A Survey Of Fusion Of Remote Sensing Images To Avoid Spectral Distortion

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Abstract

Nowadays spectral distortion is one of the important problem in the fusion of remote sensing images. Earth observation satellites such as IKONOS and Quick Bird imagery provide multispectral (MS) and panchromatic (PAN) data that have different spatial, spectral, temporal, and radiometric resolutions. The fusion of a PAN image that has high spatial resolution but low spectral resolutions with MS image is the key issue in many remote sensing applications that require both high spatial and high spectral resolutions. The fused image provide feature enhancement and increase the accuracy . In the previous studies IHS, GIHS, FIHS, methods are used for fusing the images. Sometimes they produce unnatural colors in the vegetation areas. This survey deals with IHS based fusion methods and a new fusion approach that produces images with natural colors.

1. Introduction

The term fusion means the extraction of information acquired in several domains. The goal of image fusion (IF) is to integrate complementary multi-sensor, multi-temporal and multi-view information into one new image containing the quality of information which cannot be achieved. Image fusion has been used in various application areas. In remote sensing and in astronomy, multisensory fusion is used to achieve high spatial resolution and spectral resolutions by combining images from two sensors, one of which has high spatial resolution and the other one has high spectral resolution.

Remote Sensing systems, particularly those deployed on satellites, which provide a repetitive and consistent view of the Earth. To meet the needs of different remote sensing applications the systems offers a high range of spatial, spectral, radiometric and temporal resolutions. Satellites may take several images from frequency bands in the visual and non-visual range. Each monochrome image is referred as a band and a collection of several bands of the same scene acquired by a single sensor is called Multispectral Image (MS). The spectral resolution and spatial resolutions have an inverse relationship. Therefore, a high spectral resolution results in a low spatial resolution and vice versa. Hence, there is an increasing use of image processing techniques to fuse the MS and PAN images. These image processing techniques are called as pan-sharpening or resolution fusion techniques.

The Intensity-Hue-Saturation (IHS) approach is the most widely used in practical applications [4]. This technique is suitable when exactly three MS bands such as R, G, B are concerned. When more than three bands are available, a good solution is to use all the MS bands located within the PAN band, particularly the Near Infrared (NIR) band. A fast IHS (FIHS) transform for three bands and a generalized IHS (GIHS) transform four bands such as R,G,B, an the NIR band in the computation of the intensity component (I). Aside from its fast computing capability for fusing images, the fast IHS transform method can extend the traditional three-order transformations to an arbitrary order. FIHS fusion also reduce color distortion in the same way as the traditional IHS fusion technique. Various methods, like fast IHS in [5] and generalized IHS [7] and the spectral adjusted IHS developed in [3], were proposed in order to improve the fusion based on the IHS transform. These methods make use of the spectral characteristics of the sensors in the fusion process, that is, the I(Intensity) component which is obtained by weighting the MS bands according to their spectral responses. For vegetation visualization applications, recent methods make use of vegetation

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enhancement to improve color quality of the fused images.

In particular, the Intensity-Hue-Saturation (IHS) based methods are well known in quick image pan-sharpening process. However, most of these processes generate color distortion due to the unnatural spectral response of IKONOS sensors, particularly in vegetated areas. Hence, many recent methods such as Vegetation Indexes, normalized difference VI that make use of vegetation enhancement in order to correct the unnatural color appearance. Generally, the vegetation enhancement is accomplished using Vegetation Indexes VIs. A new fusion method that produces images with natural colors is proposed. Moreover, in this technique, a high-resolution normalized difference VI is also proposed and used in delineating the vegetation areas.

2. Literature survey

There are several techniques used for fusing PAN images with high spatial resolution but low spectral resolution and MS images with high spectral resolution but low spatial resolution. The techniques are based on related papers.

2.1 Fusion of IKONOS Satellite Imagery Using (IHS) Transform and Local Variation

Many satellite sensors provide both high-spatial panchromatic (PAN) images and low-spatial-resolution multispectral (MS) images. An image with high spatial resolution and spectral resolution is necessary for many remote sensing applications, such as change detection, land-use classification, and map updating [5]. An ideal image fusion algorithm should have three essential components, i.e., high computational efficiency, enhancing high spatial resolution, and reducing the color distortion. Conventional image fusion methods such as Intensity- Hue- Saturation (IHS) transform, principal component analysis, and Brovey transform methods [1]. However, these methods show high color distortion of spectral information.

In this a remote sensing image fusion algorithm based on local variation and IHS transform and its modified approach with low computational complexity. Visual effect and quantity evaluation results shows that the proposed algorithm out performs the conventional image fusion methods in the spectral domain with the spatial quality similar to that of the undecimated wavelet transform-based method. The proposed method can obtain the similar spatial resolution of the merged image with the IHS-based fusion algorithm and the better spectral quality in the green vegetated areas. The merged MS image of the proposed simple algorithm can obtain high spectral quality resolution with similar spatial resolution to that of the udWT-based image fusion scheme. The proposed modified scheme can provide better visual effect with high spatial and spectral quality similar to natural color. The simple algorithm can be used for classification of images, while the modified algorithm is more suitable for mapping applications.

2.2 New Vegetation Enhancement and Extraction Technique for IKONOS and Quick Bird Imagery

For accurate vegetation mapping, remote sensing information with different, spectral, spatial and temporal resolutions through image fusion . If an MS image has unnatural color responses on vegetation areas where the color in vegetation areas appears unnatural. Many ground objects details become ambiguous, uncertain, and difficult to recognize, particularly on planted areas where the color of vegetation and soil appears dark brown. Fig1. shows the spectral reflectance of typical land cover types water, green vegetation and soil. To extract the vegetation information by using the method called Normalized Difference Vegetation Index (NDVI) and injecting this information to adjust the hue component [2]. Although this method provided better color quality in vegetation areas, but some color distortion occurred in other regions.

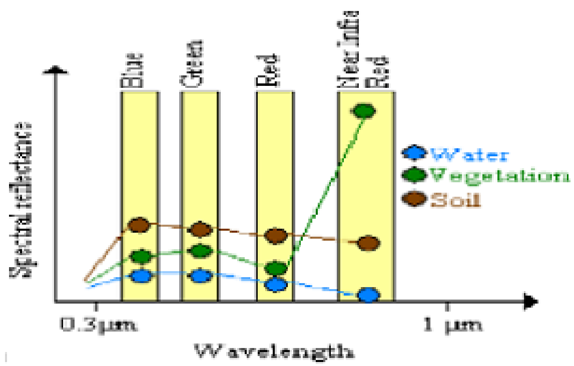

Figure 1. Spectral reflectance of typical land cover types water, green vegetation and soil [2].

To overcome the color distortion problem of unnatural color responses in image fusion, a new VI is proposed by integrating with a Fast Intensity-Hue-

Saturation (FIHS) method for high resolution imagery, which can enhance and extract green vegetation from IKONOS and QuickBird imagery [14]. It has some advantages that, it not only performs better than other conventional methods in vegetation enhancement but also functions well in vegetation extraction. The disadvantage is not good for non vegetation areas like building sand etc.

2.3 A New Intensity-Hue-Saturation Fusion Technique with Color Distortion Reduction for IKONOS Imagery

When the IHS method is used for IKONOS imagery, there is a significant color distortion, due to the range of wavelengths in an IKONOS Pan image. The gray values of PAN images in the green vegetated regions are far larger than the grey values of intensity (I) and that vegetation appears are relatively high reflectance in Near Infrared (NIR) and Pan bands. A new technique known as Normalized Difference Vegetation Index (NDVI) to identify the vegetation area and then enhances it in the green (G) band by using the red (R) and the near infrared (NIR) bands [4]. To obtain an intensity image with the grey values comparable to pan image's gray value. So there by the color distortion in the fused image is reduced. Visual and statistical analyses prove that the concept is promising, and it significantly improves the fusion quality compared to other conventional IHS techniques. Its advantages are a better color quality in the green vegetation region and Improves the fusion quality of the images. Its disadvantages are No vegetation enhancement and false vegetation detection.

2.4 Image Fusion Processing for IKONOS 1-m Color Imagery

Image Fusion (IF) produces color distortion in 1-m fused IKONOS images due to nonsymmetrical spectral responses of IKONOS imagery. A new fusion process helps to minimize this spectral distortion in IKONOS 1-m color images [6.] The 1-m fused image is produced from a 4-m multispectral (MS) and 1-m panchromatic (PAN) image, and maintaining the relations of spectral responses between PAN and each band of the MS images. The below Fig.2 shows the Spectral response of the PAN and MS sensor of IKONOS.

To obtain this relation, between MS and PAN four spectral weighting parameters are added with the pixel value of each band of the original MS image. Then, each pixel value is updated by using a method called steepest descent method to reflect the maximum spectral response on the fused image. This method has succeeded to generate 1-m fused images where spectral distortion has been reduced significantly, although some block distortions appear at the edge of the fused images.

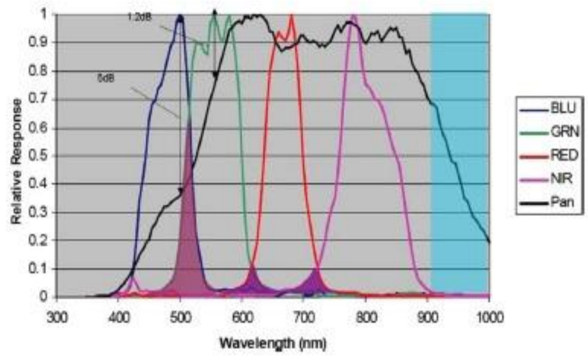

Figure 2. IKONOS spectral response [6].

To remove this block distortion, a sharpening process using a wavelet transform, which removes the block distortion without significant change in the color of the entire image. This technique has four steps. The MS image is expanded to the same size as that of the PAN image, in order to get perfectly superposable images. The first step is the pre-processing step ,in step 2 the pixel value of the fused MS images is initialized , in step 3 minimize the energy function, the steepest descent method is used, and the pixel value is updated repeatedly. Finally the convergence determination is processed and it helps to end the update process .

2.5 An Improved Intensity Hue Saturation (IHS) for IKONOS Image Fusion

A useful technique in various applications of remote sensing which involves the fusion of panchromatic (PAN) and multispectral (MS) satellite images. Recently, Tu et al. introduced a new method called Fast Intensity-Hue-Saturation (FIHS) method of image fusion with spectral adjustment for IKONOS imagery [7]. Aside from its fast computing capability for fusing images, this method can help reduce the color distortion problem inherent in IHS-like fusion. Because the spectral response of an IKONOS PAN image does not cover the spectral response of the blue band and green band, Tu et al. used the FIHS method in a special way: that is, they applied a modified intensity image with weighting parameters of 0.75 for the green band and 0.25 for the blue band. However, the response of the IKONOS PAN image extends far beyond the Near Infrared (NIR) band, additional spectral adjustment of the NIR band is desirable. Therefore an FIHS method is proposed that will incorporates spectral adjustment of all IKONOS MS bands. Even though the eFIHS SA method gives a satisfactory result for IKONOS image fusion, we can achieve a better results through the FIHS method in which additional spectral adjustment is considered for all IKONOS MS bands. Images fused by the proposed method have a better spectral quality than images fused by the eFIHS SA method. The spectral quality of the images fused by this method is as good as the spectral quality of images fused by the wavelet-based method.

2.6 A Fast Intensity Hue Saturation (IHS) Fusion Technique with Spectral Adjustment for IKONOS Imagery

For various image fusion methods, Intensity– Hue–Saturation (IHS) technique is capable of quickly merging the massive volumes of data. Fig.3 shows the IKONOS relative spectral responses.

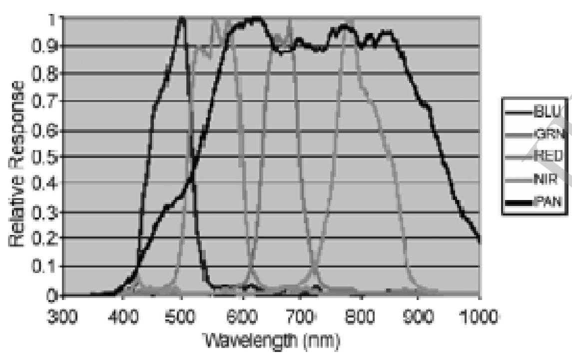

Figure 3. IKONOS relative spectral responses [3].

For IKONOS imagery, IHS can yield satisfactory "spatial" enhancement but introduce "spectral" distortion, appearing as a change in colors between compositions of resampled and fused multispectral bands. To solve this problem, a new method called Fast IHS fusion technique with spectral adjustment is presented [3]. This new approach can provide better performance than the original IHS method, both in processing speed and image quality.

Clearly visible images means seeing individual trees, automobiles, road networks, and houses, the IKONOS images allow for a more accurate understanding of phenomena on the ground. To take the advantage of the high spatial information content in the PAN image and of the essential spectral information in MS images, in the image fusion technique is often an efficient and economical means to produce MS images with high spatial resolution. For IKONOS data fusion, this paper presents a detailed study of the color distortion problem arising from the spectral mismatch between the Panchromatic and MS bands. To effectively solve this problem, a simple spectral-adjusted scheme is proposed and integrated into a fast IHS fusion method.

The Table 1 shows the comparison between different survey methods on the fusion of remote sensing images.

3. Conclusion

A survey on the reduction of color distortion in images after the fusion in the remote sensing images . The approaches which have been used are with an aim to reduce the color distortion , improve the spectral and spatial qualities of the image ,vegetation enhancement ,vegetation detection etc. Many challenges are faced by the existing methods. First , When the IHS method is used for IKONOS imagery, there is a significant color distortion, mainly due to the range of wavelengths in an IKONOS PAN image [7] .

The gray values of PAN in the green vegetated zone are far larger than the grey values of intensity (I) and that vegetation appears of relatively high reflectance in Near Infrared (NIR) and PAN bands. A new technique is called Normalized Difference Vegetation Index (NDVI) to identify the vegetation area and then enhances it in the green (G) band by using the red (R) and the NIR bands. Second, If there is an unnatural spectral response, the fused image will be unsuitable for visualization. To enhance the vegetation content in such cases, applying the Normalized Difference Vegetation Index (NDVI) to tune the color of MS images is a feasible method. However, the NDVI is commonly used to generate lower resolution vegetation maps, and particularly, the threshold needs to be chosen manually for various scenes. In order to overcome the drawback, using Vegetation Index (VI) with a fixed threshold which integrates a fast technique of Intensity-Hue-Saturation fusion.

Table 1. The comparison between different survey methods on the fusion of remote sensing images.

S.No	Methods	Advantages	Disadvantages
[2.1]	• Conventional IHS based image Fusion	• Better Spectral quality in green vegetation areas • Better visual effect with high spatial quality and spectral quality similar to natural color	• Not good for non vegetation areas
[2.2]	• Vegetation index (VI) Method	• Enhance green vegetation • Lose less spectral information	• Non vegetation regions are displayed in gray
[2.3]	• Normalised Difference Vegetation Index (NDVI)	• A better color quality in the green vegetation region • Improves the fusion quality	• No vegetation enhancement • False vegetation detection
[2.4]	• Steepest Descent Method • Sharpening Process	• Reduced spectral distortion • Remove block distortion • Improved spectral quality of fused images	• Loss of spatial information.
[2.5]	• An Improved Intensity-Hue-Saturation(IHS) Method or Choi method	• provides a satisfactory result, both visually and quantitatively. • fast computing capability suitable for IKONOS image fusion.	• Color distortion
[2.6]	• Fast IHS with spectral adjustment	• High quality image • High processing speed	• Not used in vegetation

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