Dark Object Subtraction of Landsat MSS Satellite Images

حسين محي الموسوي
ايتقال نقي حسن
جامعة الكويفه / كلية العلوم للنبات

Abstract

Solar radiation reflected by the Earth’s surface to satellite sensors is modified by its interaction with the atmosphere. In this research, Dark Object Subtraction (DOS) have been applied to reduce the atmospheric effects. The principle of the DOS based on the signal reaching the satellite sensors from a dark object, especially the atmosphere at visible wavelengths. Therefore, the pixels of dark targets indicating the amount of upwelling path radiance in this band. The atmospheric path radiance has been added to the surface radiance of the dark target to give the true target radiance at the sensor. A suitable dark target, such as a deep water area is selected in the studied area of this research. Moreover, histogram method has been used for calculate the mean, most probable, standard deviation, and maximum values which can then be considered as path radiance, then have been subtracted from each spectral band for original image. The most suitable value selected as a path radiance is the most probable value.

1- Introduction

Earth's atmosphere has always been a center of curiosity especially in the field of remote sensing [Prashant et al., 2007]. The existence of the atmosphere causes problems, because electromagnetic radiation (EMR) from the sun that is reflected by the earth and detected by the satellite or aircraft-born sensor must pass through the atmosphere twice, once in its journey from the sun to the earth and once after being reflected by the surface of the earth back to the sensor. During its passage through the atmosphere, EMR interacts with particulate matter suspended in the atmosphere and with molecules of the constituent gases. This interaction is usually described in terms of two main processes, scattering and absorption [Qihao et al., 2011]. The interaction between electromagnetic radiation and Earth's surface changes the characteristics of the radiation. Radiance energy that is scattered into detectors by an atmosphere, and that does not interact with the ground surface, is known as path radiance. This usually is unwanted information for a field investigator, because it reveals nothing about the nature of the land surface [John et al., 2006 and Jay et al., 2009].

This interaction with the atmosphere is stronger when the target surfaces consist of non-bright objects, such as water bodies or vegetation. This problem is especially significant when using multi-spectral satellite data for monitoring purposes, such as agricultural or land use studies. Hence, it is essential to consider the effects of the atmosphere by applying a reliable and efficient atmospheric correction during pre-processing of digital data [Hadjimitsis et al., 2010 and Chaves et al., 1988].
2- Study Area

The study area is located within (33° 2' N, 43° 23' E) and (32° 50' N, 43° 38' E). This area is a part from AL-Razzazah lake, north-west of Karbala city, located at 20km from the city center. It is the second lake in Iraq after AL-Tharthaar lake that located at the north, in terms of area, where estimated area about 1700 km². This lake linked from the north with AL-Habaniya lake by AL-Majara channel. The lake basin includes a number of Valleys, the most important is AL-Ubayad and AL-Gaddaf Valley. The study area is characterized relatively by the flat sandy terrain, including some of the rocky barriers.

The image data used for this study were Landsat MSS data collected on 24 July 1976 (path 182, row 37) with ground cell resolution (79 m×79m). Image size is (406 pixel) in rows and (396 pixel) in columns.

3- Correction Method Applied

In the simplest correction for the visible wavelength region (0.45µm-0.69µm), the effort is focused on estimating the upwelling atmospheric path radiance [Robert et al., 2007]. The (DOS) method assumes that within a satellite image there exist features that have near-zero percent reflectance (i.e., water, dense forest, shadow), such that the signal recorded by the sensor from these features is solely a result of atmospheric scattering (path radiance), which must be removed [Paul et al., 2009 and Michael et al., 2011]. In this research, the histogram method has been adopted to estimate the path radiance, according to the procedures which are summarized in the following steps:

1- Extracting image region that contains a dark object which can be used for correction.
2- Utilizing unsupervised image classification for the extracted image.
3- Binarizing the classified image regions using color slicing method, setting the selected class color (dark area) into "1", and the rest of the image to "0".
4- Isolating the selected dark object from the other regions.
5- Getting the statistics of the resulted image from step (4) i.e. calculating the histogram of the isolated image data and then determine the non-zero values; maximum, mean value, most probable value, standard deviation value and other statistics factors that help in specifying the path radiance value of each band.
6- Repeat step (1-5) for other.
7- Subtract the path radiance from its own band such as most probable value, mean, maximum and standard deviation of the isolated areas.

Table (1) represents some statistical features extracted from the isolated regions of the considered Multi Spectral Scanner(MSS) bands. Figure (1) illustrates the flow chart of the correction process. Figure (2) illustrates the isolation processing steps.

Table (1): Statistical features extracted for the isolated region.

<table>
<thead>
<tr>
<th>Band</th>
<th>Minimum value</th>
<th>Maximum value</th>
<th>Mean value</th>
<th>Most probable value</th>
<th>Standard Deviation value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>47</td>
<td>7.9</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>64</td>
<td>6</td>
<td>6</td>
<td>12.5</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>53</td>
<td>9.7</td>
<td>9</td>
<td>11</td>
</tr>
</tbody>
</table>
Figure (1): General flow chart for atmospheric correction.

1. Original Image
2. Classified image regions using unsupervised method
3. Binarization image using density slice approach
4. Multiplication binary image by each band
5. Calculate statistic of the isolated object in each band
6. Determine the path radiance from each image
7. Subtract the mean value which regard it as path radiance
8. Subtract the most probable value which regard it as path radiance
9. Subtract the maximum value which regard it as path radiance
10. Subtract the standard deviation value which regard it as path radiance
11. Compare between the principal components before and after correction for each band
Figure (2): Illustration of isolation process, the classification process is carried out by adopting the unsupervised k-means classifier, number of classes=5, change threshold=5, max.iteration=1.

Figures (3),(4),(5),(6) illustrates the result of correction three adopted MSS bands image by subtraction the standard deviation, most probable, mean values, and maximum values respectively as path radiance, the images at left represent uncorrected images and at right corrected images.
Table: Results of the digital number correction using the standard deviation value (std.) as Path radiance (original band and correction band).

<table>
<thead>
<tr>
<th>Band</th>
<th>Band image before correction</th>
<th>Band image after correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><img src="image1.png" alt="Image 1" /></td>
<td><img src="image2.png" alt="Image 2" /></td>
</tr>
<tr>
<td>2</td>
<td><img src="image3.png" alt="Image 3" /></td>
<td><img src="image4.png" alt="Image 4" /></td>
</tr>
<tr>
<td>3</td>
<td><img src="image5.png" alt="Image 5" /></td>
<td><img src="image6.png" alt="Image 6" /></td>
</tr>
</tbody>
</table>

Figure (3): Results of the digital number correction using the standard deviation value (std.) as Path radiance (original band and correction band).
Table 1: Band image before and after correction

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<td><img src="#" alt="Image 4" /></td>
</tr>
<tr>
<td>3</td>
<td><img src="#" alt="Image 5" /></td>
<td><img src="#" alt="Image 6" /></td>
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</table>

Figure (4): Results of the digital number correction using the most probable value as path radiance (original band and the corrected band).
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<td><img src="image6.png" alt="Image" /></td>
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</table>

Figure (5): Results of the digital number correction using the mean (m) value as path as path radiance (original band and the corrected band).
Figure (6): Results of the digital number correction using the maximum value (max) value as path radiance (original band and the corrected band).

Classification could be adopted as a basis for comparison between the image before and after correction, figure (7) and (8) illustrates that:
The image after correction have a new regions classified as a water where before correction it classified in other class.

Figure (7): The classified image before correction.

Figure (8): The classified image after correction using mean value as path radiance.
4- Conclusions

Atmospheric correction of satellite images is a critical image processing step where the influence of the atmosphere is removed or greatly reduced. In this research an atmospheric correction technique has been used to correct remotely sensed data from the atmospheric effects for several bands of MSS Landsat images and getting several conclusions arranged as follows:

1- The correction of the atmospheric scattering is very important, especially in the shorter visible bands because the path radiance has serious effects on them.

2- The most suitable value selected as a path radiance is the most probable value because the values of reflectance at the Earth surface and at the sensor have been approximated.

3- From the classification results, it can be seen that there is some differences in values of each class, part of classes are increase and another are decrease after correction, this means that some features are apparent and another disappear after correction because influence of path radiance.

References


