. It is widely used application mainly for medical and multifocus imaging. Here in this paper we have proposed combination of multilevel image fusion and geometric based fusion technique. Initially fusion is carried out by multilevel image fusion technique, which includes either wavelet transform or curvelet transform, and at second level fusion is carried out by spatial or laplacian pyramid transform. Further geometric fusion technique will be applied by using the technique of Affine transform. Finally the performance will be evaluated by different quality metrics, which are used to prove the curvelet transform result better performance than wavelet transform in multilevel fusion, and affine transform will produce more resultant than both wavelet and curvelet transform. The proposed system is very unique technique in which this application will be more useful for medical, and satellite imaging.

Keywords:*Image Fusion,Image Quality Metrics,Laplacian Pyramid,Minimu selection,RMSE,PSNR,SD, Discrete Wavelet Transform,Fast Discrete Curvele Transform,PCA,Averaging.*

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I. Introduction

Now a days different sensors are available in market, which produces different characteristics for the same image, in which it may be of physical or geometric characteristics, it is difficult for sensors to acquire all these characteristics in to single image. To avoid these type of problems the technique called Image Fusion is used. Image Fusion is a technique which refers to the combining or integrating the two or more images into a single image in which produced image will be more informative and complete. This technique can mainly be used in medical imaging, multifocus imaging, satellite imaging. The Fusion technique can mainly be described in two ways, The first one is Spatial domain and the other one is transform domain. Again the spatial domain contains PCA, Averaging, Brovey method and IHS. The spatial domain method which contains the drawback of spatial distortion in the fused image, these problems can be avoided by using frequency domain approaches. The other fusion technique called Transform domain method which consists the technologies like Multiresolution Analysis(MRA, such as pyramid transform (laplacian pyramid, gradient pyramid etc). Wavelet transform (Discrete Wavelet transform(DWT), Multiwavelet Transform, complex wavelet transform, etc)[1].

The transform domain also contains Ridgelet[8], curvelet and control as multiscale transform methods. The explained transform domain methods which produces better performance in spatial as well as spectral quality at fused image.

The medical image fusion can be handled by spatial domain methods of image fusion, in which it may be of PCA, Averaging or some other methods of spatial domain. Image fusion also contains the technology like multiresresolution transforms like Discrete Wavelet transform, multiscale transform, Laplacian pyramid transform. The laplacian pyramid which contains the drawback of blocking effect in fused image and also fail during decomposition process[4,5], to overcome these problems Discrete Wavelet transform is used, which contains better signal to noise ratio[1], and straight edges which can be detected based on the point singularity. The image fusion technique also be handled by the geometric transformation, in which it refers to the moving the points from one coordinate to the another coordinate. Affine transform is a technique for geometric transform in which is mainly based on the ratio of length and angles which are preserved. Affine transform contains Scale and Shear Techniques in which Scale does not preserve the length, and Shear will not preserve the angles.

II. Literature Survey

Most of the research paper have covered fusion technique at single level by using both spatial and transform domain[2,3], the PCA, Averaging methods of spatial domain are used to improve the fusion result[2]. But in this paper we have covered the comparison of multilevel and geometric transform techniques, which can be compared by different quality metrics like Mean, Standard Deviation, PSNR, RMSE etc. The proposed system contains multilevel image fusion consisting two levels of image fusion for the same image. At first level of image fusion methods are applied like Discrete Wavelet or Fast Discrete Curvelet Transform, after performing the first level of image fusion at the second level of image fusion the fusion methods are used such as spatial or laplacian pyramid transform. The spatial methods contains PCA, Averaging, Minimum Selection and Maximum Selection methods. Further

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the result will be maintained by tabular form for both wavelet or curvelet transform. After performing the multilevel image fusion technique, geometric transform like Affine transform will be used for the fusion for the same input images which are used for the multilevel image fusion technique. Then finally compare the tabular values of both multilevel and geometric transform based fusion techniques. The proposed system which is used to prove the curvelet based image fusion performs better than wavelet transform, and affine transform will produced more resultant and completion of fused image as compared to both wavelet and curvelet transform.

III. Proposed System

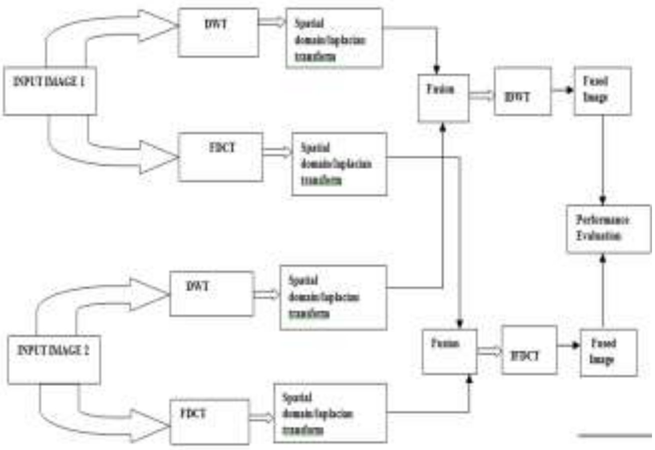

Fig 1(a):Block Diagram for Multilevel Fusion Method

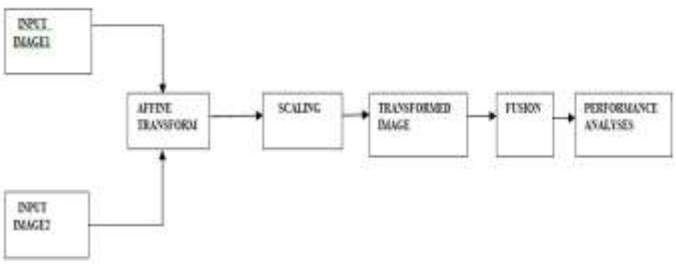

Fig 1(b):Block diagram for Affine Transform

The above fig 1(a) shows the block diagram for multilevel image fusion, in which multilevel image fusion contains two levels of image fusion for the same images. Initially in multilevel image fusion the methods such as DWT or FDCT is applied to get the coefficients from the source image. Either it may be Discrete Wavelet or Fast Discrete Curvelet transform is applied to get the coefficients. After applying the first level of image fusion, The result will be in coefficient form. The second level of image fusion contains methods like spatial or laplacian transform methods, which can apply to the resultant coefficient from first level of image fusion. The spatial method which mainly consist of methods like Minimum Selection, PCA, Maximum Selection, Averaging. Any one of the domain can apply for second level of image fusion in which it may be of spatial or laplacian transform. After applying the second level of image fusion the new coefficients will be obtained, which gives the high spatial resolution, and high spectral quality contents. The final fused image can be obtained by applying Inverse Discrete transform on wavelet coefficients and Inverse Fast Discrete Curvelet Transform on curvelet coefficients. After applying the Inverse Transform both on Wavelet and Curvelet transform the Fused image will obtain which can be analyses by different quality metrics parameters. The parameters may be the Mean, Standard Deviation, RMSE, PSNR, etc.

The fig 1(b) shows the block diagram of Affine transform in which it contains the same input images which are applied for the multilevel image fusion. Initially Affine transform is applied on the source images in which it produces the transformed image for both the source images. In affine transform technique the images are rearranged in matrix form which can be converted to transformed image by using scaling technology. The Affine transform can apply by using the techniques of Scaling, Reflection, and Shear techniques. Here in this proposed system we are using Scaling technique for affine transform. Then fused image can be analyses by the same quality metrics which are used for the multilevel image fusion. The resultant parameters will be in tabular form. After performing the analyses part of the Affine transform the final procedure is to comparison of both Multilevel based fusion with Affine based fusion technique. The efficiency can be calculated by depending on the value of PSNR. If the PSNR value is high then the fused image will more efficient one.

2.2 Image fusion Algorithms

The proposed algorithm is implemented for fusion of satellite imaging and multifocus imaging. The proposed system initially requires two source images. The fused image may be helpful for satellite imaging or for multifocus images.

The steps involved in proposed algorithm can be summarized as follows:

1. Initially two input images namely image1, and image2 are used for the fusion techniques.
2. Two input images are registered as same dimension.
3. Applying multilevel image with either DWT or FDCT.

   Stage 1.

   a. The 2d DWT is applied on both the input images using haar transform which provides rows and columns at 2 levels.
   b. After applying DWT it will produce some coefficients.

c. At second level FDCT with wrapping method is applied to both source images. The FDCT algorithm explained as follows-

- Applying 2D FFT transform to both images. It will produce some Fourier samples as A[i1,i2] and B[i1,i2].
- Input image A[i1,i2]as which produce the periodization with scale and angle consider as
- d1[i1,i2]=Us,a[i1,i2]A[i1,i2] (1)

  And source image B[i1,i2] as

  d2[i1,i2]=Us,a[i1,i2]B[i1,i2] (2)
- The obtained result will be d1[i1,i2] and

  d2[i1,i2] are wrapped around the origin to restrict the rectangular window length L1,a×L2,a near the origin. The product obtained is

  As,a[i1,i2]=W(Us,aA)[i1,i2] (3)

  Bs,a[i1,i2]=W(Us,aB)[i1,i2] (4)

Where the dimensions must be range 0 ≤i1 <L1,a,

0≤i2 < L2,a

- Apply the inverse 2d FFT for both As,a and Bs,a
- After applying inverse FFT it produce co-efficients consider as As, Bs,a from source images. Which contains high directions.

Stage 2.

a).In second level Fusion techniques contains such as Spatial or Laplacian Pyramid techniques. Such as follows

i).For minimum selection rule, it contains the minimum pixels from A(i1,i2) and B(i1,i2) sub images.

F_{min}=min imum(A(i1,i2),B(i1,i2)) (5)

ii). In PCA rule ,fusion is done with principle component analysis calculation for A(i1,i2) andB(i1,i2)sub images, and then combining the product of principal component (P1,P2) with each source sub images into a single Image. The sub images which are obtained from DWT And FDCT.

F_{pca}=P1(A(i1,i2)+P2(B(i1,i2)) (6)

iii). Averaging Rule contains the average of fixel values obtained from DWT and FDCT fusion Techniques.

F_{avg}=(A(i1,i2)+B(i1,i2)/2 (7)

iv). For Laplacian pyramid rule, fusion is done by first filtering the A(i1,i2) and B(i1,i2) sub images and then difference is calculated by expansion or interpolation way and then discrete convolution is performed to reconstruct the fused image $F_{lap.}$

v). For maximum selection rule, it contains the maximum pixels values from A(i1,i2)and B(i1,i2) sub images of source images.

F_{max}=max imum(A(i1,i2),B(i1,i2)) (8)

A binary decision map is formulated based on the obtained maximum pixel vaues from A(i1,i2) and B(i1,i2)sub images, a binary decision map is formulated. The eq. (9) gives the decision rule D_r for image fusion of DWT and FDCT obtained coefficients of two source images.

D_r(I,j)=1,A(i1,i2)>B(i1,i2) (9)

=0, otherwise

d)Any one of the fusion technique as applied at second level of image fusion, to obtain the wavelet coefficients, curvelet coefficients.

e) After obtained coefficients from both wavelet, curelet coefficients, Fusion is applied for new coefficients obtained at level 2.

(4) Apply Inverse 2D Discrete Wavelet transform(IDWT) and Fast Discrete Curvelet Transform(IDFCT) on both the concatenated images based on DWT and FDCT to reconstruct the resultant fused images and display the result.

(5) After getting reconstruction of DWT and FDCT, Further apply for the geometric transform like affine transform for the same images which are used for both DWT and FDCT.

(6) Finally after applying geometric transformation, comparatively analyse them by statistical analysis of fused images obtained multilevel image fusion by DWT, FDCT techniques, as well as for affine transformation. The statistical analysis of fused image can be analysed by some quality metrics like Mean, Standard deviation, Entropy, PSNR, RMSE and Correlation Coefficient.

IV. EXPERIMENTAL RESULTS AND STATISTICS

The results of proposed system for different image fusion are analysed in the below table. The comparative analysis of multilevel image fusion by DWT, FDCT, and further fusion of Affine transform, with resultant information will be listed in following tables. The Mean in the table refers to the average of pixel values, thus its must be high for better contrast in an image. The Standard deviation which represents the deviation of pixel values from mean. If the SD is high then image having the high contrast of an image. The Entropy which is used to measure the content of the information. The PSNR which stands for peak signal to noise ratio, so it must be high for less noise in an image. RMSE represents root mean square error, so to occur less error in fused image the RMSE must be small for better fused image. The Correlation Coefficient C_c represents correlation of fused image with any one of source images, thus value must be near to one. To provide the more efficient image then it must have higher the PSNR rate, and lower the RMSE value.

The result of both multilevel image fusion and Affine transform will be compared by quality metrics in which the Laplacian pyramid method shows better performance in multilevel image fusion. The Curvelet based image fusion shows better efficiency than wavelet based image fusion. The overall comparison of Multilevel and Geometric based image fusion technique shows the geometric based Affine transform have the better efficiency and more informative.

Table 1:Statistical analysis for Multilevel image fusion of DWT and FDCT

FUSION METHOD	Mean		SD		E		AG		RMSE		PSNR		C_c	
	WT	CT	WT	CT	WT	CT	WT	CT	WT	CT	Wt	CT	WT	CT
Minimum selection	222.45	221.41	52.93	53.10	4.71	4.48	2.28	2.28	25.49	25.1	78.4	78.63	0.96	0.97
PCA	221.45	221.45	52.93	53.10	4.71	4.48	2.28	2.28	231.86	229.19	56.36	56.47	0.84	0.90
Averaging	221.45	221.41	52.93	53.1	4.71	4.48	2.288	2.288	17.26	14.15	82.33	84.35	0.97	0.97
Maximum selection	221.45	221.411	52.93	53.10	4.71	4.48	2.28	2.28	7.88	3.6	35.4	42.65	0.8	0.83
Laplacian pyramid	221.45	221.45	52.93	53.10	4.71	4.48	2.28	2.28	18.48	23.1	56.65	81.65	0.97	0.83

Table 2:Statistical Analysis for geometric affine transform

FUSION METHOD	Mean	SD	E	AG	RMSE	PSNR	C_c
AFFINE	225.23	55.60	4.9	3.1	17.5	85.7	0.98

V. CONCLUSION

The proposed system contains the combination of multilevel fusion and geometric based fusion technique which works better for medical and multifocus imaging. The comparison made by tabular format in which the FDCT based fusion technique works better than DWT technique in multilevel fusion technique. The multilevel fusion technique contains curvelet based laplacian transform produce more resultant than other fusion techniques. While comparing multilevel fusion with Affine transform , the geometric based affine transform will produce more efficient result. The affine transform will have high PSNR and lower RMSE values which shows the fused image is more better one. The proposed system which covers the large part of the fusion techniques which will useful for medical and multifocus imaging techniques. The proposed system also contains the future work like projective geometric transform and as well as some advanced technologies in pre and post processing of image fusion

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