

Performance of Contourlet Transform in Satellite Images Using Image Fusion

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ABSTRACT: The satellite images like Google maps, military surveillances, remote sensing images like navigation and to identify the hidden objects etc., were in need of high precision images in order to improve the quality of images there are tremendous number of methods however the research is in progress to improve the quality of images in various ways. In this paper we implement a method to improve the blurring of edges in the images which improves the quality metrics of satellite image. This paper discusses the different forms of edge detection algorithm and compares the quality metrics of images. This method can also used in various application like medical imaging, robotics, agricultural etc., but we concentrate on remote sensing images. Image fusion concept is used along with the contourlet transform to improve the resolution of images in edges, curves.

KEYWORDS: quality metrics, edge detection algorithm, contourlet transform.

I. INTRODUCTION

The field of remote sensing is increasing rapidly in numerous applications like observation of earth and vegetation mapping. The sensors launched on the satellites provide a variety of images with different specifications. Therefore, it is required to introduce an efficient technique that integrates the output of two or more sensors and produces more accurate images to meet the requirements of remote sensing applications including: environmental change detection agricultural monitoring and urban planning. Therefore, image fusion is a promising research area in the image-based application fields. The aim of the paper is to produce a single image from set of images using Contourlet transform. Considerable progress has been made in the fusion of images from different imaging modalities using software approaches. One goal of fusion software is to align anatomical and functional images and allow improved spatial localization of abnormalities. The software part is using MATLAB for fusing images.

The purpose of this thesis is to present a novel image fusion technique which could be applied to various domains, but focuses on the fusion of remote sensing images. The goal of this technique is to fuse the PAN image and MS image with RGB band separation. The second objective is to perform HIS transformation of MS image and fused with the PAN image to obtain high resolution image. The third objective is to calculate the entropy for both MS image and fused image and to obtain the standard deviation for both MS image and fused image. Finally, comparing all the parameters and to improve the remote sensing image resolution.

II. THEORY OF IMAGE FUSION

Image Fusion is a process of combining the relevant information from a set of images of the same scene, into a single image, wherein the resultant fused image will be more informative and complete than any of the input images. Input images could be multi sensor, multimodal, multifocal or multi temporal. One of the goals of image fusion is to create a single enhanced image more suitable for the purpose of human visual perception, object detection and target recognition.

Image fusion find application in the area of navigation guidance, object detection and recognition, medical diagnosis, satellite imaging for remote sensing, rob vision, military and civilian surveillance, etc. Image fusion systems are widely used in surveillance and navigation applications, for both military and domestic purposes. The following figure 1 illustrates the various methods of image fusion techniques.

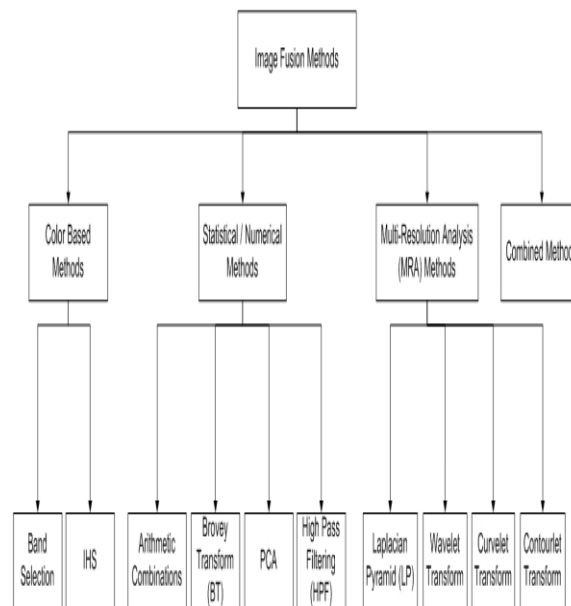


Figure 1: Evolutions of Fusion Techniques

III. EXISTING METHOD

Wavelet transform is applied to obtain high resolution satellite images. The wavelet transform is computed separately for different segments of the time-domain signal at different frequencies. Multi-resolution analysis analyzes the signal at different frequencies giving different resolutions. MRA is designed to give good time resolution and poor frequency resolution at high frequencies and good frequency resolution and poor time resolution at low frequencies. Good for signal having high frequency components for short durations and low frequency components for long duration. e.g. images and video frames. However the resulting image is not improving the resolution in the curves and edges. In order to improve the resolution in the curves and edges the edge detecting algorithm i.e, contourlet transform is used.

Wavelet Based Algorithm

- 1) Apply wavelet transformation separately to each source image to establish various images of wavelet tower shaped transformation.
- 2) Fuse images at each transformation level.
- 3) Apply inverse Wavelet Transform on fused wavelet pyramid.

IV. CONTOURLET TRANSFORM

The Contourlet Transform (CT) is a new image decomposition scheme. CT is more effective in representing smooth contours in different directions of an image than the Discrete Wavelet Transform. The Contourlet Transform consists of two steps which is the sub band decomposition and the directional transform as shown in figure 2. A Laplacian Pyramid is first used to capture point discontinuities, then followed by directional filter banks to link point discontinuity into linear structure.

In 2005 Do et al. [1] introduced a new two-dimensional transform named Contourlets. This new transform is based on using the Laplacian pyramid to capture the point discontinuities from the image. The directional filter bank is then used to link these points into contours [2]. There are many differences between the contourlet transform and the curvelet transform. The contourlet transform is flexible in choosing the number of directions at every decomposition level. Also, according to Do [2], the contourlet transform is almost critically sampled and the redundancy factor is 1.33. This redundancy factor is smaller than the curvelet transform's redundancy factor [3]. This contourlet transform is good for constructing a multi-directional and multiresolution sub-signals or sub-images. As a result of the high directionality of the Contourlet transform, it is utilized in many image fusion techniques. Most of these techniques are pixel-based [4-8] where the fusion decision is dealing with pixels in the input images. Some of these techniques are designed to merge medical images. Other techniques are utilized for pan-sharpening in remote sensing applications. Tang et al. [9] introduced a new fusion technique based on combining both wavelet and contourlet transform. Shah et al. [10] designed a procedure that utilizes a combined adaptive PCA with the contourlet transform for pan-sharpening. AL-Ejaily et al. [11] designed a fusion method that combines the IHS and the contourlet transform. This fusion method utilizes the IHS color system to separate the color information in order to maintain the original.

The main difference between Contourlet and other multiscale directional systems is that the contourlet transform allows for different and flexible number of directions at each scale, while achieving nearly critical sampling. In addition, the contourlet transform uses iterated filter banks, which makes it computationally efficient; specifically, it requires $O(N)$ operations for an N -pixel image.

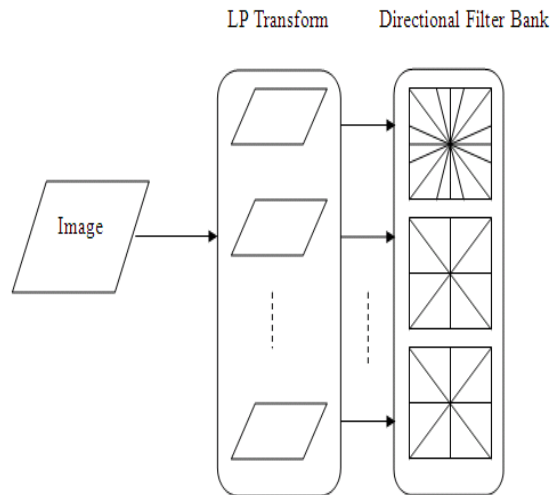


Figure 2 Contourlet Transform

Laplacian Pyramid:

A Laplacian Pyramid (LP) decomposition into low pass image and band pass image by LP decomposition. Each band pass image is further decomposed by DFB step. A DFB is designed to capture the high frequency content like smooth contours and directional edges. Multi-resolution and multi directional decomposition can be obtained by repeating the same steps mentioned for the low pass image.

In the above figure when the image is given to the DFB, first the image is decomposed by using Laplacian pyramid and then that image is given to the directional filter bank for directional decomposition. Here in Laplacian pyramid at every level the image is halved and the sampling rate was doubled. Depending upon the given image we can choose the number of level in LP stage and DFB stage.

The following are the properties provided by the contourlet transform

- ❖ Multiresolution
- ❖ Localization
- ❖ Critical sampling
- ❖ Directionality
- ❖ Anisotropy

V. PROPOSED METHOD

The purpose of this method is images. The goal of this technique is to fuse the PAN image and MS image with RGB band separation. The second objective is to perform HIS transformation of MS image and fused with the PAN image to obtain high resolution image. The third objective is to calculate the entropy for both MS image and fused image and to obtain the standard deviation for both MS image and fused image. Finally, comparing all the parameters and to improve the remote sensing image resolution. First goal is to perform RGB transformation for the given MS image and applying it to the contourlet transform. Histogram matching is performed for the PAN image in order to obtain stretched PAN image. Fusing both the stretched PAN and MS image and applying inverse Contourlet transform to obtain highresolution fused image. Corresponding Entropy value for MS image and fused image is obtained for performance measure. In similar way the standard deviation for both the MS image and fused image is calculated by calling the corresponding function in MATLAB to perform the manipulation. The figure3 shows the proposed system architecture.

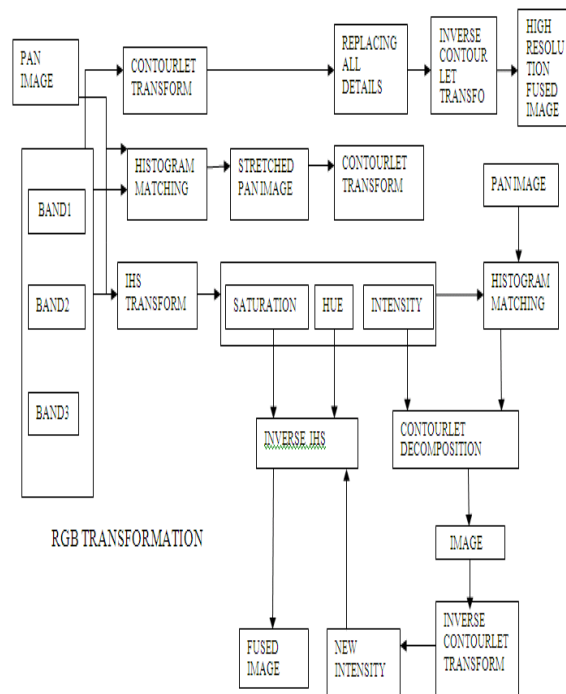


Figure 3 - system architecture

Second objective is to perform RGB to HIS transformation and fusing the stretched PAN image with the HIS transformed image applying through the Contourlet transform, Contourlet decomposition and taking inverse Contourlet transform to obtain the fused high resolution image. Entropy value for MS image and fused image is obtained for performance measure.

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Finally comparing the image obtained from the two algorithms is compared to evaluate the resolution of the given image and the corresponding entropy and standard deviation values should compare.

VI. SIMULATION RESULTS

The following figure illustrates the simulation result for RGB Transformation.

Steps for simulation: First choose PAN image and next step is to choose the corresponding MS band image. The simulation result for the selected image is shown in the figure 4.

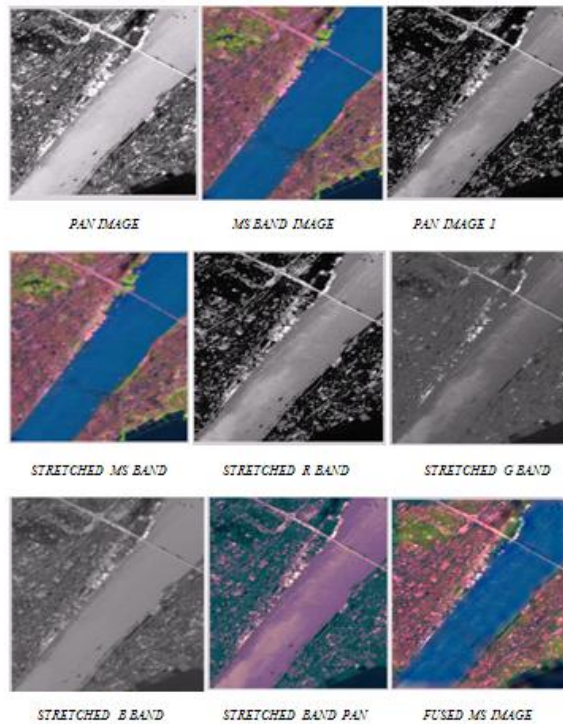


Figure 4- simulation result

Quality Metrics		Values for image input1	Values for image input2
correlation		0.3611	0.3215
Standard deviation	MS image	7.9690	7.1520
	Fused image	8.6553	7.9122
Entropy	MS image	6.8827	6.2352
	Fused image	7.0708	7.6253
Entropy factor		0.1881	0.1458

Table 1 – Quality metrics of given different images

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The presented image fusion technique was successfully used to fuse traditional and remote sensing images and to detect hidden objects for security purposes. Therefore, this technique may be used in different applications (i.e., industrial or agricultural, and medical image fusion applications). Therefore, the algorithm should be modified to suit the chosen application. For example, multiple medical images could be used for better diagnostic. The fusion of multiple images of a specific industrial product can help in making right decisions about the product quality.

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