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Study on Image Fusion & Methods of Fusion in Satellite Imagery

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ABSTRACT

In this paper, we present an overview and in depth study on Image Fusion & Categories and methods in Satellite Imagery. The image fusion is that the multiple images which obtains from a sensor or many sensors synthesizes an image, in which the information from the multiple primitive images can be reflected so as to analyze and judge the target more precisely and comprehensively. Because both the images gain from multi-sensors have the redundancy and the complement, the multi-sensor image fusion technology may enhance the reliability of the system and also enhance the use efficiency of the pictorial information. We review & discuss various Categories and Methods of Fusion & suggest which one is appropriate in given circumstances.

Keywords :- Image Fusion, Satellite Imagery, Resolution

I. Introduction

The field of remote sensing is a continuously growing market with applications like meteorology, agriculture, geology, forestry, landscape, biodiversity conservation, regional planning, education, intelligence and warfare and observation of the environment. The increase in applications is due to the availability of high quality images for a reasonable price and improved computation power. However, as a result of the demand for higher classification accuracy and the need in enhanced positioning precision (e.g. for geoscience information systems) there is always a need to improve the spectral and spatial resolution of remotely sensed imagery. These requirements can be either fulfilled by building new satellites with a superior resolution power, or by the utilisation of image processing techniques. The main advantage of the second alternative is the significantly lower expense. One of the technique to improve quality of high resolution image is IMAGE FUSION.[5]

II. Image Fusion

The human eye is sensitive to a limited range of the electromagnetic spectrum as well as to low light intensity. In order to answer the need for obtaining data that can not be sensed by the eye, one can use sensor data such as thermal sensors or image intensifier night time sensors. In certain tasks, the human observer needs data from multiple sensors. For example, using the visual channel as well as the thermal channel can substantially improve the ability to detect a target (Toet et al., 1997). When the target is cold (early morning, rain) the contrast between the target and the background is larger in the visual channel then in the thermal channel, resulting in higher detection in the visible channel. On the other hand, it is hard to detect a hidden target in the visual channel, yet the difference between the target's thermal signature and its surroundings may ease its detection in the thermal channel.

According to Toet (1992), the simultaneous use of different sensors in different displays increases the operator workload. It is difficult to reliably integrate the visual information from different displays, both in a spatial display which puts the display of each sensor side by side, and in a sequential display which shows the displays one after another. Recognizing relationships among patterns can be difficult, since an object can appear quite differently in the different sensor displays. A solution for this problem is to display the different sensor data using one display, combining the data using a process which is called sensor or image fusion.

Another potential advantage of image fusion is to provide scene information not present in the input bands. By deriving information based on the differences between the input images, information not presented in the input bands can be shown in the fused image. (Sinai et al. 1999 dp1).

Image fusion refers to the process of combining the signals provided by different sensors of the same image in one display. Image fusion tends to improve the reliability of the images using the redundant information between the different images and to improve the capability by using the complementary information between the images. This type of image fusion is also called pixel-level multi-sensor fusion (Luo et al. 2002). The sensors used for image fusion need to be accurately co-aligned so that their images will be in spatial registration.

Our goal in image fusion is to combine and preserve in a single image, all the perceptually important information that is present in the input images, so that the resulting image will be more suitable for the purpose of human visual perception, object detection, and target recognition

III. Satellite Imagery

All satellite images produced by NASA are published byEarth Observatory and are freely available to the public. Several other countries have satellite imaging programs, and a collaborative European effort launched the ERS and ENVISAT satellites carrying various sensors. There are also private companies that provide commercial satellite imagery. In the early 21st century satellite imagery became widely available when affordable, easy to use software with access to satellite imagery databases was offered by several companies and organizations.

a. RESOLUTION and DATA

There are four types of resolution when discussing satellite imagery in remote sensing: spatial, spectral, temporal, and radiometric. The resolution of satellite images varies depending on the instrument used and the altitude of the satellite's orbit.

b. Multispectral images

Multispectral images are images from two or more discrete bands of the electromagnetic spectrum. Each individual image is of the same scene and resolution, but of a different spectral band. For example, a digital camera can capture three separate images from the electromagnetic spectrum: red, green and blue. Later, they are combined to form a single RGB image. The bands of a multispectral image can be from the visible or non-visible wavelength of the spectrum. This technique can provide an optical spectrum of each pixel of the image. Image processing techniques can then be applied to extract the required data from the image.

Objects of different materials normally have unique spectral signatures. In other words, different objects will reflect and absorb light differently. Thus, we can define a spectral signature for each type of object in the scene. In this way, we can use the fusion of multispectral images to enhance the view of objects of interest in the scene.

Another application of multispectral data is automatic target recognition. Computers are able to quickly and efficiently segment and analyze images when based both on their brightness and on their spectral signatures (Caefer et al. 2002). Point targets become clear when matched target algorithms and anomaly detection algorithms (Raviv and Rotman, 2003) are applied.

c. Panchromatic Image

Is a type of black-and-white photographic image that is sensitive to all wavelengths of visible light only.

Digital panchromatic imagery of the Earth's surface is also produced by some modern satellites, such as QuickBird and IKONOS. This imagery is extremely useful, as it is generally of a much higher (spatial) resolution than the multispectral imagery from the same satellite. For example, the QuickBird satellite produces panchromatic imagery having a pixel equivalent to an area 0.6m x 0.6m, while the multispectral pixels represent an area of 2.4m x 2.4m.

IV . Categories and Methods of FUSION

A multispectral image or different sensor images can be fused using various methods. These can be divided into categories: pixel level, data level or feature level fusion and decision level fusion. Our study, like most studies today, focuses on the pixel level fusion.

a. Pixel level fusion

On this level, the input images are fused together on the pixel level. Methods using this level either use arithmetic operations (like addition, subtraction) on corresponding pixel intensity from different input images or use the frequency domain. Using the frequency domain, the input images are first transformed in the frequency domain using various pyramid based methods like Laplacian, or Wavelet transforms. After transformation, algebraic operations are performed on the input images fusing them to one image. Then, that image is inverse transformed to the final fused image.

b. Feature level fusion

At the feature level, features from the input images will be first extracted, and then fusion will be done based on these features. The typical algorithms used are feature-based template methods (like edge enhancement), Artificial Neural Networks, and knowledge based approaches.

c. Decision Level Fusion

In decision level fusion first the features are extracted from each input. Then a decision is made on each input, and only then the decisions are fused to a final decision.

- **Methods of Image Fusion**

In this part the most common methods of fusion are described.

(1)Multiscale Decomposition based methods [3]

Multiscale transforms are very useful for analyzing the information content of images for the purpose of fusion.[3] discuss the different multiscale image fusion approaches in detail. Most of the methods combine the multiscale decomposition of the source images. Most commonly used multiscale decomposition fusion methods are pyramid transforms and wavelet transforms.

(2)Pyramid transforms

Pyramid transforms can be used as a multiscale transform for the fusion process. A pyramid transform fusion consists of a number of images at different scales which together represent the original image. An example for a pyramid transform is the Laplacian Pyramid. Each level of the Laplacian Pyramid is constructed from its lower level using blurring, size reduction, interpolation and differencing in this order [3]. Toet and Franken (2003) [4] used a Laplacian Pyramid fusion to fuse infrared and image intensified images. They say that as a side effect of this method details in the resulting fused images can be displayed at higher contrast than they appear in the images from which they originate. Alternative pyramid transforms are contrast pyramid which preserves local luminance contrast in the sensor images (Toet 1990), and gradient pyramids which applies the gradient operator on each level of the Gausian pyramid representation (Burt and Kolezynski, 1993).

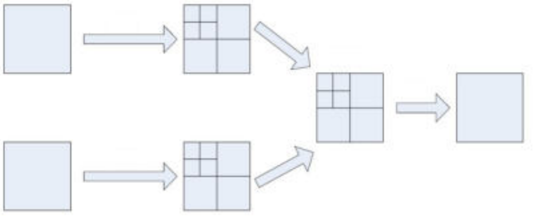

Figure 1 – Diagram of a generic multiscale decomposition fusion.

(3)Discrete Wavelet transform[3]

Wavelets are a type of multi-resolution function approximation that allow for the hierarchical decomposition of a signal or an image. The Wavelet transform is a useful method to fuse images (Scheunders and Backer 2001, Gomez et al. 2001, Zhang and Blum 1999, Singh et al, 2004). The wavelet transform has several advantages over other pyramid-based transforms: It provides a more compact presentation, separates spatial orientation in different bands, and decorrelates interesting attributes in the original image.

Using the Wavelet transformation, the source images are first transformed using the wavelet transform. Then, a fusion decision map is generated based on a set of fusion rules. The fused wavelet coefficients can be built from the source images wavelet coefficients using the decision map. Finally, the fused image is obtained using the inverse wavelet transform.

(4)Principal Component Transform Fusion

PCA (Principal Component Analysis) is a general statistical technique that transforms multivariate data with correlated variables into one with uncorrelated variables. These new variables are obtained as linear combination of the original variables. PCA has been widely used in image encoding, image data compression, image enhancement and image fusion. When this technique is used in image fusion, it is performed on the images with all its spectral bands. William Krebs has used this method in many of his experiments (Krebs and Sinai, 2002, McCarley and Krebs, 2000, Krebs et al., 2001).

(5)False color

A simple fusion method introduced by Alexander Toet (Toet and Walraven, 1996) and used frequently (Toet and Franken, 2003, McCarley and Krebs 2000) tries to utilize the ability of the human visual system to perceive color. The method assigns each band of the input image to a corresponding band in an RGB color image, assigning one band to the R channel, a second band to the B channel and the third band to the G channel. This will work if we are merging three images. If trying to merge two images, then one image can be assigned to both the B and G channel (cyan) while the other image will be assigned to the R channel. Some manipulation can be done on the input images before assigning them to the RGB bands. Toet and Franken (2003) have shown that this method is better for human perception and target detection than a normal contrast enhancement method.

IV. Conclusion

We have presented an overview & study on Image Fusion & Categories and methods in Satellite Imagery. Various methods are discussed and compared, it seems False color method is better among all.

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