Hyperspectral image denoising via contourlet transform based image fusion

P.Rajalakshmi,D.Vishnu,J.Vengat Raman,R.Sarath

Abstract— In remote sensing and geoscience applications hyperspectral images play a major role. But the hyperspectral image may contain noises, these noises can be removed by hyperspectral image denoising methods in order to get sharpened images. Hyperspectral image has better spectral correlation and panchromatic image has better spatial correlation. In this paper we propose an effective and efficient method to remove noise in hyperspectral image and also improving the spectral and spatial correlation of the hyperspectral image by using the image fusion of hyperspectral and panchromatic images by employing contourlet transform which is better than wavelet transform. The resultant image obtained by our proposed method is better for machine and human interpretation. The Color distortion problem in the hyperspectral image is also reduced by proposed method based on local spectral and spatial correlation (SSC).The results of proposed method is better than the existing methods.

Index Terms— Contourlet transform , Hyperspectral image,Hyperspectral image denoise,Panchromatic image,Spatial correlation, Spectral correlation, Spectral and Spatial correlation., Support Vector Machine (SVM).

1 Introduction

HYPERSPECTRAL data analysis is of growing interest as an approach to meteorology, geology, earth remote sensing, and military surveillance. However, the large volume of spectral data not only limits its applications, but also presents a challenge for image processing and analysis techniques. Compared with hyperspectral images have many numbers of spectral bands with a very small increment in wavelength and high sensibility for different objects. For example, a standard airborne visible/infrared imaging spectrometer (AVIRIS) hyperspectral data can simultaneously collect spectral information of an object in the visible to infrared range from 400 to 2500 nm and record it in 224 spectral bands with approximately 10 nm width in the increments[1]. Therefore, the hyperspectral data can provide high spectral resolution and solve the problems that the multispectral data cannot, because multispectral data usually contain only five to seven bands.

Traditionally, hyperspectral remote sensing image classification is implemented by a single classifier, for example, support vector machine (SVM), using original hyperspectral data and other derived features as input signals. Those methods have proved their effectiveness for many applications, but there are still some problems. First, each classifier has its own merits and limitations, and it is often difficult to achieve satisfied accuracy by a single classifier [2]. The fusion quality will be greatly reliant on the registration results due to the division of processes of registration and the fusion, and also the registration errors overlooked in the fusion process can considerably reduce the fusion quality [3].

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2 Exisiting System

In the Exsisting System the wavelet transform is used in the fusion process inorder to remove the noises present in the hyperspectral image by fusing the hyperspectral image and panchromatic image.By employing wavelet transform the accuracy is low.So we propose a system from which accuracy can be improved in a SECTION 3

3 Proposed System

The proposed fusion algorithm which uses the hyper-spectral (HS) image and the corresponding panchromatic image which is based upon spectral and spatial correlation (SSC) using Contourlet transformer is summarized in the below mentioned steps . First the
Hyper- spectral (HS) image and the panchromatic image are taken as source images. In detail information of HS image and PAN image, the two images taking part in fusion are registered. Histogram matching technique is applied. The images are decomposed into Contourlet transforms. The 1st band of HS image's all details and coefficient is replaced with that of PAN image. Then the each band of the image for the separation of the pixel is calculated. An Inverse Contourlet Transform is then performed.

$$\sigma = \sqrt{\frac{1}{MXN}\sum_{i=1}^{N}\sum_{j=1}^{M}(c_f(i,j)-\overline{m})^2} \quad (1)$$

Where C (i, j) is the (i, j) th pixel intensity value and is the sample mean of all the pixel values of the image. For an image consists of grey levels, Quantification of information content of the image scale level should be evaluated to increase the pixel level.

$$Entropy \approx \sum P_i \log_2 p_i$$

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Where P(i) is the probability of each grey scale level.

In this section, we propose a SVR classifier image fusion method that uses local SSC which is used to improve the spatial correlation.

3.1 Improved Model Based On SSC

In the image fusion, the spectral preserving correlates with the interband structure of the MS image, and the spatial preserving correlates with the injection of the spatial structure from the PAN image. The fusion method such as SVR only uses the spectral correlation between the PAN and MS images to build the multiple-linear-regression model. However, the pixels in an image are spatially correlated, meaning that, for a source image, if one pixel contributes to the fused image, its neighbors are likely to contribute to the fused image as well. Therefore, the decision making during the fusion process should exploit the property of spatial correlation [6].

$$PANori = \phi iMSi + \beta Gs \quad (3)$$

In addition, the wavelength of the PAN image is relatively wide thus, the information in the PAN image not only contains the spectral characteristics of the HS bands but also contains more spatial details than the HS bands. Based on the aforementioned reasons, we build a more appropriate regression model to calculate weight including both the SSC fraction.

3.2 Contourlet Transform

The Contourlet transform provides more affluent set of directions and shapes which is why in images they are very effectual in producing smooth contours and geometric structures as well . The capturing of image edges with generally used separable extensions of one-dimensional transforms, such as the wavelet and Fourier transforms, has limitations which are well known. In this paper, we put into practice a Contourlet transform that can incarcerate the intrinsic geometrical structure that is vital in visual information. The key challenge in exploiting geometry in images arises from the discrete data nature such as curvelets that primarirly develops a transform in the continuous domain and then discretizes for sampled data .After which it processes its convergence to expand to a domain which is continuous . This results in an output obtained by construction in a flexible local, multi resolutional and directional image expansion using contour segments, and, thus, it is named the Contourlet transform [7]. A fast iterated filter bank algorithm which is present in the discrete Contourlet transform requires an order operation for N-pixel images. Additionally we institute a linking with the developed filter bank and the associated continuous-domain Contourlet expansion by means of a directional multi resolution analysis frame work is shown in the below fig 1.

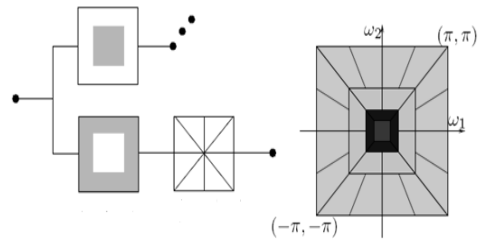

Fig 1. Contourlet filter bank with a DFB which is applied to each band pass Channel.

3.3 The Nonsubsampled Pyramid

The multi-scale characteristic of the Non Sub sampled Contourlet Transform (NSCT) is achieved from a shift-invariant filtering formation that obtains sub band decomposition comparable to that of the Laplacian pyramid. Such progress is similar to the 1-D Non Sub sampled Contourlet Transform calculated with the fusion algorithm and has a redundancy of J+1 ,where J is the number of decomposition stages. The ideal pass band support of the low pass filter at the j-th stage is the region on the square. Accordingly, the support of the high-pass filter is the complement of the low-pass support region on the square. The filters for consequent stages are presented by up sampling the filters of the first stage. This decomposition process is shown in Figure 3. In the process mentioned xj+1 is the low frequency signal at scale J+1 and yj+1 is the high frequency signal at scale J+1. *Hj, Gj*is the scale expansion of H0, G0 respectively at the 2 j -th stage.

3.4 Directional Filter Banks

By combining critically sampled two-channel fan filter banks the Directional Filter Banks (DFB) is constructed as proposed by Bamberger and Smith [8]. The resultant filter bank produces a tree-structured filter bank that divides the frequency plane into directional wedges. A shift invariant directional expansion can be obtained with a DFB. The shift invariant directional filter is constructed by eliminating the down samplers and up samplers in the DFB. This is done by switching off the down samplers/up samplers in each two channel two channel filter bank in the DFB tree structure and also accordingly up sampling the filters.

3.5 .Image Fusion Techniques

A widely used multi resolution analysis based image fusion technique, which can fuse any number of images in one fusion process, i.e. Contourlet transform based image fusion. The principle of the Contourlet transform based image fusion here a two images (HS image and pan image) is used. The detail information about decomposition of source image into approximate sub image and detail sub images, as well as reconstruction from the corresponding fused sub images to the final

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fused image, which uses the Contourlet transform based image fusion in a recursive way for hyperspectral image application. As image fusion is concerned with the extraction is for determining the following weight, which is based on the calculation of the local information in sub images as follows

$$Elk - j = QI\,(l, j, k) \qquad (4)$$

Where *Ql*is the quantity of information on level j and orientation $\boldsymbol{k}$ in the I is approximate image or detail images. And the quantity of information can be defined by different application according to the special considerations. In the standard entropy is used as a measure for image information [4]. When the quantity of information *EL.*, of the approximate image and detail images in the window is obtained, the weights of each sub image can be calculated (4).

In some methods of fusion, matching of histogram is needed. To match histogram, intensity of an image is linearly stretched according to the coefficient of the another image

3.6 Proposed Fusion Algorithm

The fusion procedure can be implemented at various levels of bands, on behalf of a common method to distinguish between pixel level and image level. At pixel-level, Image fusion employs fusion taking place in a processing level at the lowest, in relation to the merging of measured physical parameters. At image-level, fusion requires the image by fragmentation procedure. The features can be acknowledged by characteristics such as size, shape, contrast and texture. The fusion procedure enabling the recognition of higher coefficient is thus based on that extracted features. Fusion procedure implemented at symbol level permits the information to be combined efficiently at the abstraction of highest level [5]. The preferences of the appropriate level depend on many diverse factors, for instance, data sources, application and accessible tools. A good number of image fusion applications make use of pixel-based techniques. The benefit of pixel fusion is that the images used embraces the original information, in addition, the algorithms are fairly easy to employ and time proficient.
A fusion technique involving data transformation and classification for the RGB band in visualization of the hyper spectral data which has been proposed in [10]. The accuracy of image registration is insisted in the sub-pixel level since the present fusion methods based upon pixel-level are very susceptible to misregistration. The sections that are based on the fusion process become more stout and robust. The robustness of these regions evades blurring effects high sensitivity to noise, misregistration and other familiar problems in pixel-level fusion.
The performance outcomes of fusion methods are fundamentally reliant on the fusion scheme and its associated transform. The preference of Contourlet bases for the Contourlet transform approach is from a standpoint view of fusion performances and computation time.

IV. EXPERIMENTAL RESULTS

To test the effectiveness of the proposed algorithm, we have tested it on several hyperspectral image with several techniques. Here we provide the experimental results of the proposed technique over image fusion method and the original HS image is compared with the fusion method based on the IHS transform. In the proposed fusion rule, the low frequency sub band for correlation coefficients of the HS image are selected as that of the fused image from figure 2(a) and the high frequency directional sub band coefficients of the PAN image is selected from figure 2(b) as that of the fused image. The proposed algorithm of the source images from figure 2(c) fusion based on IHS method shows the most obvious spectral

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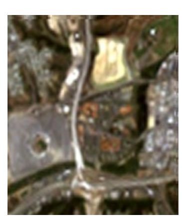
Methods	Correlation efficiency	Entropy	Standard Deviation
IHS transform	0.9298	7.4591	9.8352
Wavelet Transform	0.9250	7.6194	10.3866
Proposed Method	**0.9302**	**7.6239**	**10.7562**

Table 1. Comparison of proposed & existing fusion methods

The paper makes use of three modes of statistical parameters to analyze the performance of the fusion methods. The parameters which reflect the spatial detail information are entropy, correlation efficiency and standard deviation, whereas those selected to describe about spectral characteristics in HS image. The metric values are evaluated between the fused image and the input image. Table 1shows the analysis performance of different fusion methods. From the table the entropy value based on proposed algorithm is highest and the correlation efficiency value based on proposed algorithm is comparatively lower than IHS methods. Thus proposed algorithm effectively improves the spatial and spectral characteristics of the image. Also from the table, proposed method results in highest standard deviation from the rest of the other methods. Thus proposed algorithm preserves most of the spectral information of original HS image. The performance analysis shows the proposed method is the best, the same can be observed through the figure 2.



(a) (b)

(c) (d)

Figure 2. Source images and fused results with different methods: (a) The Hyperspectral (HS) image. (b)The PAN image. (c)The fused image by HIS. (d) Fused image by proposed method

V. CONCLUSION

In this paper, a SSC based image fusion algorithm has been presented to keep the spatial resolution of the PAN image and preserve the spectral characteristics from the HS image. And we have addressed the Contourlet transformer method to resolve them by representing the edges of the images. The proposed method has been compared with the original HS image, HIS methods. The experimental results suggest that the images obtained with the proposed algorithm have higher correlation coefficient and entropy for the fusion quality compared with other well-known methods in terms of visual analysis.

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