FUSION OF PAN AND MULTISPECTRAL IMAGES BASED ON CONTOURLET TRANSFORM[1]

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ABSTRACT:

Contourlet transform can give the asymptotic optimal representation of edges and contours, so it can capture smooth contours and geometric structures in images much more efficiently than the wavelet transform. The nonsubsampled contourlet transform (NSCT) not only has multiresolution and multidirectional properties but also has shift-invariant property by contrast to the contourlet transform. A new method of fusing panchromatic (Pan) and multispectral (MS) remote sensing images was proposed based on NSCT and IHS transform. IKONOS images were used to verify its validity. The experiment results show that the proposed method has greatly improved spatial resolution and keep the spectral information, and is better than the fusion method based on CT and IHS.

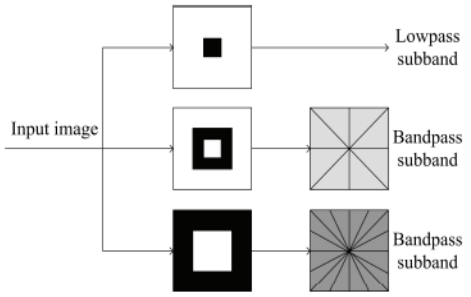
1. INTRODUCTION

In recent years, the fusion algorithm based on multiscale analysis tools is attached a great importance such as ridgelet ,wavelet, curvelet and contourlet [Arthur L Da C, Zhou J P, Do M N, 2006]. As a multiscale analysis tool, the contourlet transform (CT) have the characteristics of localization, multi-direction and anisotropy[M. Choi, R.Y. Kim, M.-R. Nam, H.O. Kim, 2005]. The CT can give the asymptotic optimal representation of contours and applied in image fusion effectively. However, the CT is lack of shift-invariance and results in artifacts along the edges in some extend. The nonsubsampled contourlet transform (NSCT) is in virtue of nonsubsampled filter banks to meet the shift-invariance [Arthur L Da C, Zhou J P, Do M N. 2006]. Therefore, the NSCT is more suitable for image fusion. So a fusion algorithm based NSCT and HIS (NSCT +HIS) transforms was proposed [YANG X H, Jiao L C. 2008]. They demonstrated that the NSCT+HIS algorithm was better performance compare to PCA, HIS and wavelet transform weighted fusion method. However, the high frequent coefficients of the fused image are the sum of the high frequent coefficients of intensity and the histogram-matched panchromatic image. Different from Yang's method, A new NSCT +HIS fusion method using reasonable fusion rule is proposed in this paper, a lower resolution MS image of IKONOS and its high resolution panchromatic image was fused using the proposed method , and the fusion method based on CT and HIS (CT+HIS) , simultaneously. The outputs were evaluated in objective and subjective performances. Compared with the fusion of CT+HIS, the NSCT+HIS fusion technique proved to be a better option.

2. METHODOLOGY

2.1 Nonsubsampled Contourlet Transform

Do and Vetterli proposed a "true" two-dimensional transform called the contourlet transform, which combined with nonseparable filter banks and provides an efficient directional multiresolution image representation. By virtueof the Laplacian pyramids (LP) and directional filter banks(DFB), the CT provides the multiresolution decomposition and directional decomposition, respectively. The CT cancapture the intrinsic geometric structure information of images and achieves better expression than discrete wavelet transform (DWT), especially for edges and contours.



Figue 1(a) NSFB structure

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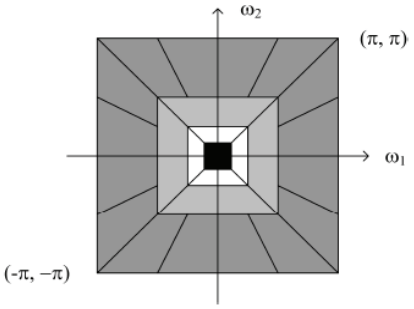

Figure 1(b) Corresponding frequency partition

Figure 1. Two level Nonsubsampled Contourlet transform decomposition

Different to the CT, the multiresolution decomposition step of NSCT is realized by the shift-invariant filter banks satisfied Bezout identical equation (perfect reconstruction) not the LP filter banks. Because of no decimation in the pyramid decomposition, the lowpass subband does not bring frequency aliasing, even the band width of the low-pass filter is lager than π/2. Hence, the NSCT have better frequency characteristics than CT. The two-level NSCT decomposition is shown in figure 1.

2.2 Fusion Method Based on NSCT combining with HIS (NSCT+HIS)

The core of the NSCT is the nonseparable two-channel nonsubsampled filter banks. It is easier and more flexible to design the needed filter banks that lead to a NSCT with better frequency selectivity and regularity when compared to the CT. Based on mapping approach and ladder tructure fast implementation, the NSCT frame elements are regularity, symmetric and the frame is close to a tight frame. The multiresolution decomposition of NSCT can be realized by nonsubsampled pyramid (NSP), which can each the subband decomposition structure similar to LP. A fusion method based on NSCT combining with HIS is proposed. If the multispectral images are registered to the panchromatic image , A general scheme for the NSCT+ HIS fusion methods is shown in Figure 2.

This method can be performed in the following steps:
Step 1: Perform HIS on the multispectral image and get saturation, hue and intensity components;
Step 2: Apply histogram matching between the original panchromatic image and intensity to get a histogram-matched panchromatic image.
Step 3: Employ NSCT on intensity and the histogram-matched panchromatic image, and get low frequent subband and high frequent subbands.
Step 4: Fuse the intensity and the histogram-matched panchromatic image. The fused low frequent data employ the low frequent coefficient of intensity. The fused high frequent coefficient adopt ☰ Maximum the region-energy for every coefficient of each subband of panchromatic image and intensity get by step 3.
Step 5: Apply NSCT reconstruction with new coefficient to obtain the new intensity.
Step 6: Perform the inverse HIS transform to obtain the fused image.

The scheme for the CT +HIS fusion method differ only from NSCT+HIS method in the applied CT .

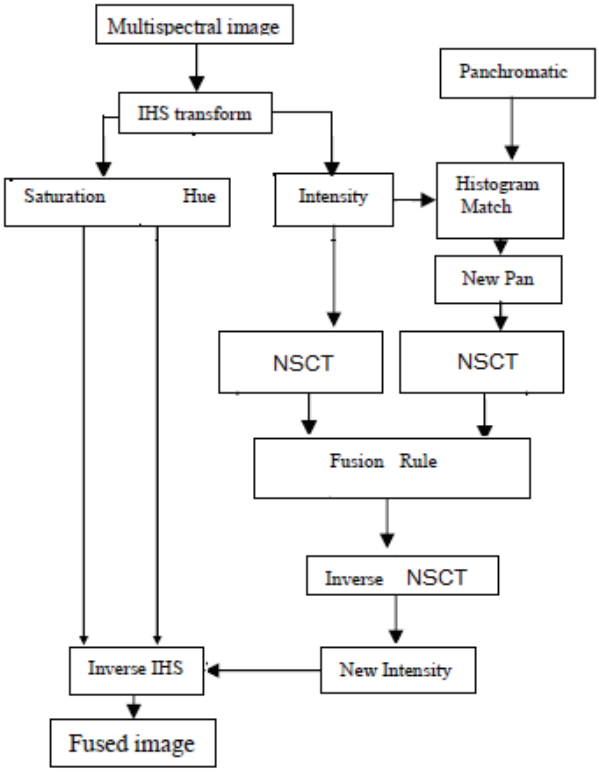

Figure 2. Image fusion flow chart of NSCT+HIS

3. EXPERIMENTS AND FUSION RESULT ANALYSIS

The tested remote sensing images consist of 1m panchromatic and 4m multi-spectral IKONOS images. Figure 3 shows the fusion results of the IKONOS images. The visual inspection shows that the fused images produced by proposed algorithms have more details than that of the algorithm CT+HIS.

Three different measures are used to evaluate the performance of the algorithms under investigation. These measures are: the normalized correlation, the entropy and the average gradient. Detailed equations of these measures can be found in the literature. Table 1 shows the results of the fusion experiment of the fused images where the correlation is measured between the PAN image and the corresponding gray fused image, and correlation between gray MS and gray fused image. The entropy and the standard deviation are measured for the fused images.

Figure 3(a) Ikonos spectral image

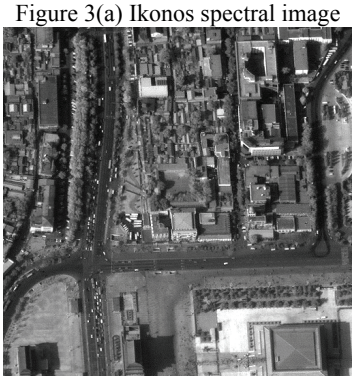

Figure 3 (b) IKONOS Pan image

Figure 3 (c) Image fused by CT+HIS

Figure 3 (d) Image by NSCT+HIS

Figure 3. IKONOS images and fused images

	Average correlation of pan to the fused image	Entropy	Average gradient
CT+HIS	0.81	7.84	39.1
NSCT+HIS	0.82	7.86	41.2

Table 1. Performance measures for fused IKONOS images

The results indicated in the Tables 1 and the visual inspection of the images of Figure 3 (c) and Figure 3(d) reveal that, in general, the performances of the proposed algorithms outperform the algorithm CT+HIS.

2. CONCLUSIONS

A panchromatic image and multi-spectral images fusion technique is proposed in this paper, which is based on nonsubsampled contourlet transform combine with HIS transform. NSCT have better frequency characteristics than CT, comparison with CT+HIS method, the proposed fusion technique have better objective and subjective performances

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