Developing an Image Fusion Algorithm Using Double Density Dual-tree Complex Wavelet Transform

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Abstract - *Double-density Dual-tree Complex Wavelet transform is introduced to image fusion based on multi resolution, images are decayed by double-density dual tree complex wavelet transform with multi-level, multi direction and shift-invariance and according to characters of low and high frequency coefficients correspondingly, different permutation rules are adopted to fuse images and combination coefficients are reconstructed by double-density dual-tree complex wavelet inverse transform. Some fusion experiments are completed by numerous sets of images with different modalities and objective performance assessments are satisfied to calculate fusion results. The tentative results indicate that the planned approach can appreciably outperform the traditional image fusion method based on Laplacian pyramid and discrete wavelet transform. For medical diagnosis, doctors usually monitor the images manually and fuse them in the mind. The aim of image fusion is to acquire useful complementary information from CT/MRI multimodality images. By this method we can get more balancing information and also satisfactory Entropy, Better correlation coefficient, PSNR (Peak- Signal-to-Noise Ratio) and less MSE (Mean square error).*

Keywords: Double Density Dual Tree Complex Wavelet Transform, image fusion.

1. INTRODUCTION

Medical image fusion has been also a admired research topic. In general, medical image fusion means the matching and fusion between two or more images of the same lesion area from different medical imaging equipment, and aims to obtain harmonizing information and increase the amount of in succession. Medical image fusion procedure is to merge the information of a multiplicity of images with computer-based image processing technique. It is being used for medical image fusion so as to get a superior image which is clearer and contains more information. In the experimental diagnosis and treatment, the use of fused images can provide more useful information. It is key for lesion location, diagnosis, making treatment and pathological study.

With the improvement of new imaging sensors arises the need of a consequential combination of all employed imaging sources. The actual fusion process can take place at different levels of information demonstration; a generic classification is to consider the different levels as, sorted in increasing order of abstraction: signal, pixel, feature and symbolic level. This paper focuses on the so-called pixel level fusion procedure, where a merged image has to be built of several input images. To date, the result of pixel level image fusion is measured primarily to be accessible to the human observer, in particular image fusion sequence (where the input data consists of image sequences). A possible application is the fusion of forward looking infrared (FLIR) and low light visible images (LLTV) obtained by an airborne sensor platform to aid a pilot navigates in poor weather conditions or darkness. In pixel-level image fusion, some generic necessities can be compulsory on the fusion result. The fusion process should preserve all significant information of the input imagery in the merged image (pattern conservation). The fusion act should not introduce any artifact inconsistency which would divert the human observer or subsequent processing stages. The fusion procedure should be shift and rotational invariant, i.e. the fusion result should not depend on the location or orientation of an object the input imagery. In case of image succession fusion arises the further crisis of temporal stability and reliability of the fused image sequence. The human visual scheme is primarily sensitive to moving light stimuli, so moving artifacts or time depended contrast changes introduced by the fusion process are highly disturbing to the human observer. So, in case of image succession fusion the two supplementary requirements apply. Temporal stability: The fused image progression should be temporal stable. Temporal consistency: Gray level changes going on the input sequences must be present in the fused progression without any interruption or contrast change.

II. METHODS OF FUSION

I. Existing method

- Image averaging and maximization method
- Principal component analysis
- Discrete wavelet transform
- Thresholding and K means clustering methods for segmentation.

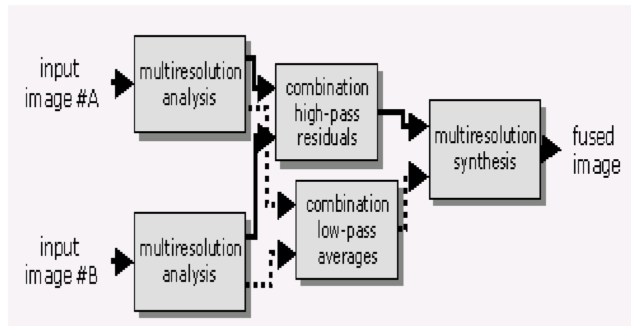


Fig 1 Blocks Diagram Of Basic Image Fusion Process

Here we take four types of images which are as follows: multispectral images, medical images, merging out of focus images, Applications and trends navigation aid.

II. SYSTEM ARCHITECTURE

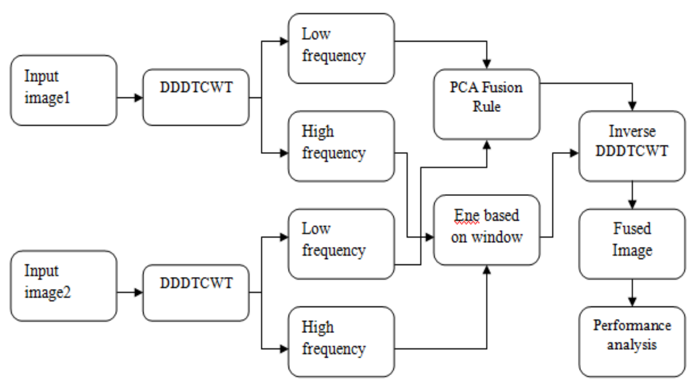


Fig 2: Block Diagram of DDDTCWT

III. METHODOLOGIES

1. Test images, Pre-processing:- A test image is a digital image file used across different institutions to test image processing and image compression algorithms. The images are in many cases chosen to represent natural or typical images that a class of processing techniques would need to deal with. Other test images are chosen because they present a range of challenges to image reconstruction algorithms, such as the reproduction of fine detail and textures, sharp transitions and edges, and uniform regions. Preprocessing of any image is to rectify the inconsistencies that are inside in captured images for obtaining better object for further processing.

2. Double-density Dual-tree Complex Wavelet transforms: - Multiscale image fusion includes three stages: decomposition, combination and reconstruction. At decomposition stage, the input images are decomposed by DD-DTCWT to low-frequency and high-frequency subbands representing different physical meanings. At the combination stage, because of their different physical meaning, the low-frequency and high-frequency subbands should be treated by different fusion rules to form different fused coefficients. Finally, Double density dual-tree complex wavelet inverse transform (DD-DTCWIT) is employed to reconstruct an image.

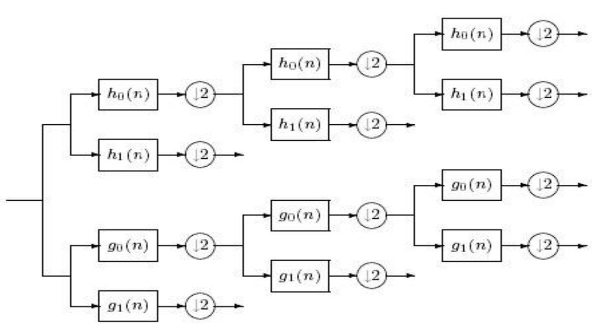


Fig 3: Iterated filter bank for the double-density dual-tree CWT

3. Fusion rules (PCA & Energy based on window)

3.1 PCA fusion rule of approximation images:

- Assuming that source approximation images are I1L and I2L, combined approximate image is IL, PCA fusion steps are followed.

Step 1: The coefficient matrices of decomposed approximate images I1L and I2L are arranged by fore-row-post-column to create one dimension vectors, that is *x*, *y* respectively.

Step 2: Calculate the mean of vector *x*, *y*.

Step 3: Calculating the covariance of vector *x* , y

Step 4: Calculating the covariance matrix.

Step 5: Calculating eigen values and eigenvectors of covariance matrix.

Step 6: Confirming principal component Eigen value and calculating approximate combination image.

3.2 Selecting bigger Energy based on window region fusion rule of detail images

Step 1: In coefficient matrices of decomposed detail images.

Local energy (*E*) and local medium are local characteristic of image. The local energy of any area which center is M*ed (i,j)* in image G has been defines as following:

$$E = \sum_{i'<P, j'<Q} \left[G\left(i+i', j+j'\right) \right]^2$$

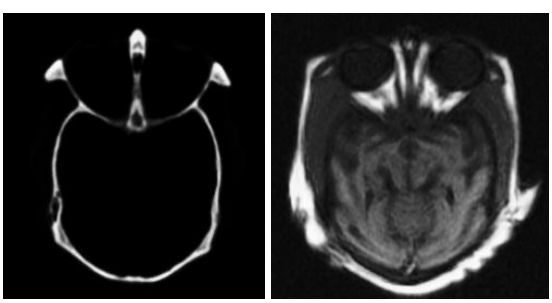
IV. EXPERIMENTAL RESULTS

In this section, for test the validity of the planned approach, four sets of different modality images i.e. multifocus images, CT and MRI images, infrared and visual images, remote sensing images respectively are provided to be fused and experiment results are shown below.

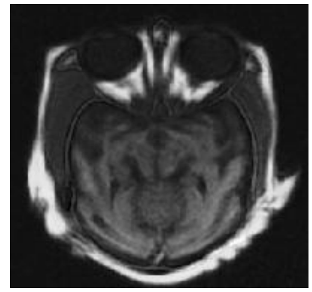
(a)Left focus image (b) right focus image

(c) DDDTCWT image

Fig 4 Multi Focus Images



(a)CT image (b) MRI image



(c) DDDTCWT image

Fig 5 Medical Images

(a) Saras 51 (b) Saras 52

(b) DDDTCWT image

Fig 6 Remote Sensing Images

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(a)Infrared image (b) visible image

(c) DDDTCWT image

Fig 7 Visible and Infrared Images

SSIM is used for measuring the similarity between two images. The SSIM index is a full reference metric; in other words, the measurement or prediction of image quality is based on an initial uncompressed or distortion-free image as reference. SSIM is designed to improve on traditional methods such as peak signal-to-noise ratio (PSNR) and mean squared error (MSE), which have proven to be inconsistent with human visual perception. The SSIM index is calculated on various windows of an image. The measure between two windows x and y of common size $N \times N$ is:

$$\mathrm{SSIM}(x,y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)}$$

With μ_x the average of x; μ_y the average of y; σ_x^2 the variance of x; σ_y^2 the variance of y; σ_{xy} the covariance of x and y; $c_1=(k_1L)^2$, $c_2=(k_2L)^2$ two variables to stabilize the division with weak denominator;

Table 1: Fusion Performance Of Different Images

Parameters	Multi focus images	Medical images	Remote sensing images	Visible & infrared images
E	7.23391	6.61546	4.6593	6.8008
MI	3.11522	2.80051	2.67055	1.3913
SSIM	0.896539	0.49839	0.931509	0.682633

From tab.1 data, fusion performance by planned approach is best, this is due to DDDTCWT that can decompose 16 main orders, each of the main orders includes two wavelets that is measured as the real and imaginary parts of complex wavelet which can describe characteristic more accurately, in addition, the trait of approximate shift-invariance can be more improve the accuracy of image decay and reform.

V. CONCLUSION

In this paper, a new image fusion algorithm using the DDDTCWT is planned. The effectiveness of the fusion ruling is resolute by the objective consideration of the fusion routine using parameters such as the MI, SSIM and factor E. From the experiments conducted and human surveillance of the fused images, we conclude that the planned fusion algorithm based on DDDTCWT is a well-organized technique for fusing multisource image.

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