Assessment of Atmospheric Correction Methods for Hyperspectral Remote Sensing Imagery Using Geospatial Techniques

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Abstract. Atmospheric correction is a main problem in visible or near-infrared remote sensing images since the existence of the atmosphere continuously influences the radiation from the ground to the sensor. Hence, atmospheric correction is necessary. Remotely sensed imagery has noise affected by atmospheric particles that can unclear the image and make quantitative analysis unreliable. The aim of this research is to evaluate atmospheric correction methods for remotely sensed imagery using ENVI software to get accurate results. In this research, three methods of atmospheric correction have been selected depend on the essential parameters whether from the image or field for hyperspectral imagery by using ENVI software. These methods include: IAR Reflectance, Flat field correction, and Empirical Line Correction. The results showed the corrected images from three methods give better interpretation of Z-profile than original image which helps to determine the absorption feature and increase the possibility to get a good result after processing. IAR Reflectance method gives easier spectral curve to be interpreted when comparison between radiance spectrum and reflectance spectra than other correction methods.

1. Introduction

Hyperspectral remote sensing (HRS) imagery has huge numbers of continuous bands. It provides a complete record of spectral responses of materials over the wavelengths considered. HRS data can be analysed in a much more advanced ways than multispectral data, thus providing more information [1]. In the image analysis, an accurate representation needs for a land area, whether analysing vegetation, locating an object, or detecting change in an area over time [2]. HRS has a huge of data, but data mining procedure needs an exact considerate of the kind of ground surface materials that it is trying to measure and how relate to the measurements gathered by hyperspectral sensors [3]. Several of the recorded data may be create to be redundant and require some processing to decrease the redundancy, either in spatial or spectral data space [4]. Atmospheric particles is a main concern in visible or near-infrared remote sensing as the presence of the atmosphere always influences the radiation from the ground to the sensor[5]. So the atmospheric correction is compulsory. The purpose of atmospheric correction is to save the surface reflectance from remotely sensed imagery by eliminating the atmospheric effects [6]. Atmospheric correction has been presented to considerably increase the accuracy of image classification [7]. This problem has received a considerable care from researchers in remote sensing who have devised a number of solution methods [8].

The aim of this research is to assess three relative atmospheric correction methods for hyperspectral remotely sensed imagery using ENVI software to improve the accuracy of image classification and get a good results.
2. Problem Statement
One of the sources of noise is due to atmosphere that includes: irradiance variation (solar energy, aerosols, and water vapour), atmospheric attenuation (scattering, absorption) and atmospheric path radiance (multiple scattering). Hence, the atmospheric correction is needed since the occurrence of the atmosphere often effects the radiation from the ground to the sensor that leads to know which methods that used in this correction and its evaluated using geospatial techniques such as ENVI software.

3. Materials and Methodology
In this research, three methods of atmospheric correction for hyperspectral image are used in ENVI software. These methods are: IAR Reflectance, Flat field correction, and Empirical Line Correction. These methods are selected because they are common and very basic methods. These methods involve empirical approaches that exist in ENVI software. These methods can be explained as following:

3.1. IAR Reflectance correction method
IARR approach stands for “internal average relative reflectance”. It computes the mean spectrum of a scene. The spectrum of any pixel in the scene is divided by the mean spectrum to predict the relative reflectance spectrum for the pixel [9]. This method assumes that average contains no surface features anymore. Data with combined bands (182,177,172) as shown in the Figure 1.

Figure 1. Data with combined bands (182,177,172).

3.2. Flat field correction (FF) method
Flat Field Correction assumes that target shows no spectral features. This method needs spectrally flat, bright target and needs only information from scene [10]. Also, it needs to choice a region of interest (ROI) [11]. The mean spectrum from the ROI is used as the reference spectrum which it is divided into the spectrum at each pixel of the scene as shown in the Figure 2.

Before applying this method, some point should be considered:
A- Defining a region of interest for an area having overall high albedo showing little or no absorption features.
B- The area should be spectrally homogeneous as much as possible.
3.3. Empirical Line Correction method

Empirical Line needs bright and dark target (homogenous) and absolute spectral information for two targets. Also, it makes regression for each wavelength and corrects all other pixels in scene that leads to remove the solar irradiance [12]. The relationship between reflectance and radiance given by the equation below [9, 13]:

\[
\text{Reflectance (field spectrum) = offset + gain \times radiance (input data)}
\]

Before perform the steps of this method, should specify the bright and dark target from the image: The bright target is the “Playa” and the dark target is the asphalt road no. 95 as shown in the figures 3 and 4.
4. Results and discussion

Based on three methods of atmospheric correction, the results for each method using ENVI software as following:

1- The result which is reflectance image of IAR Reflectance correction method as new display and link it with radiance image. Then, open the Z Profile (Spectrum) for each one to see the difference between them as shown in the fig.5 where the Radiance image is on the left side of this figure, whereas the Reflectance Image of IAR method is on right side of this figure. Consider that the spectral curve of radiance image dominated by solar energy and atmospheric reflectance.

![Figure 5. Difference between Radiance image and Reflectance Image of IAR method.](image)

2- The result which is reflectance image of Flat field correction (FF) method display with same bands combination and link it with radiance image to see the differences between radiance and reflectance images as shown in the Figure 6 where the Radiance image is on the left side of this figure, whereas the Reflectance Image of FF method is on right side of this figure.

![Figure 6. Difference between Radiance image and Reflectance Image of FF method.](image)
3- Evaluation of the reflectance result for four samples based on previous three methods results as follows:

A- Sample 505, line 580; a pure kaolinite spectrum:
The three methods give different amount of reflectance within different range of wavelength so it can be seen that the high amount of reflectance notices in the IAR method which recorded reflectance in 2.05 and the minimum reflectance recorded in 2.5 bandwidth. As overall reflectance it can be noticed in second method (flat field method) as shown in the Figure 7. Where IAR method is represented left image of this figure and Flat Field method is represented the middle image of this figure, whereas empirical line method is represented the right image of this figure.

Figure 7. Evaluation of the reflectance result of sample 505.

B- Sample 589, line 565; a playa spectrum:
In this sample, it is very clear to see the graduated amount of reflectance can be seen in the first result also it has more amount of reflectance than other as shown in the Figure 8 where IAR method is represented left image of this figure and Flat Field method is represented the middle image of this figure, whereas empirical line method is represented the right image of this figure.

Figure 8. Evaluation of the reflectance result of sample 589.
C- Sample 538, line 532; an alunite spectrum:
In this sample, the comparison result of three method also the first result five the higher amount of reflectance than other as shown in the Figure 9 where IAR method is represented left image of this Figure and Flat Field method is represented the middle image of this Figure, whereas empirical line method is represented the right image of this Figure.

![Figure 9. Evaluation of the reflectance result of sample 538.](image)

D- Sample 259, line 610; a calcite spectrum
The three methods give different amounts of reflectance in different region of wavelength. It can be seen there is same region of absorption in 2.35 wavelength as shown in the Figure 10 where IAR method is represented left image of this figure and Flat Field method is represented the middle image of this figure, whereas empirical line method is represented the right image of this figure.

![Figure 10. Evaluation of the reflectance result of sample 259.](image)

Based on the previous results, as overall shapes of spectral curves of three methods results, it can be easily determine the absorption features positions which help us to find and identify the materials when comparison between radiance spectrum and reflectance spectra of kaolinite of three methods results. In addition, as overall shapes of spectral curves of three methods results, it can be difficult to determine the absorption features positions except the IAR method which give us easy spectral curve to be interpreted when comparison between radiance spectrum and reflectance spectra of Playa of
three methods. Hence, the current study gives good results and can optimal method for atmospheric correction as compared with past studies.

5. Conclusion
The atmospheric correction means to remove or reduce the effects of atmosphere from image. These effects influence on the quality of data which in turn reduce the quality of the getting result from the processing steps, especially image classification. In ENVI software there are three methods to do the atmospheric correction. These methods divided to three methods depend on the essential parameters whether from the image or field. As a result of applying atmospheric correction methods in this research, the corrected images from three methods give better interpretation of Z-profile than original image in which helps to determine the absorption feature and increase the possibility to get a good result after processing. It can be concluded that atmospheric correction is an important preprocessing step. IAR correction method gives easier spectral curve to be interpreted when comparison between radiance spectrum and reflectance spectra of Playa spectrum than other correction methods. Also, the high amount of reflectance notices in the IAR method which recorded reflectance in 2.05 and the minimum reflectance recorded in 2.5 bandwidth. Overall reflectance it can be noticed in second method (flat field method) that leads to determine the absorption features positions easily which help to find and identify the materials when comparison between radiance spectrum and reflectance spectra of kaolinite spectrum.

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