AN IMPROVED FUSION METHOD FOR PAN-SHARPENING BEIJING-1 MICRO-SATELLITE IMAGES

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1. INTRODUCTION

Beijing-1 Micro-Satellite is a recently launched small earth observation satellite with medium/high spatial resolution. It provides both multispectral (MS) and panchromatic (PAN) data with spatial resolutions of 32 and 4 m, respectively. The MS images have three wavelength bands: near infrared [NIR: 0.77 - 0.90 µm], red [R: 0.63 - 0.69 µm], and green [G: 0.52 - 0.60 µm]. The single wavelength band for a PAN image is 0.47-0.83 µm. The spatial resolution ratio of Pan to MS image is 8:1. It is often a challenge to pan-sharpen images with such a high spatial resolution ratio.

Image fusion is to combine the geometric detail of a high-resolution PAN image and the spectral information of low-resolution MS images, thereby producing a fused image with the highest possible spatial information content while still preserving spectral integrity [1]. Many research papers have reported the limitations of existing fusion techniques. The most serious issue is spectral distortion [2]. In this paper, we carry out image fusion research by using the Pan and MS channels of Beijing-1 Micro-Satellite, in order to find the best fusion technique for Beijing-1. We compare the popular fusion techniques: IHS, PCA, Brovey, wavelet transform techniques for pan-sharpening Beijing-1. We also develop an improved method to achieve better results. To verify our technique, the evaluation process has been done by comparing to existing processes.

2. METHODOLOGY

A fused product reaches good quality only if the characteristics and differences between input images are taken into account [3]. For Beijing-1 Micro-Satellite data, dissimilarities existing between these PAN and MS images originate from different spectral bands of acquisition; for instance, the wavelength band PAN of Beijing-1 doesn't cover the NIR band completely. This difference leads to object occultation and contrast inversion [3]. Given these local dissimilarities, we develop an improved method to merge the PAN and MS images of Beijing-1. This method can take full advantage of the localized feature information of the images. The steps are as follows:

1) Co-register the PAN and MS images; resample the MS images so that they have the same spatial resolution as the PAN image.

2) Convert the MS image from the red, green, and blue (RGB) space into the IHS color space. (Forward IHS transform).

3) Perform histogram match between PAN image and intensity component (I), and get new panchromatic image (New PAN).

4) The I component and the New PAN image is first decomposed into a set of low-resolution images with corresponding wavelet coefficients for each level. We employ Db4 wavelet transform.

5) The new intensity component is obtained by fused the wavelet coefficient data of New PAN and I through adaptive weights based on window region local features [4].

6) Transform the new intensity, the hue, and the saturation components back into RGB space (inverse IHS transform).

Here are more explanations for STEP 5. Let A be the New PAN image and B be the intensity component. They are both transformed with wavelet transform. We can obtain approximate coefficients $S_A(2^J;x,y)$, $S_B(2^J;x,y)$ and detailed coefficients $W_A{}^K(2^j;x,y)$, $W_B{}^K(2^j;x,y)$. Here, J denotes decomposition level, K=1, 2, 3 denotes the three directions and $j=1,2...J$ denotes different resolutions.

In the step 5, the adaptive weights based on window region local features are like this: for the detailed components, in order to preserve localized feature information as more as possible, we compare the coefficient of New PAN with the correspond coefficient of intensity component, and give a greater weight to the one that contains more detail information. It can be defined as:

$$W^K(2^j;x,y) = k_1 W_A{}^K(2^j;x,y) + k_2 W_B{}^K(2^j;x,y) \quad (1)$$

$$k_1 = \prod_{n=1}^{2} f_A^n / [\prod_{n=1}^{2} f_A^n + \prod_{n=1}^{2} f_B^n], k_2 = 1 - k_1 \quad (2)$$

f_A^1 and f_A^2 represents the local standard deviation and the local entropy of n*n window, respectively; the coordinate of the center of the n*n window is (x , y).

The fused approximate coefficients are obtained with the I component's approximate coefficients $S_B(2^J;x,y)$.

3. EXPERIMENTS AND RESULTS

In practice, taking the Beijing City as the study area, we conduct comparison experiments with different data fusion methods on Pan and MS images of Beijing-1 Micro-Satellite. We assess the fusion results of these different fusion techniques from both qualitative and quantitative aspects. Six quantitative parameters are chosen to assess the fusion result. Among them, standard deviation, information entropy, average cross entropy, and average gradient are used to determine whether the spatial resolution is enhanced, and whether the capacity of exhibiting spatial detail is strengthened. In addition, the spectral distortion degree and correlation coefficient are computed to measure to what extent the spectral characteristics are maintained. The correlation coefficient between MS and the fused image reflects level of change of the spectral information of MS, while the spectral distortion degree reflects the degree of spectral distortion before and after the fusion. The qualitative and quantitative evaluation indicates the new approach developed in this study produces the optimal fusion result. This fusion result map shows good visual quality and can be used in many urban remote sensing applications: city planning, information extraction, urban environment monitoring, city land use survey, etc.

4. REFERENCES

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