A Correction Approach to Bidirectional Effects of EO-1 Hyperion Data for Forest Classification

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Abstract: Hyperion, as hyperspectral data, is carried on NASA's EO-1 satellite, can be used in more subtle discrimination on forest cover, with 224 band in 360 – 2580 nm (10nm interval).

In this study, Hyperion image is used to investigate the effects of topography on the classification of forest cover, and to assess whether the topographic correction improves the discrimination of species units for practical forest mapping.

A publicly available Digital Elevation Model (DEM), at a scale of 1:25,000, is used to model the radiance variation on forest, considering MSR(Mean Spectral Ratio) on antithesis aspects. Hyperion, as hyperspectral data, is corrected on a pixel-by-pixel basis to normalize the scene to a uniform solar illumination and viewing geometry.

As a result, the approach on topographic effect normalization in hyperspectral data can effectively reduce the variation in detected radiance due to changes in forest illumination, progress the classification of forest cover.

Keyword: Hyperion, Topography, Classification, Normalization, Forest Cover

1. Introduction

Hyperion, as hyperspectral data is widely studied in multi purpose. In actually application as if researching for a gold mine or other resources, it is more effect for higher spectral resolution.

In this paper, hyperspectral data is used to investigate the effect of topography on a forest classification, and to asses whether the topographic normalization improves the discrimination of forest cover.

We present the method of topographic normalization of hyperspectral data, which has 242 spectral band. The topographic normalization can effectly reduce the variation in detected radiance due to changes in local illumination. As a result, it's estimated in forest classification, and show the more effect.

2. Study area and dataset

The study area is the Ghanak Mountain, located in Seoul and Kyunggi province(central coordinate : 126°58'40", 37°18'40"), and covers an area of about 89.5 km^2(Fig.1).

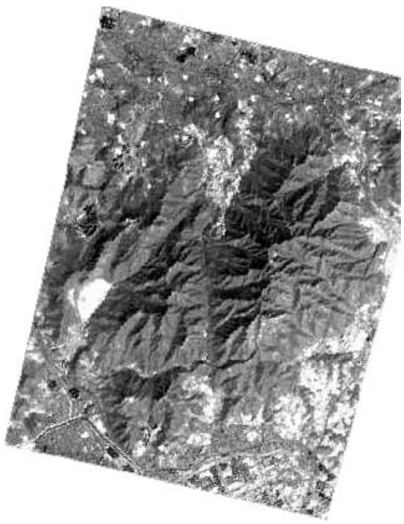

Fig. 1. Hyperion 40 band in Ghanak Mountain

The dataset is an image of Hyperion, hyperspectral sensor, which is carried on NASA's EO-1 satellite, was launched on November 21, 2000. it's spectral resolution is very high as 242 bands in 0.36 ~ 2.58μm(Fig.2), which is overlapped 21 spectral bands in 0.85 ~ 1.06 μm, and 1~7 Band (0.36~0.42 μm) and 225~242 Band (2.41~2.58 μm) to has zero value. Actually usable range is total 196 bands in 0.43~2.4 μm(Fig.3).

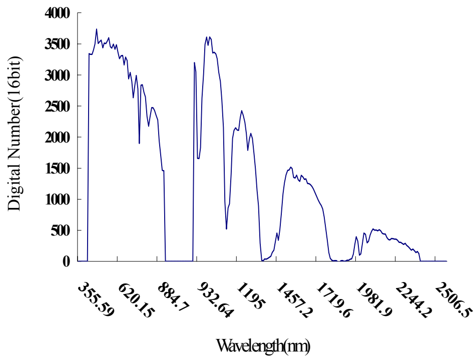

Fig. 2. Original Spectral Range in bare soil

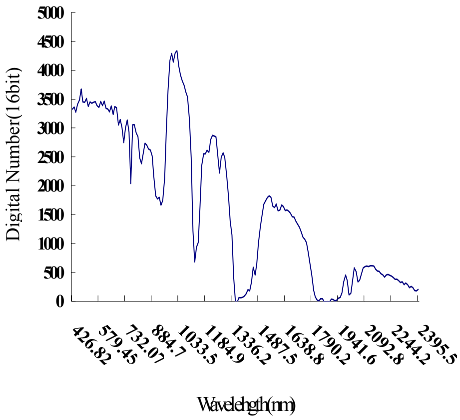

Fig. 3. Corrected Spectral Range in bare soil

The purpose of this study is that explores how a topographic correction applied to hyerspectral data, and generate more detailed and exact classification in forest cover by Hyperion. So a relative atmospheric correction method avoiding an absolute atmospheric correction by site data is only implemented in the preprocessing of the data prior to the application of the radiance correction using a digital terrain model (DTM).

Dark current removal is performed, followed by scaling by 40 for the VNIR and 80 for the SWIR, used only 183 bands out of a total of 242 bands, which don't have noise. We have scaled the VNIR bands by a factor of 1.18 to ensure radiometric fidelity(1).

$$\text{VNIR} \times 43.2 \quad \text{and} \quad \text{SWIR} \times 94.4 \quad \ldots\ldots\ldots (1)$$

For effective process, about 10 bands in radiometric simillar is compressed by mean to regenerate total 18 radiometric groups. Geocoding of the Hyperion data to Transvers Mercator(TM) projection resulted in a root-mean-square (RMS) error of 0.2765 for the VNIR and SWIR using 12 ground control points (GCPs).

3. Radiance correction

In remote sensing for forest cover, it's very important to correct the radiance due to changes in forest illumination. The illumination over the study area comes from two major sources, direct and diffuse solar illumination. Terrain relief changes the direct solar illumination by modulating the solar radiance at different slop angles and aspects. Diffuse light, which is a result of multiple scattering from atmospheric constituents, can be simplified as non-directional and significantly modulated by topography. Therefore, it can be treated as an additive term to the surface illumination assuming horizontally isotropic atmospheric conditions.

$$Cos\ i_{OPP} = Cos(90-\theta_S)\cdot Cos\theta_N + Sin(90-\theta_S)\cdot Sin\theta_N \cdot Cos(\phi_{OPPS}-\phi_N)$$
$$DN_N = DN_T \cdot Cos\ i_{OPP}\cdot(1-\omega)+\omega \quad \ldots\ldots\ldots (2)$$

i_{OPP} : the opposite angle between the solar rays and the normal to the surface

θ_S : the elevation of the sun　　ϕ_{OPPS} : the opposit azimuth of the sun

θ_N : the slope of each surface element　　ϕ_N : the aspect of each surface element

DN_N : Digital Number at the normal to the surface

DN_T : Digital Number at terrain relief,　ω : coefficient for topographic normalization

In this study, we are trying to suggest the function for topographic normalization with relative radiance quantity for terrain effects and mean radiance ratio in a opposite slop(2). It is basically based on a Lambertian scattering model in unified surface assumption.

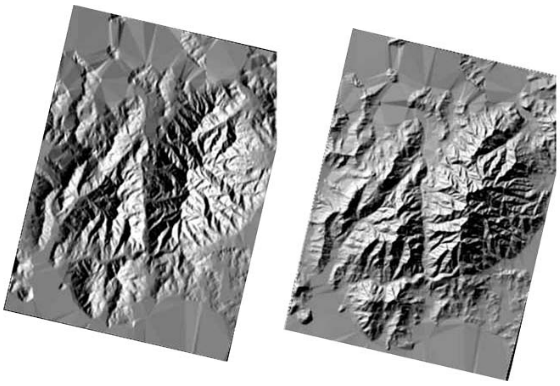

Fig. 4. the change of radiance for an opposite solar direction in forest terrain

4. Estimation by Classification

After classification in 10 grades by ISODA unsupervised classification method in more ease to apply, the image is classified on only forest area in 7 grades (fig 5). As a result, it can be more clearly recognized the classification error, which cause by the radiance variation due to changes in terrain, is reduced a lot. Also it is more variable into 7 grades after topographic normalization from 5 grades before, but the classified forest area isn't changed after and before.

5. Result

Although a primary advantage of hyperspectral data is their ability to provide more detail and exact classification of forest cover, there is difficulty to normalize topographic effect for many bands.

So we are focusing on finding the Topographic Normalization Method to apply in more easy. The method suggested in this paper yielded more good classification results for mapping forest cover type, is more effect to reduce a terrain effect in Hyperspectral dataset involving so many bands over 100.

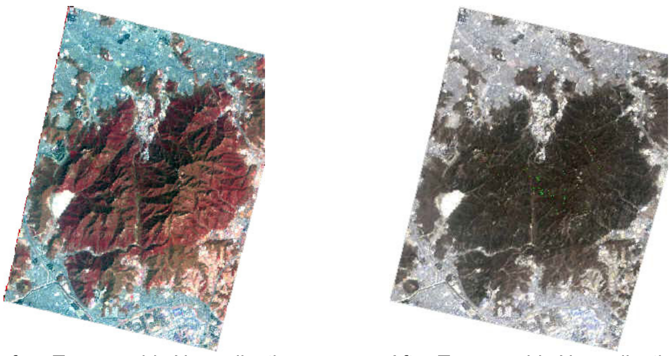

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Fig. 5. The HYPERION image normalized topographic effects (band 9, 5, 3)

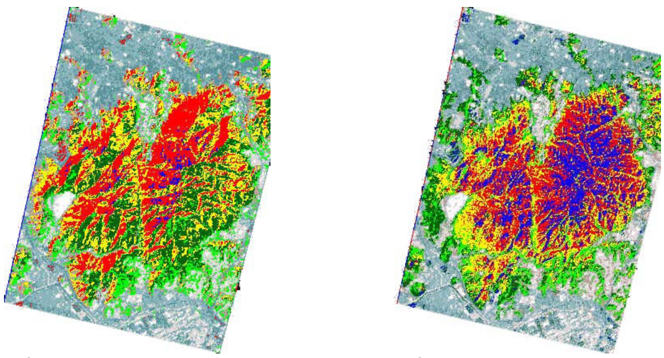

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Fig. 6. The classification on only forest area in 7 grade