MEDICAL IMAGE FUSION THROUGH CT AND CT BASED MULTI-FEATURE SET ANALYSIS

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Abstract: *this paper proposes a novel multimodal image fusion method using Contourlet transform (CT) and multiple features. First, this work performs CT on each source image to obtain low frequency coefficients and high-frequency coefficients. CT provides a richer scale space analysis for image compared to other Multi Scale Decomposition tools because it can decompose image into magnitude and phase information. Instead of a single feature, this work extracts three features for the fusion of low frequency subbands. The first one is based on the phase information of low frequency coefficient, which can be used to measure its clarity. The second one is the magnitude information of low frequency coefficient, which presents its energy information. The third one is the variance of spatial region corresponding to the low frequency coefficient, which is used to represent the salience of coefficient. Next, a choose-max fusion rule based on the contrast and energy of coefficient is proposed to integrate the high-frequency subbands. Finally, the final fused* image is constructed by inverse CT.

Keywords: Image fusion, Contourlet Transform, Multiple Features, LF rule, HF rule, Mutual Information

I. INTRODUCTION

Multi-modal image fusion is a way of fusing the most focused parts of several images of the same scene, in order to extract a new image of the scene where all parts are in focus. This can be done manually, in which case the photographer first takes several photographs of the same scene using different camera settings in order to get different focus levels for each photograph. Once this is done, the photographer uses an image editing software to put together a new image where the entire scene is in focus. One of the issues with this technique, is the fact that the photographer has to retake the photographs should he notice the first photographs don't work out.

There are also more automatic ways of performing multi-focus image fusion. One of which wavelet functions are used to determine what is in focus and what is not. The end results are usually accurate, however, the technique is advanced and is therefore difficult to implement properly. Also, the source images have to align perfectly in order for the technique to work. This is difficult for the photographer to achieve, and if it's not achieved then manual post-processing of the photographs is required.

Most of the existing multi-focus image fusion approaches are developed based on wavelet transform. Here the WT is used to decompose the source images into low frequency and high frequency sub bands. Further the obtained low frequency sub bands are fused based on the weighted average rule and the high frequency sub bands are fused based on the maximum absolute rule. After fusing both the low frequency and high frequency sub bands, inverse WT is applied over them to reconstruct the fused image. However the fused images don’t carry entire information of source images. The mutual information of the fused image is observed to be less. The edge features of source images are not recovered in the fused image due to the not shift invariant property of WT. The weighted average rule considered only the magnitudes of low frequency sub bands by which the fused image becomes phase sensitive.

To overcome the above mentioned problems, this work proposes a novel multimodal image fusion method using Contourlet transform (CT) and multiple features. First, this work performs CT on each source image to obtain low frequency coefficients and high-frequency coefficients. CT provides a richer scale space analysis for image compared to other Multi Scale Decomposition tools because it can decompose image into magnitude and phase information. Instead of a single feature, this work extracts three features for the fusion of low frequency subbands. The first one is based on the phase information of low frequency coefficient, which can be used to measure its clarity. The second one is the magnitude information of low frequency coefficient, which presents its energy information. The third one is the variance of spatial region corresponding to the low frequency coefficient, which is used to represent the salience of coefficient. Next, a choose-max fusion rule based on the contrast and energy of coefficient is proposed to integrate the high-frequency subbands. Finally, the final fused image is constructed by inverse CT.

Reminder of this paper is organized as follows; section II outlines the literature survey. The proposed approach details are described in section III. Simulation results are described in section IV and conclusions are given in section V.

II. LITERATURE SURVEY

Image fusion is a very important subtopic of image processing. Various image fusion methods have been discussed to reduce the blurring effects, and to enhance the quality features of the image. Related work based on image fusion started basically from mid –eighties. Now we would like to introduce literature survey on image fusion in a chronological order. Burt (1984) [1] Make use of the laplacian pyramid for efficient computation, he proposed the pyramid algorithms, which was widely used in image fusion Adleson (1987) [2] proposed a depth of focus imaging proposed method Lillquist (1988) [3] disclosed an apparatus for composite visible/thermal infrared imaging, same year Nandhakumar and Aggarwal [4] working on an approach for computer perception of outdoor scenes. In this approach information was extracted from thermal and visual images, and then valuable information is integrated.

Later Toet (1989) [5] introduces a hierarchical image combining technique.The composite images produced by this technique preserve those details from the input images that are most relevant to visual perception. Rogers et al. [6] worked on target segmentation in the same year using image fusion of LADAR and passive infrared images, this combination of processed LADAR and forward-looking infrared images can be used for object identification. Simultaneously Li and Chipman et al. [7] proposed the discrete wavelet transform (DWT) in image fusion. This paper describes an approach to image fusion using the wavelet transform. When images are combined in wavelet space, we can use different frequency ranges differently. Koren et al. (1995) [8] presented a steerable dyadic wavelet transform decomposition of multi-sensor images, the maximum local oriented energy is determined at every level of scale and spatial position. Waxman et al. [9] generated a real time fused combinations techniques. This paper describes how quality of image fusion gets effected .Li, H et al. (1995) [10] suggested that the wavelet transforms of the input images are appropriately combined, and the new image is obtained by taking the inverse wavelet transform of the wavelet coefficients fused after the rule of maximum selection of local base and a pitch of consistency check is used for feature selection.

O, R et al. (1997) [11] has discussed a novel approach for the fusion of spatially registered images and image sequences. The fusion method includes a shift invariant extension of the DWT, which yields an over complete signal representation. Same year Y-T, K et al. (1997) [12] has proposed a bi-histogram equalization for brightness preservation (BBHE) algorithm for contrast enhancement in an images. In this algorithm images is decomposed into two sub images based on the mean of the input image after that histogram equalization is applied to preserve the mean brightness of the given image. Qing Wang et al. (2004) [13] mainly discuss the structures of image fusion process, which is categorize as hierarchical, overall, and arbitrary fusion structure. Effects of such image fusion structures on the performances of image fusion are analyzed. He, D et al. [14] explained that the challenge in image fusion is to fuse two types of images by forming new images integrating both the spectral aspects of the low resolution images and the spatial aspects of the high resolution images. T.Zaveri, M et al. (2009) [15] proposed a new algorithm. Proposed algorithm is applied on large number of registered images and results are compared using fusion parameters. Malviya, B et al. [16] this paper presents pixel based and region based fusion schemes, including a wavelet based approach. An area-based maximum selection rule and the steps of checking consistency are used for feature selection. The performance evaluation was based on various objective metrics and the results are promising, comparable with existing algorithms. Susmitha Vekkot,P et al. [17] proposed a new architecture with a hybrid algorithm based pixel selection rules for maximum low frequency approximations fusion mask to filter high frequency detail wavelet decomposition is applied.

Pei, Y et al. (2010) [18] this paper proposes an improved discrete wavelet framework based image fusion algorithm, after studying the principles and features of the discrete wavelet framework. The enhancement is the careful consideration of the high frequency subband image region characteristic. Haghighat, M et al. [19] in the same year has explained that discrete cosine transformation (DCT) based methods of image fusion are more suitable and time-saving in real time system. In this paper an effective approach for fusion of multi-focus images based on variance calculated in DCT domain is presented. Lavanya, A. et al. (2011) [20] proposed a new image fusion method based on wavelet combined IHS and PCA transformations for remotely sensed lunar image data in order to extract features accurately. Same year Ghimire, D et al. [21] proposed a method to enhance the color images based on nonlinear transfer function and pixel neighborhood by preserving details.

III. FUSION MECHANISM

1. Contourlet Transform

Contourlet Transform form a multi-resolution directional tight frame designed to efficiently approximate images made of smooth regions separated by smooth boundaries. The contourlet transform has a fast implementation based on a Laplacian pyramid decomposition followed by directional filter banks applied on each band pass subband. The contourlet transform uses a double filter bank structure to get the smooth contours of images. In this double filter bank, the Laplacian pyramid (LP) is first used to capture the point discontinuities, and then a directional filter bank (DFB) is used to form those point discontinuities into linear structures. The Laplacian pyramid (LP) decomposition only produce one bandpass image in a multidimensional signal processing, that can avoid frequency scrambling. And directional filter bank (DFB) is only fit for high frequency since it will leak the low frequency of signals in its directional subbands. This is the reason to combine DFB with LP, which is multiscale decomposition and remove the low frequency. Therefore, image signals pass through LP subbands to get bandpass signals and pass those signals through DFB to capture the directional information of image. This double filter bank structure of combination of LP and DFB is also called as pyramid directional filter bank (PDFB), and this transform is approximate the original image by using basic contour, so it is also called discrete contourlet transform

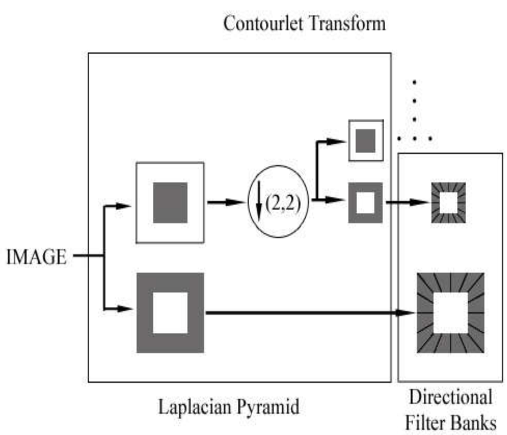


Figure.1 Schematic of Contourlet Transform

2. Fusion Framework

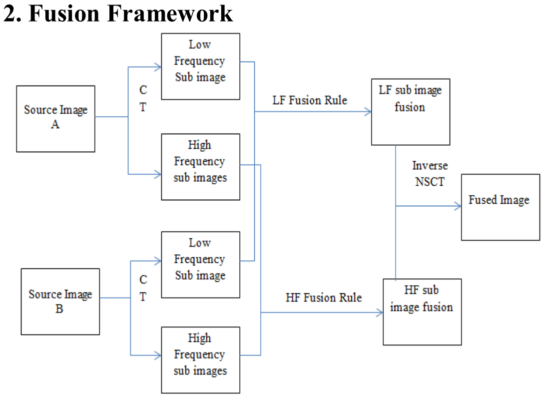


Figure.2 Proposed fusion framework

As can be seen from Fig.2, the fusion processing can be divided into three parts. In the first part, the source image A and B are decomposed by QWT into low frequency part and high frequency part. In the second part, the weighted average fusion rule and the choose-max fusion rule are proposed to fuse the low and high frequency coefficients respectively. Finally, the fused image is obtained by using inverse QWT. The detail fusion procedure is described as follows.

1) Assuming that the source images have been registered. QWT is performed on the two source images A and B to obtain low frequency part L_A^n, L_B^n and high frequency part $H_A^{l,d,n}$, $H_B^{l,d,n}$. L_A^{*} is the n-th low frequency subband, $H_*^{l,d,n}$ represent the n-th high frequency subband at level l in d direction.

2) The weighted average fusion rule based on multi-feature is proposed for low frequency parts, in which the multi-feature is proposed by the combination of the phase information of coefficient, the magnitude information of coefficient and the regional variance of image.

$$L_F^n(x,y) = L_A^n(x,y) \times w(x,y) + L_B^n(x,y) \times (1 - (w(x,y))) \qquad (1)$$

Where (x; y) is the location of coefficient and *w*(*x*; *y*) is the weight of coefficient. The calculation of weight *w*(*x*; *y*) is based on multi-feature of low frequency coefficient, which will be discussed in further sections.

3) The choose-max fusion rule based on multi-feature is designed to get the fused high frequency parts, in which the multi-feature $M_{*,l,d,n}^H(x,y)$ is obtained by combining the energy and local contrast of coefficient:

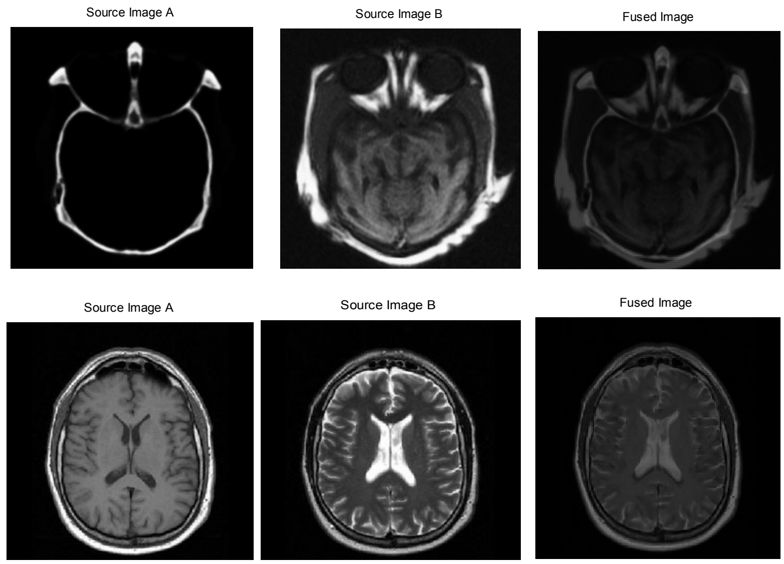
$$H_F^{l,d,n}(x,y) = \begin{cases} H_A^{l,d,n}(x,y), & \text{if } M_{A,l,d,n}^H(x,y) > M_{B,l,d,n}^H(x,y) \\ H_B^{l,d,n}(x,y), & \text{if } M_{A,l,d,n}^H(x,y) \le M_{B,l,d,n}^H(x,y) \end{cases} \qquad (1)$$

Where $M_{*,l,d,n}^H(x,y)$ are defined as the activity level measure of high frequency coefficient, which will be described in Further Sections.

4) The final fused image F can be obtained by inverse QWT over the fused low frequency coefficients L_F^n and the fused high frequency coefficients $H_F^{l,d,n}$.

IV. SIMULATION RESULTS

To verify the effectiveness of the proposed method in various types of source images, the experiments are conducted on different pairs of source images. They are multi-focus images, medical images, infrared-visible images and remote images downloaded from the homepage of Yu Liu [18]. The source images are decomposed into three levels in the above mentioned MSD based fusion methods. All parameters of comparison experiments are set according to the reference paper. All experiments are conducted with Matlab 2015b and run on a PC with a Pentium 3.5 GHz CPU and an 8GB RAM.



(a) (b) (c)

Figure.3 (a) Source imae A, (b) Source Image B, (c) Fused Image

Table.4.1 Objective Evaluation Metrics

Metric	Image set 1	Image set 2	Image set 3	Image set 4	Image set 5
AG	6.7328	9.4095	4.5659	5.5852	12.7244
EI	74.3371	76.6909	53.2226	74.9879	90.4396
MI	3.3965	5.8316	7.5975	7.7779	4.5539
SF	16.1812	11.5602	18.2471	10.9362	14.0247
QAB/F	0.8317	0.8320	0.8457	0.86632	0.8329

IV. CONCLUSION

Image fusion provides comprehensive information which advances the analysis and characterization of the image content in many different areas. In this paper, a novel image fusion method Using CT and multiple features is proposed. Compared to traditional MSD tools, the CT can provide abundant magnitude and phase information, which meet approximate translation invariance and limited redundancy. Different from the traditional fusion methods using a single feature as the activity level measure, we combine the magnitude, phase and spatial variance of low frequency coefficient into a comprehensive feature as the activity level measure of low frequency coefficient and combine the contrast and energy of high frequency coefficient into the other comprehensive feature as the activity level measure of high frequency coefficient. These two multi-features are reliable and robust, which are available for image fusion. Finally, the experimental results demonstrate the proposed method is effective in all kinds of image fusion.

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