

NEW ATMOSPHERIC CORRECTION METHOD BASED ON BAND RATIOING

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ABSTRACT

The Atmosphere plays a central role in the reflectance of the Earth and contributes an additive path radiance term that will cause an error in the sensor readings of the data acquired by the satellite. It is necessary then to get rid of the atmospheric effect to retrieve the actual surface reflectance. Atmospherically corrected surface reflected images improve the accuracy of surface land use and Earth's reflected data. The problem to estimate surface reflectance is the assessment of the path radiance. In this paper, characteristics computation was based on the dark object theory; the atmospheric parameters are considered in regions where the absorption is maximal. Histogram satellite image has been used the correction factor; i.e. histogram peak value was adopted. Histogram mean and standard deviation are also used for the path radiance estimation. For the image bands in the visible spectrum, water areas involve some non-zero DN value. These non-zero DN values are adopted to represent the path radiance. The most probable "histogram-peak" is introduced to overcome the problem of non-zero existed values.

As a fidelity test, regions that have been considered to represent the path radiance are classified and isolated from other image regions. The degree of correlation between isolated image regions has been considered to satisfy the method for path radiance estimation. Eigen values and covariance matrix of the principal components have been used for this qualification test.

1. INTRODUCTION:

Landsat thematic mapper TM have been extensively used for agricultural evaluation, forest management inventories, geological surveys, water resource estimations, coastal zone appraisals and host of other applications. The enhanced thematic mapper ETM+ on landsat7 that was launched on April 15, 1999 was providing observation at higher spatial resolution and with greater measurement precision than the previous TM. [1]. As the utility of these data become more quantitative, the accurate retrieval of the surface reflectance become increasingly important. (e.g. almost all of the canopy radiative

transfer models that are used for inverting land surface biophysical parameters are based on surface reflectance).

Unfortunately, a very large percentage imagery are severely contaminated by aerosols, clouds, and cloud shadows. TM images can be potentially more useful if we can remove the effect of aerosols, thin clouds, and cloud shadows. This procedure for retrieving surface reflectance is usually called atmospheric correction.

Atmospheric correction consists of two major steps; parameter estimation and surface reflectance retrieval. As long as all atmospheric parameters are known, retrieval of surface

reflectance is relatively straight forward when the surface is assumed lambertian for TM-type data.

Earlier studies attempted to develop approximate solutions to the atmospheric radiative transfer equation for quick calculations, but the typical approach that now being widely accepted is the so-called look-up table method [2]. With this approach, radiative transfer codes are used off-line to compute tables for on-line corrections. So then, the estimation of atmospheric parameters from the imagery itself is the most difficult and challenging step.

Atmospheric effects include molecular and aerosol scattering and absorption by gases. Such as water vapor, ozone, oxygen and aerosols. Molecular scattering and absorption by ozone and oxygen are relatively easy to correct because their concentrations are quite stable over both time and space. The effect of water vapor absorption is significant for the TM/ETM+ 's near infrared (IR) channels, but there is insufficient information that allows us to estimate water vapor content from TM/ETM+ imagery. The practical approach is to use climatology data or other satellite products. The most difficult component of atmospheric correction is to eliminate the effect of aerosols. The fact that most aerosols are often distributed heterogeneously makes this task more difficult.

After reviewing the historical development of atmospheric correction, we will present a new algorithm designed to handle general atmospheric and surface conditions and is therefore suitable for operational applications. The key feature of this new algorithm is the automatic estimation of heterogeneous aerosols distribution from the imagery itself. Because of the high spatial resolution, the surface adjacency effect is considerable and it is not homogeneous. this has also been considered in this study.

2.Review of the existing atmospheric correction algorithms

There is relatively long history of the quantitative atmospheric correction of TM imagery. All methods reported in the literature can be roughly classified into the following groups :

Invariant-object, histogram matching, dark object, and the contrast reduction. It is not our intention to review each algorithm conclusively, but it will be helpful to understand the advantages and limitations of representative algorithms. Each group will be briefly evaluated in the following sections. Note that most statistical methods (e.g., [3], [4], [5]) and the methods that do not correct heterogeneous aerosol scattering are not discussed here.

A. Invariant-Object Methods

The Invariant-Object method assumes that there are some pixels in any given scene whose reflectance are quite stable.

A linear relation for each band on the reflectance on these "invariant objects" can be used to normalize images acquired at different times. This method was successfully used in the FIFE (first ISLSCP field experiments) TM imagery processing [6]. It is relative normalization. If there are simultaneous ground reflectance measurements available or some assumptions about surface properties are made [7], [8], it can be an absolute correction procedure.

This method is simple and straightforward, but it is essentially a statistical method and performs only a relative correction. Another major limitation is its difficulty in correcting heterogeneous aerosol scattering.

B. Histogram Matching Methods

In the histogram matching method, it is assumed that the surface reflectance histograms of clear and hazy regions are the same. After identifying clear sectors, the histograms of hazy regions are shifted to match the histograms of their reference sectors (clear regions) [9], [10]

The idea behind this method is quite simple and it is also easy to implement. This method has been incorporated into ERDAS Imagine image processing software package. The PCI image processing software package is also based on a similar principle. However, the major assumption is not valid when the relative compositions of different objects and their spectral reflectances are different. This method also does not work well if the spatial distribution of aerosol loadings changes very dramatically. If the scene is divided into many small segments to deal with the variable aerosol loadings, it is most likely that the major assumption of this method will be violated.

C. Dark-Object Methods

If a scene contains dense vegetation, ETM+TM 7 band (around $2.1 \mu\text{m}$) can be used to identify these dense vegetation pixels and their reflectances have strong correlation with band 1 (blue) and 3 (green) reflectances. Since dense vegetation has very low reflectance in the visible spectrum, they are referred to as "dark objects," this method has a long history [11], [12], [13], [14], [15], [16] and is probably the most popular atmospheric correction method. Both the moderate-resolution imaging spectrometer (MERIS) and medium resolution imaging spectrometer (MERIS) atmospheric correction algorithms

[13], [17] are based on this principle. However, this method does not work well if the dense vegetation is not widely distributed over the hazy regions. The required existence of dense vegetation canopies is a serious limitation to many land surface imagery acquired over the

winter season in the northern hemisphere. The empirical relations between band 7 reflectance and blue (band 1) and green (band 3) reflectances may also vary under different vegetation conditions.

D. Contrast Reduction Methods

For regions where surface reflectance are very stable, the variations of the satellite signal acquired at different times may be attributed to variations of the atmospheric optical properties. The Aerosol scattering reduces variance of the local reflectance. The larger the aerosol loading, the smaller the local variance. Thus, the local variance can be used for estimating the aerosol optical depth. This method has been successfully applied to desert dust monitoring. Its assumption of invariant surface reflectance limits its global applications because under general conditions surface reflectance changes in both space and time.

3- The new method

To overcome the problems associated with the existing methods discussed above, we have developed a new atmospheric correction algorithm in which the key component is to estimate the correction factor that can be obtained from the what we called band ratio to get rid of undesirable effect in the satellite images

4-Ratioing :

Sometimes the differences in the brightness values from the similar surface materials are caused by topographic conditions, shadows or seasonal changes in the sunlight illumination

angle and intensity. These conditions may hamper the ability of interpreter or classification algorithm to correctly identify surface materials or land use in a remotely sensed image. Fortunately, ratio transformation of remotely sensed data can, in certain instances, be applied to reduce the effect of such environmental conditions (friendman 1978). In addition to minimizing the effects of environmental factors, ratios may also unique information not available in any single band that is useful for discriminating between soils and vegetation (satterwhite 1984)

The mathematical expression of the ratio function is:

$$BV_{ijr} = \frac{BV_{ijk}}{BV_{ijl}}$$

Where BV_{ijr} is the output ratio value of the pixel at row i , column j , BV_{ijk} is the brightness value at the same location in the K band; and BV_{ijl} is the brightness value in the I band. unfortunately, the computation is not always simple since $BV_{ij} = 0$ is possible. However, there are alternatives e.g. the domain of the function is $1/255$ to 255 (i.e. the range of the ratio function includes all values beginning at $1/255$, passing through 0 and ending at 255). the way to overcome this problem is simply to give any BV_{ij} with a value of 0 , the value of 1 . alternatively, some like to add a small value (e.g. 0.1) to denominator if it equal to zero.

To represent the range of the function in the linear fashion and to encode the ratio values in standard 8-bit format (values from 0 to 255), normalizing functions are applied. Using this normalizing function, the ratio value 1 is assigned the brightness value 128 . ratio value within the range $1/255$ to 1 are reassigned values between 1 and 128 by the function

5-Results :

We use MSS image that captured at 1976 path 181 and row 38 near alnajaf city – iraq and extract image from the full scene and it can be seen the difference of the image before and after correction using band ratio correction factor.



Figure (1):The original image type MSS captured at 1976 band 1 p181 r38



Figure (2):The band1 image before correction



Figure (3): The band 1 image after correction b1-b1/b2



Figure (4): The image after correction b1-b1/b3

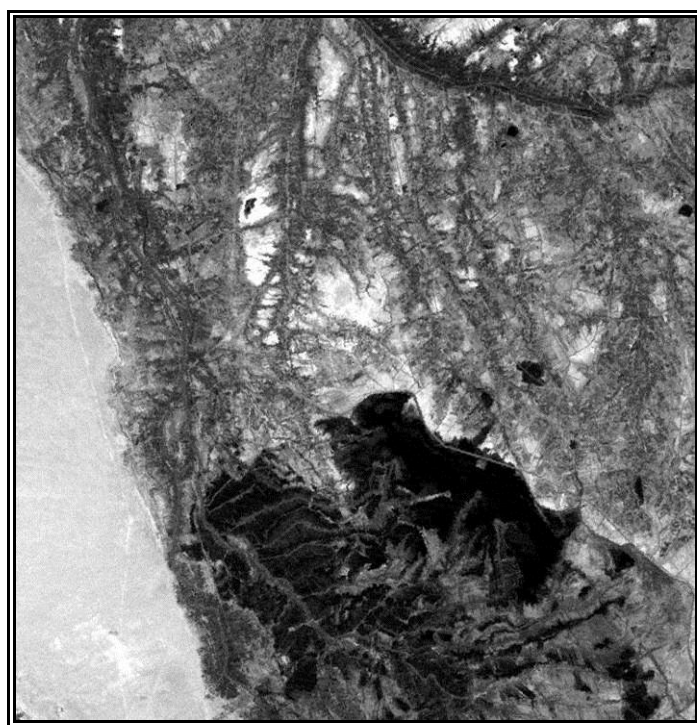


Figure (5): The image after correction b1-b1/b4

6- Correction Examples

Figures compares three true color composite imagery before and after atmospheric correction using this method . these are three 600*600 windows from the same ETM+ imagery acquired on November 17,1999,but they have different surface reflectance and aerosol distribution patterns >the solar zenith angle is 63.51 and azimuth angle is 162.83. the atmospheric effects are much larger in these blue band images. In these examples ,the ratios of band 1 to band 4 images were segmented to generate clear / hazy regions. From these figures, we can see that atmospheric correction produces significant different visual effects. Most of the hazy regions have been cleaned up. Note that all pixels seem brighter after atmospheric correction. The reason is that the dynamic range of pixel values becomes smaller after atmospheric correction, but the display brightness range is the same. It is important to point out that dark –object method fails to correct these three images since no dense vegetation canopies are widely distributed over the agricultural region in the winter season .use of the histogram matching algorithm is also inappropriate since landscape of the hazy and clear areas are not exactly the same and the spatial distribution of aerosol optical depth changes dramatically .

In the companion paper ,we will quantitatively evaluate the accuracy of this atmospheric correction algorithm over the EOSLANDCORE VALIDATION SITE.BELTVILLE,MD.

References:

- [1] S. N. Goward and D. L. Williams, "Landsat and earth systems science: Development of terrestrial monitoring, " photogramm. Eng. Remote Sensing, vol. 63, pp. 887-900, July 1997.
- [2] R. S. Fraser and Y. J. Kaufman, " The relative importance of scattering and absorption in remote sensing, " IEEE trans. Geosci. Remote Sensing, vol. GE-18, pp. 2577-2584, 1985.
- [3] P. Switzer, W. Kowalik, and R. J. P. Lyon, "Estimation of atmospheric path-radiance by the covariance matrix method, " Photogramm. Eng. Remote Sensing, vol. 47, pp. 1469-1476, 1981.
- [4] J. F. Porter, "The channel correlation method for estimating aerosol levels from multispectral scanner data," Photogramm. Eng. Remote Sensing, vol. 50, pp. 43-52, 1984.
- [5] J. Lavreau, "De-hazing Landsat thematic mapper images," Photogramm. Eng. Remote Sensing, vol. 57, pp. 1297-1302, 1991.
- [6] R. Richter, "A spatially adaptive fast atmospheric correction algorithm," Int. J. Remote Sens. Environ., vol. 17, pp. 1201-1214, 1996.
- [7] "Atmospheric correction of satellite data with haze removal including a haze/clear transition region," Comput. Geosci., vol. 22, pp. 675-681, 1996.
- [8] P. M. Tellet and G. Fedosejevs, "On the dark target approach to atmospheric correction of remotely sensed data," Can. J. Remote Sensing, vol. 21, pp. 374-387, 1995.
- [9] Y. J. Kaufman, A. Wald, L. A. Lorraine , B. C. Goa, R. R. Li, and L. Flynn, "Remote sensing of aerosol over the continents with the aid of a 2.2 um channel," IEEE trans. Geosci. Remote Sensing, vol. 35, pp. 1286-1298, July 1997.

- [10] Y. J. Kaufman, and C. Sendra, "Automatic atmospheric correction," Int. J. Remote Sensing, vol. 9, pp. 1357-1381, 1988.
- [11] Y.J Kaufman and C. Sender, " Automatic atmospheric correction," int.J. Remote Sensing vol. 9, pp. 1357-1381.
- [12] S. liang, H. Fallah-Adl, S. Kulluri, J. JaJa, Y. Kaufman, and J. Town- shend, "Development of an operational atmospheric correction algorithm for TM imagery ," J. Geophys. Res., vol. 102, pp. 17 173-17, 1997.
- [13] T. Popp, "Correcting atmospheric masking to retrieve the spectral al bedo of land surface from satellite measurements," Int. j. Remote Sensing, vol. 16,pp. 3483-3508, 1995.
- [14] R. Santer, V. Carrere, P. Dubuisson, and J. C. Roger. "Atmospheric correction over land for MERIS," Int. J. Remote Sensing, vol. 20, pp. 1819-1840, 1999.
- [15] D. tanre and M. legrand , "On the satellite retrieval of Saharan dust optical thickness over land: tow different approaches," J. Geophys Res., vol. 96, pp. 5221-5227, Mar. 1991 .
- [16] D. Tanre, P. Y. Deschamps, C. Devaux, and M. Herman "Estimation of Saharan aerosol optical thickness from blurring effects in Thematic Mapper data, "J. Geophys. Res., val. 93,pp. 15955-15964, Dec. 1988.
- [17] FRIEDMAN, S. Z. 1980.Mapping Urbanized Area Expansion through Digital Image Processing of Landsat and Conventional Data , Pasadena , Galif.: jet Propulsion Laboratory Publication 79-113.
- [18] SATTER WHITE,M. B. 1984. "Discriminating vegetation and soils using Landsat MSS and Thematic Mapper Bands and Band Ratios," Technical papers ,50th Annual Meeting of the American Society of Photogrammetry , Vol. 2, pp. 479-485.