Spectral Fidelity Analysis of Compressed Sensing Reconstruction Hyperspectral Remote Sensing Image Based on Wavelet Transformation*

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Abstract. For hyperspectral image research, spectral characteristic retainment is more important than the spatial details retainment, so it is necessary to evaluate the spectral influence of hyperspectral image compressed sensing. In this paper, the researchers select a hyperspectral remote sensing image PROBE CHRIS with abundant coastal wetland ground objects to analyze spectral fidelity of wavelet transform compressed sensing algorithm on the basis of three indicators between reconstruction and original image pixel spectra: correlation coefficient, error and relative error. Meanwhile, eight typical ground objects are chosen to analyze their respective spectral deviation. The results indicate: (1) Image reconstruction algorithm based on wavelet transform compressed sensing functions well. Between the pixels of reconstruction image and original one, their average spectral correlation coefficient is 0.9428, error is 6.4096, and relative error is 13.81%; (2) Spectrum fidelity indicator values vary with wavebands. Reconstruction algorithm is selective about objects.

Keywords: Spectral fidelity, compressed sensing reconstruction, hyperspectral remote sensing image.

1 Introduction

Hyperspectral remote sensing data include both image information and spectral information. It can obtain continuous spectral curves of each pixel while imaging, so it is suitable for quantitative remote sensing, fine classification and target detection. However Along with the increasing abundance of spectral information from hyperspectral remote sensing data, the data quantity increases dramatically. This demands more effective data storage and transmission. Compressed sensing (CS) measures and encodes the image projection value from higher dimension to lower dimension with the sampling rate far below Nyquist. Its decoding process is not the conventional reverse process, but the accurate or approximate reconstruction of images based on

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signal sparse decomposition theory with blind source separation reverse. Compressed sensing is an image reconstruction algorithm which features low storage and transmission data quantity and excellent image restoration, but the pixel spectrum of the restored images will change. However, for hyperspectral image research, spectral characteristic retainment is more important than the spatial details retainment, so it is necessary to evaluate the spectral influence of hyperspectral image compressed sensing.

Compressed Sensing (CS) theory is put forward in 2006 by D. Donoho[1], E. eandes and J. Romberg[1, 2, 3]. From then on the CS theory has undergone rapid development and been applied in photography [4], medicine [5], face recognition [6], geophysics [7] and remote sensing [8]. It is a valuable vehicle of remote sensing image compression, transmission and reconstruction. Spectral fidelity research has focused on image fusion in recent years [9, 10, 11, 12], especially that of high spatial resolution and multispectral image data. In the research, the emphasis is on the spatial information integration and spectral information fidelity, but spectral fidelity of CS hyperspectral image is not discussed in detail. In fact, the spatial-spectral resolution increase and the image coverage expansion result in the exponential increase of hyperspectral remote sensing data quantity, so it is necessary to study the remote sensing image compression, transmission and reconstruction method with high spectral fidelity.

In this paper, the researchers select hyperspectral remote sensing image PROBE CHRIS with abundant coastal wetland ground objects to analyze spectral fidelity of wavelet transform compressed sensing algorithm on the basis of three indicators between reconstruction and original image pixel spectra: correlation coefficient, error and relative error. Meanwhile, eight typical ground objects are chosen to analyze their respective spectral deviation. The eight ground objects include Phragmites austrialis, Suaeda glauca, Taramix chinensis, Spartina, Salix babylonica, tidal flat, river and aquaculture water.

2 Hyperspectral Remote Sensing Data and Data Processing

2.1 Hyperspectral Remote Sensing Data

CHRIS is a remote sensor loaded on ESA PROBA. Its full name is Compact High Resolution Imaging Spectrometer. CHRIS have five imaging modes(Table 1), and can gather remote sensing images from five angles, i.e. 0°, +36°, -36°, +55°and -55°. This paper uses a Yellow river estuary CHRIS mode 2 image data (Figure 1) obtained in 2012 June, whose spectral range is 406-1035nm, spectral resolution 1.25-11.00nm and spatial resolution 17m.

The area where the CHRIS image covers is located in the junction between new and old Yellow river estuaries, which feature natural and artificial wetlands, such as Phragmites austrialis, Suaeda glauca, Taramix chinensis, Spartina, Salix babylonica, tidal flat, river and aquaculture water. Details of the typical ground objects are shown in Table 2.