DETECTION AND CORRECTION OF SPECTRAL AND SPATIAL MISREGISTRATION FOR HYPERSPECTRAL DATA

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1. INTRODUCTION

Hyperspectral imaging sensors suffer from spectral and spatial misregistration. Optical-system aberrations and misalignments cause these artifacts mainly due to pushbroom systems, where crosstrack and spectral pixels are continuously recorded at the same time using a two-dimensional detector array. The spectral misregistration, also known as "smile" or "frown" curve, is a shift in wavelength in the spectral domain, which is a function of crosstrack pixel numbers. The spatial misregistration, also called "keystone", corresponds to a band-to-band misregistration. They prevent the accurate acquisition of the spectra and thus reduce classification accuracies.

The main objective of this work is to detect and correct the spectral and spatial misregistration of hyperspectral image. In this work, the Hyperion VNIR is used as an example. Image matching by cross-correlation is used for detection and cubic spline interpolation is used for correction of artifacts. First, detection methods and correction results for spectral and spatial misregistration are demonstrated respectively. Later on, the change of the alignment of the sensor components at the launch is investigated by a simulation of basic spectrometer model.

2. SPECTRAL MISREGISTRATION

Hyperspectral sensors collect information as a set of images, each of which is a spectral band. These images form a three dimensional cube, composed of crosstrack (x), line (y) and spectrum (λ) dimensions. The pre-launch spectral property of the Hyperion VNIR was characterized by TRW using multispectral test bed [1]. Most people use TRW information to correct spectral misregistration. But past research has shown that the pre-launch spectral property has been changed after the launch [2].

This work estimates the spectral property of band 41 of the oxygen absorption line using image matching by a normarized cross-correlation on the x-λ plane. Sub-pixel estimation using parabola fitting over three pixel grid points with their similarity can detect the distortion of the line, which shows smaller value because of "pixel-locking" effect [3]. After correction of "pixel-locking" effect, the spectral property of band 41 is finally determined. Estimated property is a little different from the pre-launch property.

We correct bands 40 and 42 using cubic spline interpolation with the estimated spectral property, and evaluate validity of the correction with the difference of bands 40 and 42 those are much influenced by "smile" effect. As a result, the estimated spectral property is proved to be valid based on band ratio.

3. SPATIAL MISREGISTRATION

The pre-launch spatial misregistration was measured at 20 locations using a point source [4]. The post-launch spatial misregistration was also measured by TRW using lunar images obtained on orbit. However, this information is not attached to the Hyperion data. Therefore almost all users use the data without correcting spatial misregistration. Past study proposed a scene-based method, based on edge detection using sharpening filter, for spatial misregistration detection [5][6]. In this work, a scene-based point source detection method is proposed for detection of the post-launch spatial misregistration.

First, point source subscenes where the radiance is high in many spectral channels are detected. Then, we estimate the spatial misregistration using image matching for this spectral direction along the bright spectral line on the x-λ plane as the same way that used in the detection of the spectral smile.

All spatial misregistrations obtained by many point source subscenes are similar in many various crosstrack pixel numbers. We estimate the spatial misregistration is constant in all crosstrack pixel numbers. The spatial misregistration of the Hyperion

VNIR is corrected using cubic spline interpolation. Comparison of the spatial misregistration between before and after correction shows enhancement of spectral and spatial feature, showing that this method is effective for detection and correction of the spatial misregistration.

4. SPECTROMETER MODEL

The change in the alignment of the Hyperion VNIR components at the launch is considered qualitatively by a simulation of basic spectrometer model. Spot diagram is obtained by rotating mounting angles of slit, grating, and two-dimensional detector array. This simulation and the comparison with the Hyperion spectral and spatial properties between pre-launch and post-launch suggest that the slit or the grating may have rotated at the launch.

5. CONCLUSIONS

Image matching by a normalized cross-correlation for characteristic lines in the x-λ plane can detect spectral and spatial misregistration for the Hyperion VNIR. Cubic spline interpolation using estimated properties makes it possible to correct the spectral and spatial misregistration. The accuracy of proposed post-launch estimation of the Hyperion properties is comparable to that of the pre-launch measurements, which makes way to precise on-board calibration of hyperspectral sensors.

6. REFERENCES

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