PANSHARPENING FOR CORRECTION OF SPECTRAL AND BLOCK DISTORTIONS

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In order to obtain valuable information for the ground from remotely sensed sufficiently high spatial resolution imagery is required for detailed structure on ground surface and it is also necessary for detection of complex features to integrate abundant spectral information. Up to now the satellite imagery with very-high resolution of less than or equal to 1m resolution can be obtained from panchromatic sensors, while multispectral data are available only with mid-high or moderate spatial resolution. Image fusion techniques can effectively integrate the spatial detail of panchromatic data and the spectral characteristics of multispectral images. It is important for human's visual interpretation or computer's autonomous recognition to improve the accuracy in analyzing land-cover types.

The techniques to integrate panchromatic and multispectral data have mainly been developed for the application to generate a RGB image of the higher spatial resolution of the panchromatic image. For this application, the IHS technique[1] and Brovey transform[2] have been most widely used in practice. The fusion techniques have been designed to obtain the synthetic images similar to the multispectral images that would have been observed from a sensor of the higher resolution. The synthesis process of multispectral images to the higher resolution of the panchromatic image is called "pansharpening" of multispectral images. Zhang and Hong[3] assorted the algorithms for pansharpening into three categories: 1) projection and substitution methods, such as IHS technique 2) band ratio and arithmetic combination, such as Brovey Transformation, and 3) fusion method which injects spatial features of a panchromatic image into multispectral images. The injection method was earlier developed by using high-pass filtering to extract the spatial features, and later multiresolution analysis such as wavelet and Laplacian pyramids[4][5][6] has been employed for detail injection. The eight algorithms recently developed and provided by seven research teams were compared with a standardized evaluation procedure[7]. In their experiments, two algorithms, generalized Laplacian pyramid with context-based decision method[6] and additive wavelet luminance proportional method[8], outperformed all others. They showed that the algorithms based on multiresolution analysis generally performed better than ones based on component substitution.

This study first proposes a pansharpening method, which aims at minimizing or reducing the spectral distortion in the synthetic multispectral image of the higher resolution. Let z_j be the multispectral vector of the *j*th pixel in the synthetic image similar to the multiband image that would have been observed from a multispectral sensor with the higher resolution of the panchromatic image. The image model is usually assumed to be additive Gaussian. Under this assumption, given μ_j and Σ_j as the mean multispectral vector and its covariance matrix of the *j*th pixel in the multispectral image at the higher resolution, the objective function for the maximum likelihood estimates of $\{z_j\}$ is:

$$\underset{\{z_j\}}{\text{Max}}\left[\prod_{\forall j}\Pr(z_j \mid \mu_j, \Sigma_j)\right]. \tag{1}$$

In image processing, it is supposed that the intensity of each pixel corresponds to the average brightness which arises from the random emission of discrete particles (called photons) with identical energy. In terms of the number of photons, the spectral response of a pixel in the lower resolution is assumed to be equal to the average response of the pixels belonging to the corresponding area in the higher resolution at a same wavelength. For this assumption, the objective of (1) must be subject to:

$$\frac{1}{K}\sum_{j=1}^{K} z_{i(j)} = z_i^{Low}. \tag{2}$$

where z_i^{Low} is the observed multispectral vector of the *i*th pixel in the lower resolution. The optimal solution of $\{z_j\}$, the multispectral image at a higher resolution, is obtained by solving the objective function with the constraint of (2).

However, this pansharpening process results in a block distortion at the boundary of the synthetic multispectral image. In this study, a sharpening process of maximum a posterior estimation is also proposed to eliminate the block distortion using the contextual information of the panchromatic image.

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