Spectral Mixture Analysis for Desertification Detection in North-Eastern China

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Abstract: This paper was carried out desertification area change detection from 1980s to 2000s per unit decade using by multitemporal satellite images (Landsat MSS, TM, ETM+).

This study aims to use Spectral Mixture Analysis (SMA) to identify and classify study area. Endmembers is selected bare soil, green vegetation (GV), water body using by Minimum Noise Fraction (MNF). Endmembers used to generate increase and decrease images respective from 1980s to 1990s and from 1990s to 2000s.

From the analysis of multitemporal change detection for three periods, it was apparent that the area of bare soil increased significantly, with simultaneous decrease of GV and water body. The multitemporal fraction images can be effectively used for change detection. Though there is no field survey dataset, SMA is reliable result of change detection in desertification in China.

Key words: Desertification, Spectral Mixture Analysis, Endmembers selection, Landsat

1. Introduction

A lower resolution sensor operation at higher altitude might focus on the same field yet have its field of view occupied by a mixture of soybean leaves, bare soil, and grass. These mixed pixels present a difficult problem for image classification, since their spectral characteristics are not representative of any singleland cover type. Spectral mixture analysis and fuzzy classification are tow procedures designed to deal with the classification of mixed pixels. They represent means by which "subpixel classification" is mixed pixels (Lillesand, et al., 2000).

Though this research has no situ data, SMA analysis can overcome this problem and reveal effective result.

2. Data and Method

Study area

The study area is located in North-Eastern China(centered near 43° 09′ 51.29″ N, 120° 43′ 59.28″ E) and included in Seoho (the meaning of West Lake). The size of study area is approximately 20152 Km2 (136km x 144km). Landsat MSS (1977.8.8), TM (1992.8.24) and ETM+ (2002.7.11) used in this research. For multitemporal change detection analysis, three Landsat images (1980s, 1990s and 2000s) used in this research.

Preprocessing

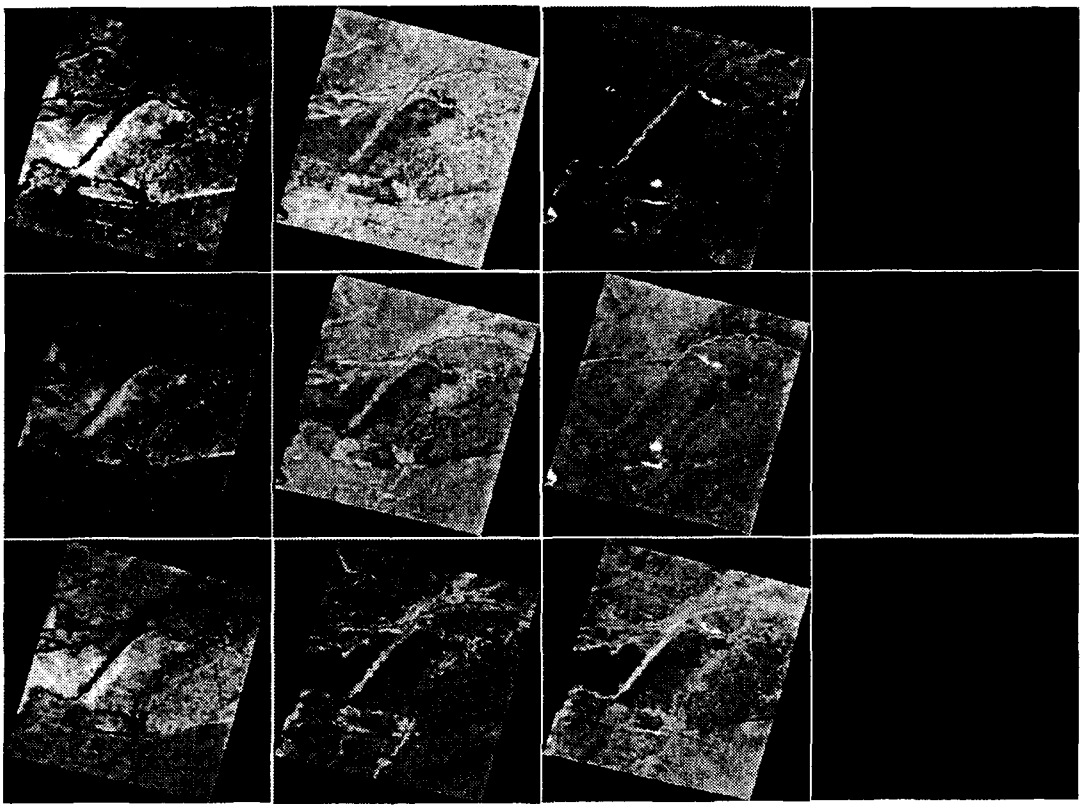
For change detection application using multitemporal remote sensing data, accurate geometric correction and atmospheric correction are tow important aspects in image preprocessing. First, the imagery were geometrically rectified based on Geometric Correction Points (GCPs) acquired from image to image method based on Landsat TM data. Landsat MSS data collected 24 GCPs and root mean squared (RMS) error is 0.48. For accurate image registration RMS error is smaller than 0.5 (pixel). Landsat ETM+ data collected 27 GCPs and RMS error is 0.41. Second, atmospheric correction is used below equation (Chavez, 1996).

$$\rho_p = \pi \cdot L_\lambda \cdot d^2 / ESUN_\lambda \cdot COS\,\theta_s$$

- d : Spectral radiance at the sensor
- L_λ : Earth-Sun distance
- $Esun_\lambda$: Mean solar exoatmospheric irradiances
- θs : Solar zenith angle in degrees

Endmembers Selection

The fundamental assumption on endmembers determination from the imagery is that endmembers are pure substance in a scene of which spectra reside at the extremities of the volume occupied by the data (Keshava and Mustard, 2002). MNF transformation and Principal Component Analysis (PCA) are often used dimension reduction method in hyperspectral images. Each image is employed MNF transformation for suitable endmembers selection in this research. MNF transformation generates 4 bands image and then examines Pixel Purity Index (PPI). Endmembers is selected three classes that is bare soil, GV, water body. Bare boil endmember is identified from the areas of dry out sands. GV endmember is represented from agricultural lands, forest areas and grass lands Water body is selected from clear and deep water.



Bare Soil GV Water RMSE

Figure 1. Fraction image (From top to down: 1980s, 1990s and 2000s)

Linear Spectral Mixture Analysis

Three endmembers is generated respective three fraction images by using linear spectral mixture analysis (Figure 1). Linear spectral mixture analysis is used least-squares solution to unmix three endmembers fraction images. Bare soil fraction image is represented abundance of soil factor so white portion point to severe bare soil. GV fraction image is appeared abundance of forest, grass and agricultural lands so white portion is indicated vegetation zone. But black and darker gray portion is represented water or bare soil. Water fraction image is appeared abundance of water and swampy lands so white portion is represented water zone.

Change Detection Analysis

Image differencing method used to change detection from respective fraction images. The image differencing method of bi-temporal fractions can be expressed as follows (Lu, et al., 2004) :

$$\Delta\text{Bare soil} = \text{Bare soil}(t1) - \text{Bare soil}(t2)$$

$$\Delta\text{GV} = \text{GV}(t1) - \text{GV}(t2)$$

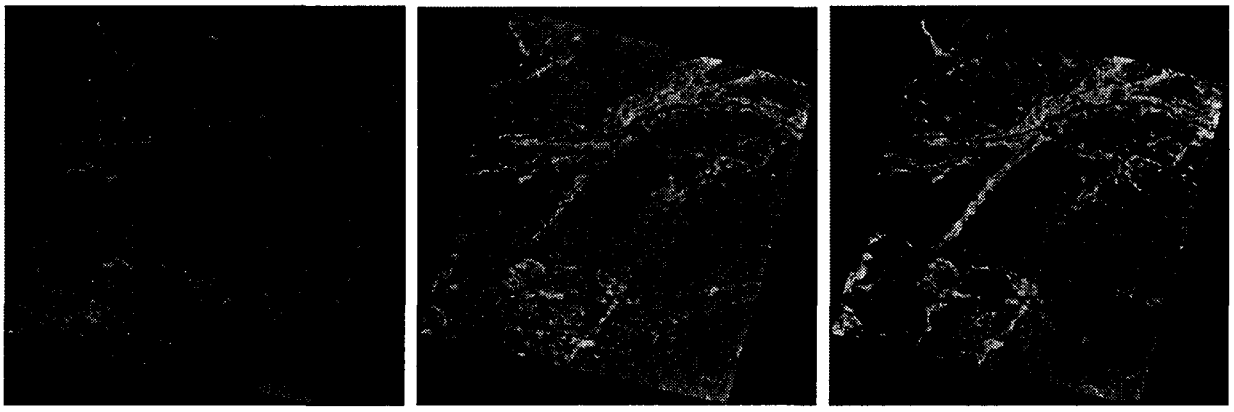
$$\Delta\text{Water} = \text{Water}(t1) - \text{Water}(t2)$$

ΔBare soil, ΔGV and ΔWater are assigned as red, green, blue, respective, the color composite image can tell us how the different land-cover types have changed.

3. Result

In respective increase-decrease image (Figure 3) and Land cover change detection between 1980s and 2000s (Table 1), from 1980s to 1990s decrease image is represented GV class decrease approximately 360 Km2. Main cause of decrease area from 1980s to 1990s is grass land change to bare soil. This result is appeared that bare soil area increase. Bare soil area is considerably decreased in mainly water edge area, but the size is smaller than GV decreased area. Water body is a little increase size. Main cause of water body decrease area from 1980s to 1990s convert to agricultural land. Agricultural land is caused water shortage for irrigate farmland. But water body increases in 1990s. Main reason of increasing water body can guess weather condition. It affects size of water body. Some areas appeared flooded area in 1990s

Bare soil area is most increase from 1990s to 2000s (approximately 90% of total increase area). Bare soil spread over the almost study area due to agricultural land expanded in 1990s. Agricultural land need irrigate for farm products growth Though agricultural land increase in 2000s, total GV area (from 1990s to 2000s) comes to decrease because grass land and forest area change to bare soil. Water body is most decrease from 1990s to 2000s (approximately 45% of total decrease area).



1980s 1990s 2000s

Figure 2. Land-cover on the Fraction image of color composite

(Red : Bare soil Green : GV Blue : Water)

Figure 3. 1980~1990s decrease (left) • increase(right) image 1990~2000s decrease • increase image

(Red : Bare soil Green : GV Blue : Water body)

Table 1. Land cover change detection between 1980s and 2000s.

Class	1980~1990s				1990~2000s			
	Decrease		Increase		Decrease		Increase	
	Km^2	%	Km^2	%	Km^2	%	Km^2	%
Bare Soil	297.23	42.06	378.20	58.84	56.17	23.88	369.37	90.07
GV	359.23	50.83	207.58	32.30	73.78	31.37	37.87	9.23
Water	50.29	7.12	56.93	8.86	105.24	44.75	2.84	0.69
Total	706.75		642.71		235.19		410.08	

4. Conclusion

This research analyzed bare soil spread phenomenon by using Landsat data from 1980s to 2000s in China. Some of North-Eastern China region have been already remained desert zone in 1980s. Desert zone get serious spread over near areas as years go by. Therefore Aim of this paper investigates desertification area change detection from 1980s to 2000s. Conclusion can be summarized by three.

First, Bare soil area from 1990s to 2000s is more increase than from 1980s to 1990s. Main reason is water surrounding department as the central figure bare soil spread and desertification of grass land. GV area from 1990~2000s is more decrease than from 1980s to 1990s. There is connection with increase of agricultural land area in 2000s. Water body from 1990s to 2000s is more decrease than from 1980s to 1990s. Though it has effect of weather condition, other reason is scarcity of irrigation water by agricultural land increase.

Second, SMA analysis is proved suitable tool for generate land cover fraction image and higher accuracy endmembers selection is need for change detection.

Third, this research can be more relevant result add to study combine with situ data. Furthermore other sensor type images are applied for SMA analysis for change detection.

Reference

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