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Gray Scale Image Fusion using Modified Contourlet Transform

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***Abstract*— The objective of image fusion is to combine information from multiple images of the same scene. The result of image fusion is a new image which is more suitable for human and machine perception or further image-processing tasks such as segmentation, feature extraction and object recognition. The major drawback of the contourlet transform is that its basic images are not localized in the frequency domain and less regularity in spatial domain. In the current, we analyse the cause of this problem, and propose a new contourlet construction as a solution. So, instead of using the Laplacian pyramid, we employ a new multi-scale decomposition defined in the frequency domain so that the resulting basis images are sharply localized in the frequency domain and exhibit smoothness along their main ridges in the spatial domain. It forms a multi resolution directional tight frame designed to efficiently approximate images made of smooth regions separated by smooth boundaries.**

***Keywords* → Activity Level Measurement, Basis Pursuit Denoising, Contourlet Transform, Discrete Wavelet Transform, Inverse Contourlet Transform.**

I. INTRODUCTION

Image fusion can be broadly defined as the process of combining multiple input images or some of their features into a single image without the introduction of distortion or loss of information. The fusion of images is often required for images which are acquired from different instrument modalities or capture techniques of the same scene or objects. Image fusion is the process by which two or more images are combined into a single image retaining the important features from each of the original images. Several approaches to image fusion can be distinguished, depending on whether the images are fused. The purpose of image fusion is to combine information from several different source images to one image which becomes reliable and much easier to be comprehended by people. The objective of image fusion is to combine complementary as well as redundant information from multiple images to create a fused output image. Therefore, the new image generated should contain a more accurate description of the scene than any of the individual sources image and is more suitable for human visual and machine perception or further image processing and analysis tasks.

In the following sections the process is defined. In the second section the contourlet transform is defined up to now. In the third section details of algorithm is explained briefly. Section four describes the analysis of performance evaluation. Section five shows the results in the tabular form of all the parameters. Section six concludes the results and analysis.

II. THE PRINCIPLE OF CONTOURLET TRANSFORM

A) Image Enhancement

Image enhancement is a more subjective process to improve image quality. In the process, the characteristics of interest in the images are made to stand out as much as possible in terms of people's feelings and experience, while suppressing unwanted characteristics. Its purpose is to improve the visual effects of the original images, and make them more suitable than the original image to a particular application. Image enhancement technologies include gray-scale modification, image smoothing, image sharpening, pseudo-colour image processing and so on. Among them, the gray-scale modification technique is simple and effective, and has been widely used in many fields, such as space exploration, remote sensing, biomedical, artificial intelligence, industrial detection and so on.

There exist the imaging sensor noise, imaging light scattering and other factors in the image acquisition process, which may make the resolution and contrast of the obtained images that hide some important information decline. Therefore, in order to get a richer picture which contains a large amount of information, the original image enhancement must be processed before image fusion. The traditional image enhancement algorithm can amplify the noise of the image, while improving image contrast and enhancing image details.

The contourlet transform was proposed as a directional multiresolution image representation that can efficiently capture and represent singularities along smooth object boundaries in natural images. Its efficient filter bank construction as well as low redundancy makes it an attractive computational framework for various image processing applications. Numerical experiments on image denoising show that the proposed new contourlet transform can significantly outperform the original transform both in terms of PSNR (by several dB's) and in visual quality, while with similar computational complexity.

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B) Contourlet Transform

For image enhancement, one needs to improve the visual quality of an image with minimal image distortion. Wavelet bases present some limitations, because they are not well adapted to the detection of highly anisotropic elements such as alignments in an image. Contourlet transform has better performance in representing the image salient features such as edges, lines, curves and contours than wavelet transform because of its anisotropy and directionality. It is therefore well-suited for multi- scale edge based colour image enhancement.

The contourlet transform consists of two steps which is the sub band decomposition and the directional transform. A Laplacian pyramid is first used to capture point discontinuities, then followed by directional filter banks to link point discontinuity into lineal structure. The overall result is an image expansion using basic elements like contour segments, thus the term contourlet transform being coined.Image fusion has brought remarkable attention over the last few years. Images with different specifications, such as resolution, spectral data, and spatial data, can be fused together to produce an image that contains the best features of the By analysing the characters of CT medical image, this paper proposes a novel method for this particular image fusion, which is using discrete wavelet transform and independent component analysis. By contrast, the efficiency of our method is better than weighted average, Laplacian pyramid method in medical image fusion field.. [5]

The low-frequency sub-bands (LFSs) are fused using the novel combined ALM, and the high-frequency sub-bands (HFSs) are fused according to their 'local average energy' of the neighbourhood of coefficients. Then inverse contourlet transform (ICNT) is applied to the fused coefficients to get the fused image. The performance of the proposed scheme is evaluated by various quantitative measures like Mutual Information (MI), Spatial Frequency (SF), and Entropy (EN) etc. Visual and quantitative analysis and comparisons show the effectiveness of the proposed scheme in fusing multimodality medical images.

III. OSTU ALGORITHM

The major drawback of the contourlet transform is that its basis images are not localized in the frequency domain and less regularity in spatial domain. In the current, we analyze the cause of this problem, and propose a new contourlet construction as a solution. So, instead of using the Laplacian pyramid, we employ a new multi-scale decomposition defined in the frequency domain so that the resulting basis images are sharply localized in the frequency domain and exhibit smoothness along their main ridges in the spatial domain. It forms a multi resolution directional tight frame designed to efficiently approximate images made of smooth regions separated by smooth boundaries.

A) Proposed Algorithm

The methodology of work will start with the overview of image fusion algorithms. The result of proposed algorithm will be interpreted on the basis of different quality metrics. Thus, the methodology for implementing the objectives can be summarized as follows:-

(a) Study of Image Fusion Techniques.
(b) Design and Implementation of Image Fusion based upon contourlet transformation using multiscale decomposition and improvement in Data filter bank (DFB)
(c) Check the developed Image fusion Technique on different images.
(d) Comparison with earlier proposed contourlet technique

B) Design and implementation

The Contourlet transform has a fast implementation based on a Laplacian Pyramid decomposition followed by directional filter banks applied on each band pass sub-band. Medical Image Fusion (MIF) method, based on a novel combined Activity Level Measurement (ALM) and Contourlet Transform (CNT) for spatially registered, multi-sensor, multi-resolution medical images. The source medical images are first decomposed by CNT. The low-frequency sub-bands (LFSs) are fused using the novel combined ALM and the high-frequency sub-bands (HFSs) are fused according to their 'local average energy' of the neighborhood of coefficients. Then inverse contourlet transform (ICNT) is applied to the fused coefficients to get the fused image. However, we will remove Laplacian Pyramid decomposition with the help of multi-scale sharp frequency localization to make image much smoother.

The design and implementation is explained in two sections: Contourlet based image fusion Process steps and Proposed Algorithm steps.

C) Contourlet Transform Process Steps:

The medical images to be fused must be registered to assure that the corresponding pixels are aligned. The steps that are followed by the Contourlet Transform Process are:

1) Decompose the registered source medical images A and B by CNT using Laplacian Pyramid decomposition to get the LFSs and HFSs.
2) Fused the coefficients of LFSs using the combined ALM to get the fused LFS.
3) Similarly to get the fused HFSs, fused the HFSs of the images A and B, according to their 'local average energy' of the neighbourhood of coefficients.
4) Apply inverse contourlet transform on the fused LFS and HFSs to get the final fused medical image.

D) Proposed algorithm steps:

The images to be fused must be registered to assure that the corresponding pixels are aligned. Here we outline the salient steps of the proposed Method which exclude the Laplacian Pyramid decomposition:

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(1) Decompose the registered source images A and B by multi-scale decomposition so that images are sharply localized in the frequency domain and exhibit smoothness along their main ridges in the spatial domain.

(2) Fused the coefficients of LFSs using the combined ALM to get the fused LFS.

(3) Similarly to get the fused HFSs, fused the HFSs of the images A and B, according to their 'local average energy' of the neighbourhood of coefficients.

(4) Apply inverse contourlet transform on the fused LFS and HFSs to get the final fused image F.


Fig.1.First image of aeroplane


Fig.2.Second image of aeroplane


Fig.3Fused image of two images

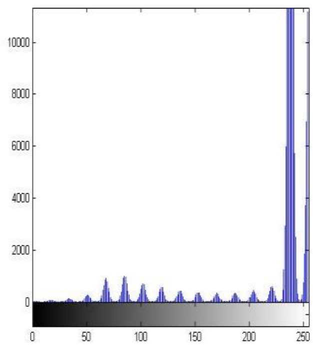

Fig.4.Histogram of first image

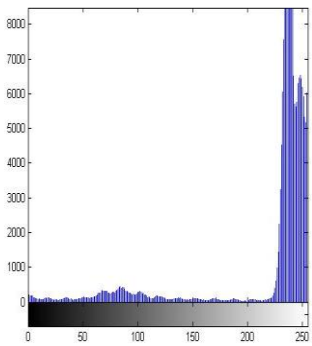

Fig.5.Histogram of Second image

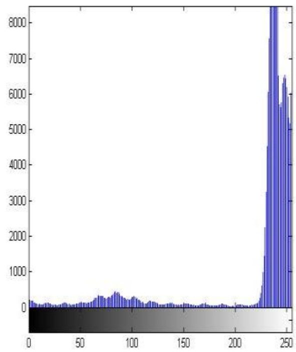

Fig.6Histogram of Fused image


Fig.7.First image of Cars


Fig.8Second image of Cars


Fig.9 Fused image of two images

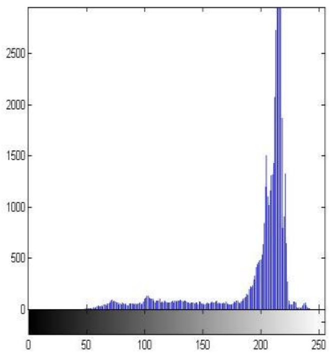

Fig.10.Histogram of First image

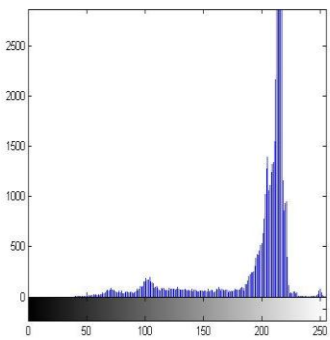

Fig.11.Histogram of Second image

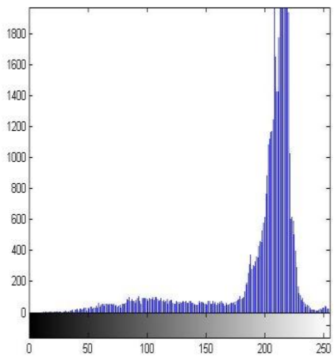

Fig.12.Fused image of two images

IV. PERFORMANCE EVALUATION

The fused image performance or properties are determined on the basis of following parameters:

A) Mean value

The mean value of an image with the size of m x n is defined as:

$$\mu = \frac{1}{m \times n} \sum_{j=1}^{n} \sum_{i=1}^{m} xij \qquad 4.1$$

Where $x_{i,j}$ denotes the gray level of a pixel with coordinate (i, j). The mean value represents the average intensity of an image.

B) Standard deviation.

The standard variation of an image is given by:

$$\Omega^2 = \frac{1}{m \times n} \sum_{j=1}^{n} \sum_{i=1}^{m} \left(xij - \mu \right)^2 \qquad 4.2$$

This corresponds to the degree of deviation between the gray levels and its mean value, for the overall image.

C) *Information entropy.*

The expression of the information entropy of an image is given by:

$$H = -\sum_{i=0}^{L-1} p_i 1np_i \qquad 4.3$$

Where L denotes the number of gray level, pi equals the ratio between the number of pixels whose gray value equals The information entropy measures the richness of information in an image. If pi is the const for an arbitrary gray level, it can be proved that the entropy will reach its maximum.

D) Spectral information

Three indicators describe spectral information of an image: bias index, correlation coefficient and wrapping degree.
Bias index The bias index is defined as Bindex:

$$B_{index} = \frac{1}{m \times n} \sum_{i=1}^{m} \sum_{j=1}^{n} \frac{\left| x_{ij} - x'_{ij} \right|}{x_{ij}} \qquad 4.4$$

Where $x_{i,j}$ and $x'_{i;j}$ represent the pixels of the original image and the fused image, respectively. The index checks the degree of the biased intensity between the low-resolution image and the fused image. The greater the value, larger is the deviation.

E) Wrapping degree.

Warping degree represents the level of optical spectral distortion of a multispectral image. Its formula is

$$W = \frac{1}{m \times n} \sum_{i=1}^{m} \sum_{j=1}^{n} \left| x_{ij} - x'_{ij} \right| \qquad 4.5$$

Where $x_{i,j}$ and $x'_{i;j}$ denote the element of the original image and the fused image. The degree of distortion increases, when W increases

V. RESULTS

The proposed algorithm has been tested on images shown in fig. 1,2,7 and 8 and the fused images are shown in fig. 3 and 9. The Result tables for evaluating performance of the algorithm are given in tables below:

Table 1. Parameters value Comparison of First,Second and fused image of aeroplanes

Figure	**Parameters**				
	Mean value	**Standard Deviation**	**Information Entropy**	**Bias Index**	**Wrapping degree**
1	226.77	18.23	0.04	2096.12	5.36
2	227.02	17.98	0.14	3200.57	7.19
3	225.49	14.66	0.24	1758.25	4.89

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Table 2. Parameters value Comparison of First,Second and fused image of Cars

Figure	**Parameters**				
	Mean value	**Standard Deviation**	**Information Entropy**	**Bias Index**	**Wrapping degree**
4	201.80	17.20	2.025	2543.60	6.19
5	200.00	43.00	2.078	2003.97	4.92
6	199.60	27.60	2.154	1987.32	4.25

The above first table represents the parameter value comparison of First image of aeroplane,Second image of aeroplane and fused image of aeroplane. Second table represents the parameter value comparison of First image of Cars,Second image of Cars and fused image of Cars. Five Parameters Mean value, Standard Deviation,Information Entropy, Bia Index and Wrapping Degree expressed individually.

VI. CONCLUSION

Multi-sensor image fusion seeks to combine information from different images to obtain more inferences than can be derived from a single sensor. It is widely recognized as an efficient tool for improving overall performance in image based application. The spectral quality of the images is preserved better than using the other approaches. The reason that we can find more spatial detail from the fused composite images is that many mixed pixels in the original composite image are decomposed into many different categories in a fused image with the improvement of the spatial resolution. The work done in this paper forms the basis for further research in contourlet based fusion and other methods which integrate the fusion algorithms in a single image. The novel algorithm presented here gives promising results in all test cases and can be further extended to all types of images by using different averaging, high-pass and low-pass filter masks.

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