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Pixel Level Satellite Image Fusion Using component Substitution Partial Replacement

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Abstract: Image fusion is capable of integrating different imagery to produce more information than can be derived from a single sensor. Preservation of spectral information and enhancement of spatial resolution are regarded as important issues in remote sensing satellite image fusion. In this paper, a component substitution partial replacement is proposed to merge a high-spatial-resolution panchromatic (PAN) image with a multispectral image. This method generates high-/low-resolution synthetic component images by partial replacement and uses statistical ratio-based high-frequency injection. Remote sensing satellite image, such as IKONOS-2 were employed in the evaluation. Experiments showed that this approach can resolve spectral distortion problems and successfully conserve the spatial information of a PAN image. Thus, the fused image obtained from the proposed method gave higher fusion quality than the images from some other methods.

Keywords: *Image Fusion, Pan sharpening, Pixel Level, Remote Sensing formatting, IKONOS-2*

1 Introduction

As Remote sensing satellites IKONOS-2, were launched, they provided low-spatial-resolution multispectral (MS) images and high spatial-resolution panchromatic (PAN) images. With regard to remote sensing, it has been a difficult task to obtain high spatial-resolution MS images because of the technical limitations of satellite sensors, the incoming radiation energy to the sensor, and the data volume handled by the sensors [10]. Image fusion is very important in that it aims to combine remotely sensed images that have different spectral and spatial resolutions with various applications such as visualization to identify the textures and shape of the various objects, feature extraction, and map updating [10].

Data fusion is capable of integrating different imagery data to produce more information than can that be derived from a single sensor. There are at least two limitations accounting for demanding pixel level image fusion technology. One is that the received energy of multispectral sensor for each band is limited because of the narrow wavelength range of the multispectral band. In general, the values of Ground projected Instantaneous Field Of View (GIFOV) of multispectral bands are larger than those of the panchromatic bands. In order to obtain smaller GIFOV value in relatively narrow wavelength range, image fusion technology is demanded to enhance structural and spatial details. The other is that the capability transmitting the acquired data to the ground is restricted. However, at present the transmission equipments of remote sensing system can not address the requirements. Henceforth, after ground stations receives multispectral images containing relatively less data, the combination of multispectral bandwidth the higher resolution panchromatic band can resolve the problem to some extent. So far, many pixel-level fusion methods for remote sensing image have been presented where the multispectral image's structural and textural details are enhanced by adopting the higher resolution.

There are various literatures on satellite image fusion techniques in the field of geo-science and remote sensing. Satellite image fusion is also called as Pan sharpening technique. Myungjin Choi [1], proposed Intensity Hue Saturation fusion technique. The Intensity Hue Saturation fusion technique is widely used in image fusion to exploit the complementary nature of MS images. The Intensity Hue saturation fusion technique converts a color image from the red, green, and blue (RGB) space into the IHS color space. The intensity band (I) in the Intensity Hue Saturation space is replaced by a high-resolution Pan image (I new)and then transformed back into the original RGB space together with the previous hue band (H) and the saturation band(S), resulting in an Intensity Hue Saturation fused image.

IHS fusion has a limitation known as minimization problem [1]. The new value of intensity is gray level image with high spatial resolution. so color distortion is there. Therefore spatial resolution of fused image is very poor. By adding trade off parameter't' to the IHS fusion technique spatial resolution can be improved. At the same time spectral distortion is there in this IHS fusion with trade off parameter. To assess the spectral and spatial quality of the fused images, spatially degraded Pan and MS images from the original images were used. For the experiment on the fusion of IKONOS images, the derived images have a resolution of 4 and 16 m, respectively. Based on quantitative analysis the quality of fused image can be measured. The quantitative analysis is based on the experimental results for the factor the relative average spectral error (RASE). RASE is expressed in percentage.

Andrea Garzelli and FilippoNencini [2] proposed component substitution multispectral and panchromatic image fusion by genetic algorithm. Here, a pan-sharpening algorithm for 4-band MS data is proposed, which is not based on MRA, but it applies a Generalized Intensity-Hue-Saturation (GIHS) transformation to the MS bands. A genetic algorithm is adopted to define the injection model which establishes how the missing high pass information is extracted from the Pan image. The fitness function of the genetic algorithm which provides the algorithm parameters driving the fusion process is based on a quality index specifically designed for quality assessment of 4-band MS images. The bands are red, green, blue and near infrared(NIR).

Analogously to all pan-sharpening methods based on the injection of spatial details, the proposed algorithm requires the definition of a model establishing how the missing high-pass information to be injected into the re sampled MS bands is extracted from the Pan image. In fact, fusion techniques which do not consider any injection model may produce unsatisfactory results in terms of spectral preservation of the fused product. This means that the spatial information of the Pan data has to be opportunely weighted and/or equalized before being injected on each band of the MS data. The aim of genetic algorithms is to use simple representations to encode complex structures and simple operations to improve these structures.

GIHS-GA visually demonstrates very accurate spectral preservation and superior performances in terms of radiometric and geometric accuracy. Cheng wc and S chang proposes High-Resolution image fusion. This method merge MS images of more than 3 bands[3] merge massive volume of data and reduce color distortion in fused image and preserve spatial details. The Resultant image have spectral distortion. Din-Chang Tseng and Yi-Ling Chen Proposes integer wavelet transform and principal component analysis (PCA) to fuse low-resolution multispectral images and a spot panchromatic (PAN) image to generate spectrum-preserving high- resolution multispectral images [4]. Din proposed an image fusion approach to enhance the spatial quality of the multispectral images while preserving its spectral contents to a greater extent. Also found that though the wavelet-based PCA can preserve more spectral information, it is not stable for enhancing spatial resolution quality.

PCA image fusion consists of four steps: First Geometric registration is formatting that size of low-resolution multi-spectral images is the same as the high-resolution image. second Transforming low-resolution multi-spectral images to the principal component images by PCA transformation. Third Replacing the first principal component image with the high-resolution image that is stretched to have approximately the similar variance and mean as the first principal component image. fourth The results of the stretched PAN data replace the first principal component image before the data are back transformed into the original space by PCA inverse transformation. Wavelet based PCA preserve more spatial information.

Vijay P. Shah and Nicolas H. Younan proposes Adaptive PCA contour let approach[5] for pan sharpening, This paper presents a combined adaptive PCA contour let approach for pan-sharpening, where the adaptive PCA is used to reduce the spectral distortion and the use of non sub sampled contour lets for spatial transformation in pan-sharpening is incorporated to overcome the limitation of the wavelets in representing the directional information efficiently and capturing intrinsic geometrical structures of the objects. This paper presents a new method of pan-sharpening based on the merger of the adaptive PCA and the contour let transform. The adaptive PCA approach helps in preserving the spectral information, whereas the contour let, which is known to have better directional representation than the wavelet, provides efficient spatial transformation for injection of high detail information. In

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general, the merger of the adaptive PCA contour let method provides better fusion results based on well-known global indexes.

Xu Li and Mingyi He proposes[6] In this paper, propose a new pan sharpening approach that integrates the advantage of both the Induction and correspondence analysis techniques to reduce the color distortion of IKONOS and Quick Bird fusion results. The low spatial resolution MS images need to be up scaled (resembled) to make their pixel size the same as that of the PAN image. The fusion process, which may be achieved either by the injection of the high-frequency content of the PAN image into the MS image or by substitution of the intensity image by the PAN image in case of the IHS-based algorithm.

II COMPONENT SUBSTITUTION FUSION TECHNIQUE

In general, the Component Substitution fusion Technique consists of three steps: Step 1, Forward transform is applied to the multispectral bands after they have been registered to the panchromatic band;

Step 2, A component of the new data space similar to the panchromatic band is replaced with the higher resolution band;

Step 3, The fused results are finally obtained via inverse transform to the original space.

(i)Construction of a High-/Low-Resolution Component Image Using Partial Replacement

The digital number (DN) values of an image depend on the spectral response function of a sensor. The spectral relationship between the PAN and MS images is not fixed because the spectral characteristics are changed with every object, area, and circumstance. The model can be defined by the equation[10]

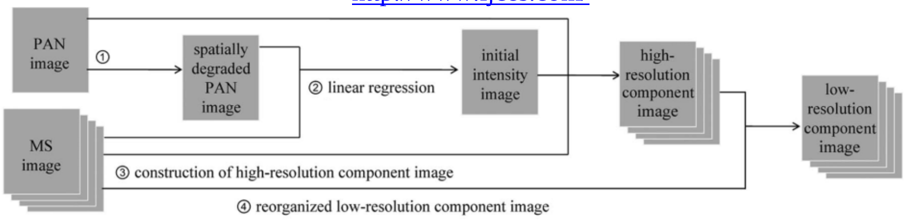
$$PAN\ (l) = \alpha 0 + \sum_{n=1}^{N} \alpha n MSn(l)$$

where $PAN_{(l)}$ means the spatially degraded low-spatial resolution PAN image when decimated by bicubic interpolation .α is the regression coefficient, N represents the spectral bands, and $MS_{n(l)}$ is the nth MS image, which is bicubically resampled with the equivalent size of PAN data .

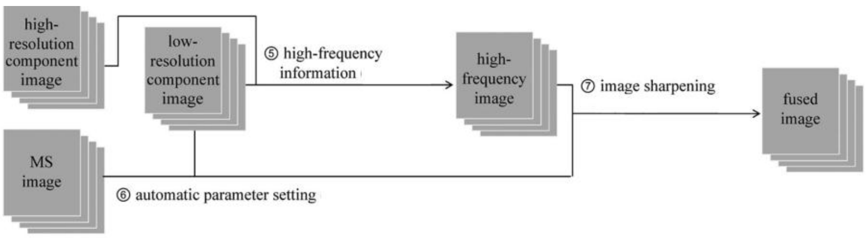
The initial intensity image I(l) is then produced using the following equation:

$$I(l) = \alpha 0 + \sum_{n=1}^{N} \alpha n MSn(l)$$

(ii) Diagram of Proposed Fusion Method



(a) Construction of a high-/low-resolution component image using partial replacement
(b) Adaptive fusion framework for minimizing the global/local dissimilarity.



The correlation coefficient between the low-spatial-resolution synthetic component image and each MS band histogram matched with $I_{(l)}$ is estimated to generate the high-resolution component image. Thereafter, by using each correlation coefficient, the new high-resolution component image is computed using

$$In(h) = CCn.PAN + (1 - CCn).MSn(l)$$

(iii) Adaptive Fusion Framework for Minimizing the Global/Local Dissimilarity

In order to inject the high-frequency information of the original PAN image, the δn is composed as follows:

$$\delta n = \big(In(h) - In(l)\big) - \overline{(In(h) - In(l))}$$

To preserve the essential characteristics of the MS bands, we applied the statistical ratio of the DN values and added the term for complementing the CS model in general CS fusion. The wn is given as

$$\omega n = \beta.CCn\big(In(l), MSn(l)\big).\, {}^{std(MSn(l))}\Big/_{1/N \sum_{n=1}^{N} std(MSn(l))}$$

β is a constant parameter for stabilization to the dynamic range of the initial input data. By using this property, the local instability adjustment parameter Li is generated as

$$Li = 1 - |1 - CCn(I(l),MSn(l).\frac{MSn(l)}{In(l)}$$

Summing up, these equations , we can obtain an optimal fused image that minimizes spectral distortion locally and globally while preserving the spatial quality.

$$MSn(h) = MSn(l) + \omega n.\,\delta n.\,Li$$

III.EXPERIMENT

To estimate the performance of the proposed fusion algorithm, various satellite sensors, such as IKONOS was selected. Each MS image was resembled with the equivalent spatial size of the corresponding PAN image by bicubic interpolation and co registered for each data set. All the MS and PAN imagery has the specific characteristics of spectral wavelength, radiometric resolution, and spatial resolution.

1) IKONOS: The IKONOS imagery used for fusion performance estimation was acquired on November 19, 2001.The site is Daejeon, Korea, and includes various land cover types. In site 1 [Fig. (a)], forest, golf course, crop, roads, and building areas are presented, mainly for estimating the fusion quality of the vegetated area. Multispectral images [Fig. (b)] represents a complex urban area, a river, and some crops to evaluate an urban area. Fig(c) the fused result

Fig a)PANCHROMATICIMAGE

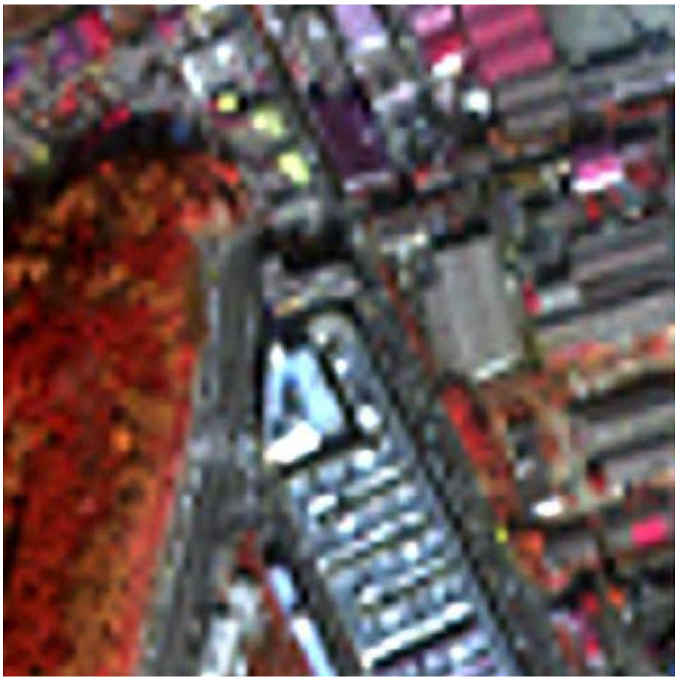


Fig b) MULTISPECTRAL IMAGE FIG c) AFTER FUSION RESULT

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