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MEDICAL IMAGE FUSION USING MULTI-SCALING AND MULTI-RESOLUTION TECHNIQUES

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Abstract: Medical image fusion using different type of image fusion techniques like DWT and DRT. Image fusion can be done with two technologies, spatial domain and Transform Domain. Transform domain use Multi-Scaling and Multi-Resolution method. A new idea is presented in paper with combination of Multi resolution and multi scaling techniques which improves the result quality and get initial fused image. The Propose Image Block Method algorithm is improving initial fused image and quality of final fused image is improved. The performance of the fused image is evaluated using different parameters like PSNR, MSE, SSIM and ENTROPY.

Keyword: Medical Image Fusion, Multi-Scaling , Multi-Resolution, Block Matching

I. Introduction

Image Fusion is a process of combining relevant information from a set of images into a single image, hence the fused image will be more informative and better than input images. Image Fusion method is improve the quality of image.

In Medical imaging, CT (Computed Tomography), MRI (Magnetic Resonance Imaging) and other modes of medical images reflected human information from various angle. CT can clearly reflect the anatomical structure of bone tissues and MRI can clearly reflect the anatomical structure of soft tissues, organs and blood vessels. A CT image gives district contours of bones but it cannot show clear image of ligaments. MRI shows the shape of both ligaments and born but fails to produce distinct contours of the bones. Fusion of CT-MRI image is used to assist in planning surgical procedure. [1-4] several techniques for medical image fusion exits. Simple pixel domain method like average and choose maximum cause loss of details or contrast, making the image more difficult to interpret. [5-6].There are two types of techniques.1) Multi-Scale 2) Multi-Resolution. Combination of the techniques results is expected to improve accuracy.

II.FUSION TECHNIQUES

Image fusion techniques are classified in two Domains.

1. Spatial Domain (Pixel Level).
2. Transform Domain. [04]

A. Pixel level or Spatial Domain image fusion.

The pixel level image fusion combine the source images into a single image. This kind of methods is usually robust to noise and miss-registration. Spatial domain techniques are simple and fused image can be obtained by directly applying fusion rules on pixel values of source image. Simple averaging, PCA (Principal component analysis) and linear fusion are some example of spatial domain techniques. But major disadvantage are that they introduce spatial distortion in the fused image and do not provide any spectral information. [07]

B.Image fusion based on Transform Domain.

Pixel level image fusion is simple and easy to implement but with simplicity, it introduces loss of information and blurring of edges [04].This can be improved by using multi-scale decomposition. Image fusion using different transforms involves three phases: 1) Decomposing the input images into high and low frequency sub-band up to certain level. 2) Combining approximate (low frequency part) and detailed (high frequency part) coefficient using some fusion rules in order to obtain new fused coefficients. 3) Using the inverse transform a new image is constructed. DWT(Discrete Wavelet Transform), CVT (Curvelet Transform), DRT (Discrete Ripplet Transform) , CNT or CT (Countourlet Transform) are some example of transform domain techniques. Image fusion based on transform domains are classified into two techniques: 1) Multi-resolution 2) Multi Scale.

II. Transform Domain(Multi-Resolution and Multi-Scaling):

Transform domain fusion enables the image's salient features are more clearly visible than in spatial domain fusion. In Transform Domain, first image is transform into frequency domain using the Fourier transform and then inverse Fourier transform to get the original image. Wavelet transform is very popular and fast development multi-resolution methods for image fusion.

Wavelet transform can retain spectral information efficiently but cannot express spatial characteristics well. So, Now a days, MGA (Multi-scale Geometric Analysis) tools has been developed. There were many MGA tools proposed, likes Curve let, Contour let, and Ripplet etc. Which have higher directional information. Some well-known Transform Domain Image Fusion methods are listed below:

- Discrete Wavelet Transform
- Curvelet Transform
- Contourlet Transform
- Discrete Ripplet Transform

A. DWT (DISCRETE WAVELET TRANSFORM) MULTI RESOLUTION TECHNIQUE

The original concept and theory of wavelet- based on multi-resolution analysis came from Mallat. DWT represent image variation at different scale. A wavelet is an oscillating and attenuated function and its integrals equal to zero. The wavelet transform is mathematical tool which detect local feature in a signal process. It can also be used to decompose two dimension (2-D) signals or images into different resolution level for multi-resolution analysis. Wavelet transform is applied in many areas, such as texture analysis, data compression, feature detection and image fusion. The DWT is spatial-spectral decomposition that provides a flexible multi-resolution analysis of an image. In a 2-D DWT, a 1-D DWT is first perform on the rows and then columns of the data by separately filtering and down sampling. This results in one set of approximation coefficients LL and three sets of detail coefficient LH, HL, HH representing horizontal, vertical and diagonal direction of the image as shown in Fig. 1 (a). The 2- D structures of the wavelet transform with two decomposition levels is shown in Fig. 1(b)

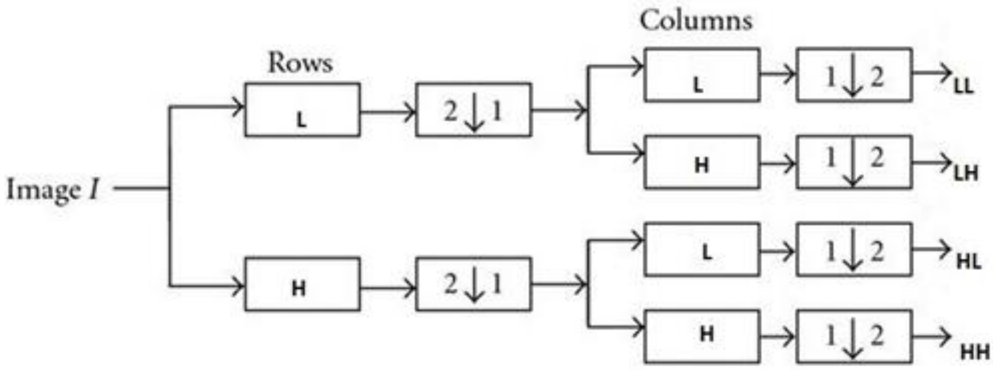


Figure. 1 (a). A structure of DWT [5]

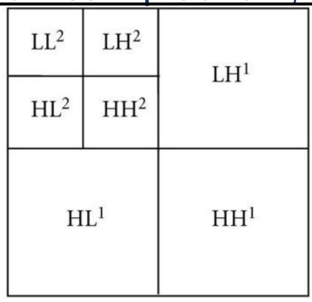


Figure. 1 (b). 2D- DWT sub-band in two-level decomposition. [5]

By the recursively applying the same scheme to the LL sub-band a multi-resolution decomposition with a desired level can then achieved. Therefore, a DWT with K decomposition level will have M=3xK+1 such frequency band (LLk) as given in Figure. 1(b) and the remain of bands are high frequency bands in a decomposition level."

B. DRT (DISCRETE RIPPLET TRANSFORM) MULTI SCALING TECHNIQUE

The Conventional transforms like Fourier Transform and Wave Transform suffers from discontinuities such as edges and contours in images. A new MGA-tool called RT is used to solution of above problem. The RT is a higher dimensional generalization of the Curvelet Transform (CVT), capable of representing images or 2D signals at different scales and different directions. Visual and quantitative analysis shows, that the Ripplet Transform technique performs better compared to fusion scheme based on Contourlet Transform (CNT). RT generalizes CVT by adding two parameters, i.e., support c and degree d. CVT is just a special case of RT with c = 1 and d = 2. The anisotropy capability of representing singularities along arbitrarily shaped curves of RT is due to these new parameters c and d [5].

Ripplet Function: Discrete Ripplet function is defined in frequency domain:

$$\hat{\rho}j(r,\omega) = \frac{1}{\sqrt{c}} a^{\frac{m+n}{2n}} W(2^{-j}.r) V(\frac{1}{c}.2^{-|j\frac{m-n}{n}|}.\omega - \quad (1)$$

$$\hat{\rho}a(r,\omega) = \frac{1}{\sqrt{c}} a^{\frac{d+1}{2d}} W \quad (2)$$

Where,

W(r) is "radial window" on [1/2,2].
V( ) is "angular window" on [-1,1].
c determines the support.
d denotes degree.

Here, the DRT is performed with support (c=1) and for degree d=3.

The DRT of MXN image

$$R_{j,\vec{k},l} = \sum_{n1=0}^{M-1} \sum_{n2=0}^{N-1} f(n1,n2)\overline{\rho_{j,\vec{k},l}} \quad (3)$$

Where $R_{j,\vec{k},l}$ is Ripplet coefficients. The image can be reconstructed through Inverse Discrete Ripplet Transform(IDRT).

IV. PROPOSE MEDICAL IMAGE FUSION MEHOD

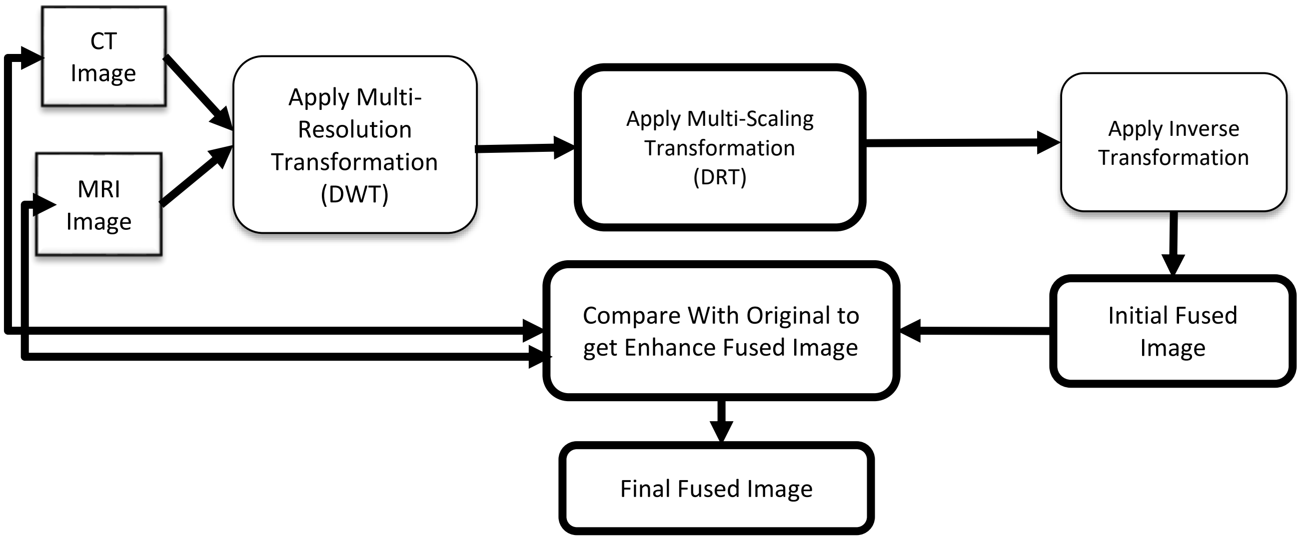


Figure:2 BLOCK DIAGRAM OF PROPOSE IMAGE FUSION MEHOD

The Block Diagram can be summarized as follows steps:

1. Take input images Like CT and MRI and register both these images so that the corresponding pixels are aligned means stay in the same magnitude.

2. Now apply any one Multi-Resolution technique to input images.

3. Then get wavelet coefficients from both input images (CT, MRI) which give high resolution and high spectral quality contents from input images.

4. After getting wavelet coefficients apply any one Multi-Scale transform and get initial fused image.

5. Then apply Image Blocking method on initial fused method.

A. IMAGE BLOCK METHOD:

- In this method, divide CT, MRI and initial fused image F_1 into equal – sized square blocks whose size are $m \times n$.
- Calculate the similarity measure values(SM) of the corresponding Pixel -blocks of CT, MRI and F_1 respectively.

$$SM_{F_1CT} = \frac{2\times\sum_{i=1}^{m}\sum_{i=1}^{n} F_1(i,j)\times CT(i,j)}{\sum_{i=1}^{m}\sum_{i=1}^{n}[F_1(i,j)^2+CT(i,j)^2]}$$

$$SM_{F_1MRI} = \frac{2\times\sum_{i=1}^{m}\sum_{i=1}^{n} F_1(i,j)\times MRI(i,j)}{\sum_{i=1}^{m}\sum_{i=1}^{n}[F_1(i,j)^2+MRI(i,j)^2]}$$

- The higher the value of SM indicates the high similarity of two images. If the similarity between the source image pixel -block and the initial fused image block is greater, the greater the probability is that the ultimate fused image blocks comes from the source image block.
- Check consistency on the Pixel -Block, and then get the final fused image F by the following calculation:
- If F_1 (i,j) nearby pixel value of SF_{MRI} then:
  F(i,j)== SF_{MRI} (i,j)
  Else if: If F_1 (i,j) nearby pixel value of then SF_{CT}(i,j) then:
  F(i,j)== SF_{CT} (i,j)
- And finally get fused Image.

Advantage:

- In Image Blocking method, each block of fused image is original block of any of the input image. So, improved the visual quality of input images.

B. Propose Work

- Take two input medical images CT and MRI.
- Find out the best Combination multi-Resolution and Multi-Scaling Method for getting high quality initial fused medical image.

- Compare the initial fused method with the original input images CT and MRI using the propose Image Block Method.
- Finally get the final fused image which is better than the original input images and initial fused image.

V. PERFORMANCE MEASURES PARAMETER OF FUSION TECHNIQUES.

A. Entropy

Entropy is one of the most important quantitative measures in image fusion. The entropy is defined as:”

$$E = -\sum_{i=0}^{L-1} P_i \log 2 \; P_i$$

Where, Pi is probability of each gray scale level.

B. Mean Square Error (MSE):

The Formula of Mean Square Error is following.

$$\sqrt{\sum_{i=1}^{M}\sum_{j=1}^{N}\frac{[R(i,j)-F(i,j)]^2}{M*N}}$$

R is Reference image and F is Resultant image. Lower value indicates good result.

C. Peak Signal to Noise Ratio (PSNR) :

Following is the equation of find out PSNR value of Input images and fused images.

$$PSNR = 10 * \log_{10}\left(\frac{fmax^2}{MSE}\right)$$

Where f_{max} is maximum gray scale value of the pixels in fused image. Higher value indicates good result.

D. Structure Similarity Index Matrix (SSIM):

The SSIM measures the similarity between two images. SSIM is an advance version of traditional techniques like PSNR and MSE.

SSIM(x,y)=l(x,y).c(x,y).s(x,y)

Where,

l(x,y)=Luminance Changes,

c(x,y)=Contrast Changes,

s(x,y)=Structural Change.

The index of SSIM is decimal value between 0 and 1. 0 value indicate that the no correlation between the original image and fused image, and 1 value indicates that the exact same image.

VI . EXPERIMENTAL RESULT AND ANALYSIS

The following sequence steps explain the fusion of image with the performance analysis.

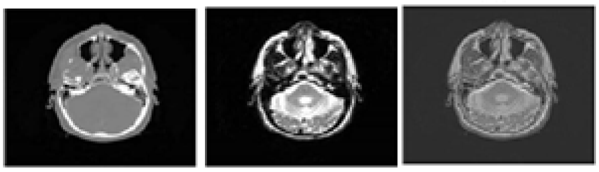
Step 1- Input images of CT and MRI. Totally two groups of images are used in analysis.

Step 2- Apply DWT method and DWT-DRT method on Datasets 1 and Datasets 2.and get the initial fused images as shown in Fig.3 (a), (b) and Fig.4 (a), (b).

Step-3-Apply image block matching algorithm on initial fused image derived by DWT-DRT on Datasets1 and Datasets2 and get the final fused images as shown in Fig.3 (c) and Fig.4 (c).

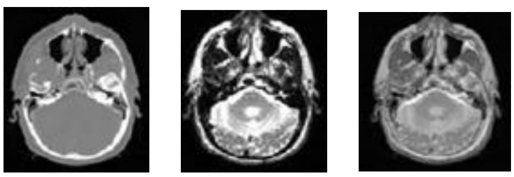
Step 4-As show in table-1, Performance and compression is done using the four fusion performance assessment metrics, PSNR, MSE, ENTROPY, and SSIM.

- **Dataset 1**



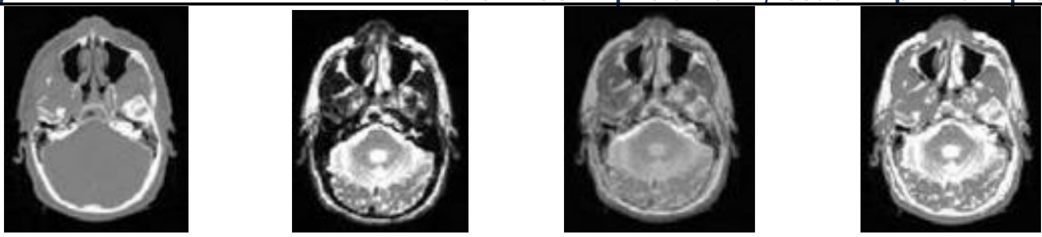
CT Image MRI Image Fused DWT Image

Figure-3 (a) DWT Fused Image



CT Image MRI Image Fused DWT-DRT Image

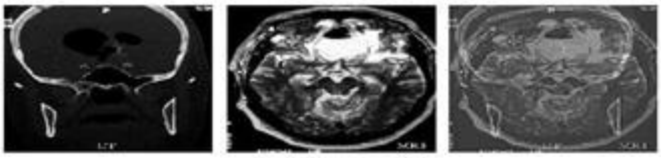
Figure-3 (b) DWT-DRT Fused Image



CT Image MRI Image Fused DWT-DRT Image BLOCK BASED Fused

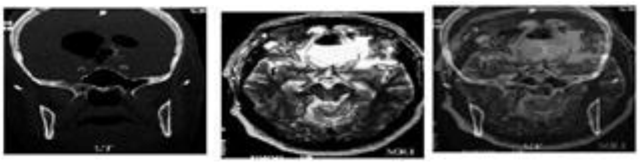
Figure-3(c) DWT-DRT-BLOCK BASED Fused image

- **Dataset 2**



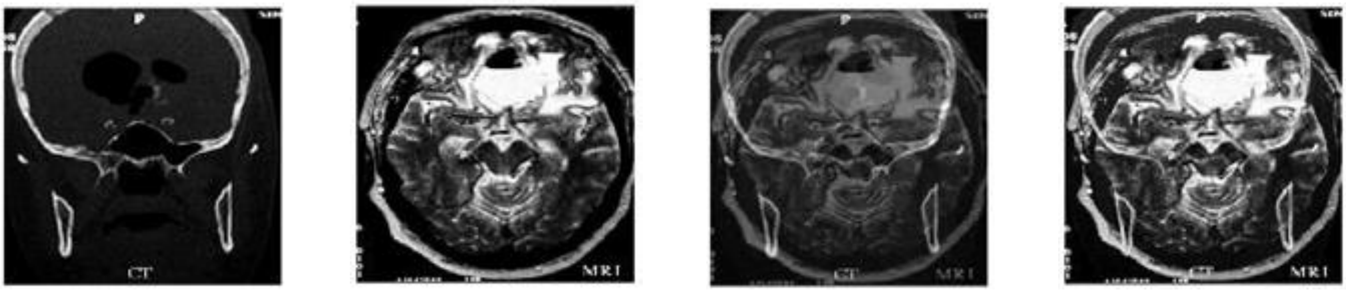
CT Image MRI Image Fused DWT Image

Figure-4(a) DWT Fused Image



CT Image MRI Image Fused DWT-DRT Image

Figure-4(b) DWT-DRT Fused Image



CT Image MRI Image Fused DWT-DRT Image BLOCK BASED Fused

Figure-4(c) DWT-DRT-BLOCK BASED Fused image

- **Result Analysis**

Table 1: Comparison

DATASETS	**METHODS**	**CT IMAGES**			**MRI IMAGES**			**FUSED IMAGES**
		PSNR	**MSE**	**SSIM**	**PSNR**	**MSE**	**SSIM**	**ENTROPY**
DATASET1	DWT	17.2698	1219.3	0.7058	18.5227	913.7110	0.8209	0.6152
	DWT-DRT	**20.5551**	**572.23**	**0.6982**	**17.2508**	**1224.6**	**0.6279**	**5.2378**
	PROPOSED	**65.3528**	**0.0190**	**0.998252**	**62.8483**	**0.0337**	**0.996394**	**5.4670**
DATASET2	DWT	13.6044	2835.6	0.3268	14.3006	2415.6	0.6180	0.6726
	DWT-DRT	**16.0686**	**1607.8**	**0.4451**	**12.8966**	**3337.5**	**0.4246**	**6.8858**
	PROPOSED	**57.3566**	**0.1195**	**0.984058**	**64.2397**	**0.0245**	**0.997246**	**7.6046**

By observing the data value of table, it is clear that the propose Image Block method give the better fused image.

VII . CONCLUSION

Medical image fusion has been derived using the combination of multi-resolution and multi-scale techniques advantages. This method is developed by DWT and combining DWT-DRT. The quality of the initial fused image measured by PSNR, MSE, ENTROPY and SSIM. Proposed block matching algorithm uses the initial fused image derived by DWT-DRT. The final fused image is superior then the initial fused image derived by DWT-DRT.

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