On-orbit Spectral Performance Valuation of HJ-1A/HSI Data using Atmospheric Absorption Lines

Lingling Ma[1], Xinhong Wang [1], Lingli Tang [1], Chuanrong Li [1]
1. Academy of Opto-Electronics, Chinese Academy of Sciences, Beijing,
100190, China
Email: llma@aoe.ac.cn

Hyper-Spectral Imaging sensor (HSI) aboarded on the HJ-1A (The Small Satellite Constellation for Environment and Disaster Monitoring) was launched Sep. 6, 2008, in China. HSI covers the spectral range from 450 nm to 950 nm, with average spectral resolution 4nm[1]. Spectral calibration is one of the key performance parameters of hyper-spectral imaging sensor, the decline of spectral performance on orbit will effect the application of hyper spectral data. Therefore it's necessary to verify the offset of the Center Wavelength compared to the pre-launch laboratory measurements.

The large number of narrow observation channels of hyperspectral sensor makes it a useful tool for exploitation of the information contained in discrete absorption features of atmosphere constituents. Assuming the Gaussian shape of the spectral response function, Robert O. Green et al. used a spectrum matching method to evaluate the spectra of hyperspectral image[2]. This method considered the atmospheric absorption characteristics, such as H_2O, O_2 and CO_2 absorption lines, implied in the remote sensing data. The bias between spectrums obtained from the image and the simulated characteristic spectrums obtained from the spectra parameters were compared, which is used to assess the bias of the center wavelength of the sensors. This approach was successfully applied on some satellite and airborne sensors, such as Hyperion and AVIRIS [2,3].

In this paper, hyperspectral remote sensing data were simulated to estimate the displacement of center wavelength for HSI based on the atmospheric absorption characteristics. Firstly, the reflectances of several classified surface, including farmland, soil, grass land, lake, etc, were measured using field spectrometer, and the atmospheric parameters were obtained simultaneously. Secondly, assuming the spectral response curve of HSI follows Gaussian distribution, combined with observing geometry parameters (solar zenith angle, solar azimuth angle, observed zenith angle, observed azimuth angle, etc.), at-sensor radiances were simulated with a resolution of 1nm, based on MODTRAN, an atmospheric radiative transfer model[4]. Thirdly, changing the value of $\Delta\lambda$ and ΔF so as to update the spectral response function, at-sensor radiance L'_i was simulated with convolution of MODTRAN output which has a resolution of 1nm. Actual at-sensor radiance L_i was obtained directly from the corresponding image. The absorption lines were also considered, such as O_2 absorption line (0.76 μm), H_2O absorption line (0.82um μm, 0.94 μm), comparison between L'_i and L_i is used to solve the cost function. Optimization algorithm was used continuously to obtain new L'_i and get the minimum cost function value, then the bias of the center wavelength for each band could be estimated.

The comparison between the calibration of center wavelength and the pre-flight measurements showed that, the average bias of HSI channel center wavelength exceeds 2nm. It means that the adjustment of the center wavelength is indeed necessary according to the evaluation of the on-orbit performance.

Due to the lack of sufficient surface measurements, the optimization algorithm in this paper is not stable. Therefore, further improvements of this algorithm are necessary to obtain more credible evaluation results. Moreover, in order to achieve better HSI calibration results, the sensitivity of every parameter related to the retrieval results should be considered to improve the estimation accuracy.

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