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Wavelet Fusion on Ratio Images for Change Detection in SAR Images

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Abstract—Image Fusion is the technique which merges or combines the information from multiple resolution images of the same scenario. As the different resolution images of same scenario contains different information. The output of fusion image is a separate new image that retains the most desirable information of each image. The main application of fusion image is in merging of the high resolution images like gray-level image and the low resolution images like colored multispectral image. It has been found that the fusion method is more useful for spatially but usually introduce spectral distortion. So to overcome this problem, many multiscale transform based fusion scheme proposed. In this paper, we focus on the fusion methods based on the discrete wavelet transform (DWT) and change detection methods.

IndexTerms—Image fusion,panchromatic image,spectral distortion,the discrete wavelet transform.

I. INTRODUCTION

Image fusion is the process of combining information from two or more images of a scene into a single composite image that is more informative and is more suitable for visual perception or computer processing. The objective in image fusion is to reduce uncertainty and minimize redundancy in the output while maximizing relevant information particular to an application or task. Given the same set of input images, different fused images may be created depending on the specific application and what is considered relevant information.There are several benefits inusing image fusion: wider spatial and temporal coverage, decreased uncertainty, improved reliability, and increased robustness of system performance.Often a single sensor cannot produce a complete representation of a scene. Visible images provide spectral and spatial details, and if a target has the same color and spatial characteristics as its background, it cannot be distinguishedfrom the background. If visible images are fused with thermal images, a target that is warmer or colder than its background can be easily identified, even when its color and spatial details are similar to those of its background. Fused images can provide information that sometimes cannot be observed in the individual input images. Successful image fusion significantly reduces the amount of data to be viewed or processed without significantly reducing the amount of relevant information.

In the context of multitemporal SAR-image change detectionanalysis, as mentioned in the literature [2], [4], [5], the ratiooperator is the most widely used technique to generate differenceimage (DI) The ratio operator is usually expressed in algorithmic or mean scale because of the multiplicative natureof speckle. In the past decade, there is a widespread concernover the logarithm of ratio image since it can transform themultiplicative speckle noise into an additive noise component.In [5], the authors proposed a ratio mean detector, which isrobust to speckle noise. This detector assumes that a changein the scene will appear as a modification of the local meanvalue of the image. Both methods have yielded effective resultsfor change detection in SAR images but still have some disadvantages:The logarithmic scale is characterized by enhancingthe low-intensity pixels while weakening the pixels in the areasof high-intensity since it compresses the range of variation ofthe ratio image [3]. Hence, the information of changed regionsobtained by the log-ratio image may not be able to reflect thereal changed trends in the maximum extent. Moreover, if thechange preserves the mean value but modifies the local texture,the mean-ratio detector may fail to detect changes since itassumes that a change in the scene will appear as a modificationof the local mean value of the image [5].

In order to address the problem previously mentioned, thisletter presents a fusion algorithm to generate DI based ondiscrete wavelet transform (DWT). To the best of the authors'knowledge, most of the existing multiresolution fusion techniquesperform suitably well with medium-resolution SARimages. For example, in [6], a wavelet-based fusion algorithmfor unsupervised change detection in medium-resolution SARimages has been proposed to produce the final change detectionmap. As mentioned in the literature [4], the information ofchanged regions reflected by mean-ratio image is relative inaccordance with the real changed trends in multitemporal SARimages. On the other hand, the information of the backgroundobtained by the log-ratio image is relatively flat on the accountof the logarithmic transformation. Hence, it is an attractiveidea that the new DI fused by mean-ratio and log-ratio imagesmay acquire better information content than the individualDIs. In general, the underlying idea of the optimal DI is thatunchanged pixels exhibit small values, whereas changed areasexhibit larger values. Moreover, the change detection task isusually considered as a two-class decision process [7]. Hence,the proposed fusion method attempts to restrain the background(Unchanged regions) and enhance the changed regions in thegreatest extent.

II. PROPOSED METHOD

A. Wavelet Based Image Fusion

Image Fusion produces a single image by combining information from a set of source images together, using pixel, feature or decision level techniques. The fused image contains greater information content for the scene than any one of the individual image sources alone. The reliability and overall detail of the image is increased, because of the addition of analogous and complementary information. Image fusion requires that images be registered first before they are fused.
Image fusion of multi-temporal and multi-sensor images is of considerable importance to earth and space observation applications, such as environmental, agricultural and maritime monitoring. Satellites sensors alone often cannot offer the necessary spatial resolution required for certain applications. Fusion of multiple temporal satellite images is used for resolution enhancement, creating a single high-resolution image. Depending on the numberof input images, the resolution can be enhanced *2 to 5* times using fusion algorithms.

In a multi-sensor environment, pixel level fusion can generate a fused image that provides the best description of a scene. Each sensor provides complementary information that can be combined together into a fused image. Fused images can be used by other algorithms for further processing, such as for target detection or tracking. Fused images are also ideal for human end users, who cannot easily visualize and combine the results from multiple sensors.

The block diagram of a generic wavelet-based image fusion scheme is shown in the following figure:

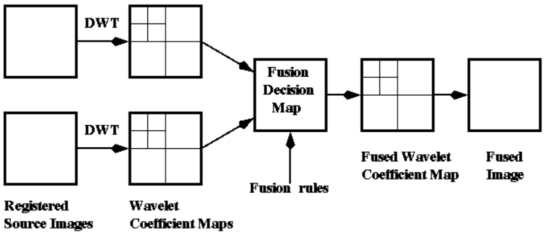

Fig. 1. wavelet based image fusion scheme

Wavelet transform is first performed on each source images, and then a fusion decision map is generated based on a set of fusion rules. The fused wavelet coefficient map can be constructed from the wavelet coefficients of the source images according to the fusion decision map. Finally the fused image is obtained by performing the inverse wavelet transform.Please find below example that shows Image Fusion for AVIRIS and RADARSAT data.

The two input images are from two different sensors: AVIRIS and RADARSAT. Although they depict the same region, each image contains complementary information. The fused image combines the details from both images.

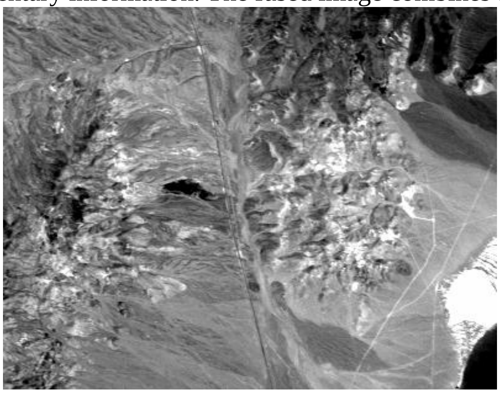

Fig. 2. AVIRIS image (band 183)

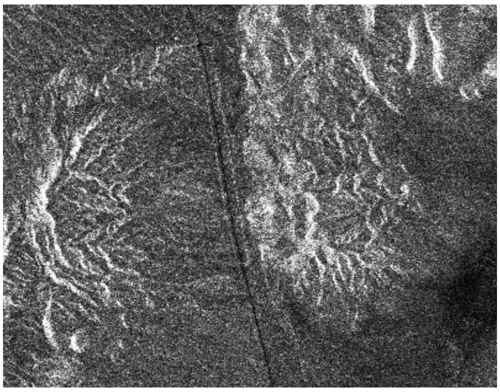

Fig. 3. High resolution RADARSAT image

The fused image, using the Shift Invariant Wavelet Transform method is shown below,

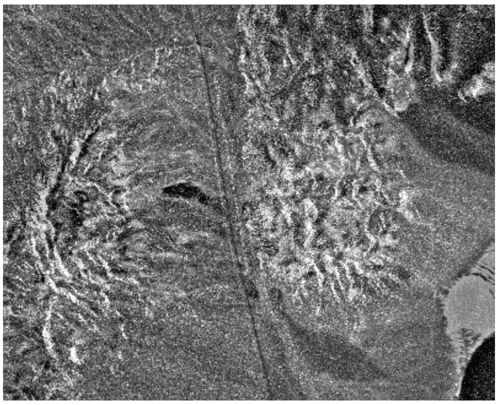

Fig. 4. Fused Image

B. Change Detection

Change detection algorithms analyze multiple images of the same scene – taken at different times – to identify regions of change (changes of water, land etc). The ability to detect regions of change in images is a powerful tool that can be used in a diverse range of applications including military surveillance, environmental baseline monitoring, land use change analysis, crop stress detection, assessment of deforestation, disaster management (e.g., monitoring of changes during flooding), ice monitoring, medical diagnosis and treatment, and urban planning.

The objective of change detection algorithms is to take a set of images of the same scene taken at different times and identify the pixels that are different between the images. A key issue is the determination of thresholds for identifying when a significant change of interest has occurred. The requirements for the sensitivity of the change detection are based on the application and data. Another key issue is that changes resulting from noise, sensor motion, variances in lighting, atmospheric effects and other similar factors should not be included in the changes identified by the algorithm. Changes that are of interest typically result from the appearance, disappearance, motion or change in the shape of a target object. Objects can also change in brightness or colour. Each application may have a different type of changes that it is would be of significance.

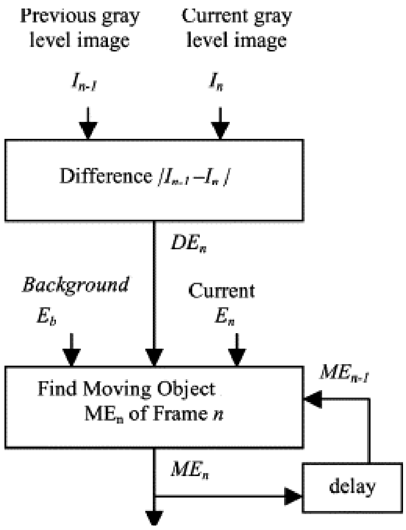

Fig. 5. Change Detection Scheme

Please find below example that shows the change detection in the two images captures at different times.

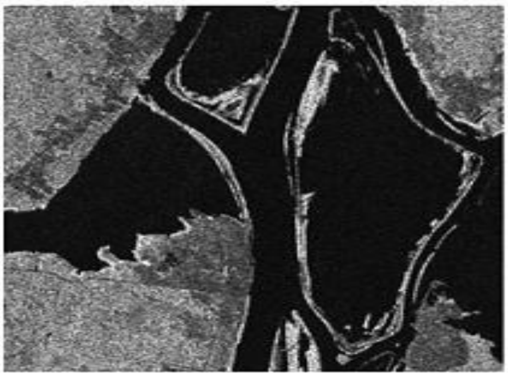

Fig. 6. RADARSAT May Month image

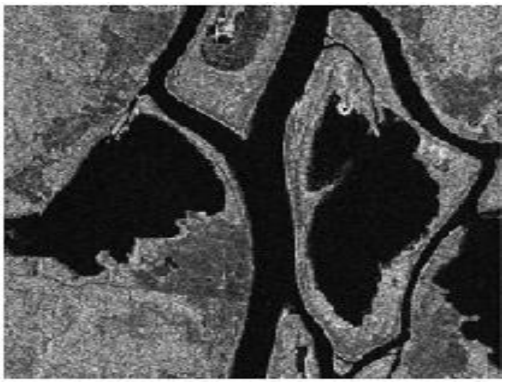

Fig. 7. RADARSAT August Month image

Fig. 8. Change Detection of Land

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