A CLASSIFICATION METHOD BASED ON MIXED PIXEL ANALYSIS FOR CHANGE DETECTION

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Abstract: One of the most important research areas on remote sensing is spectral unmixing of hyper-spectral data. For spectral unmixing of hyper spectral data, accurate land cover information is necessary. But obtaining accurate land cover information is difficult process.

Obtaining land cover information from high-resolution data may be a useful solution. In this study spectral signature of endmembers on ASTER acquired in October was calculated from land cover information on IKONOS acquired in September. Then the spectral signature of endmembers applied to ASTER images acquired on January and March. Then the result of spectral unmxing of them evauateted.

The spectral signatures of endmembers could be applied to different seasonal images. When it applied to an ASTER image which have similar zenith angle to the image of the spectral signatures of endmembers, spectral unmixing result was reliable. Although test data has different zenith angle from the image of spectral signatures of endmembers, the spectral unmixing results of urban and vegetation were reliable.

Keyword: spectral unmixing, mixed pixel analysis, classification

1. Introduction

Spectral unmixing is one of important process in hyper spectral data processing. For spectral unmixing, accurate land cover information is necessary, but obtaining land cover information may be difficult
If spectral signature of endmenbers of a image can be applied to other seasonal images, it may be useful for spectral unmixing of hyper-spectral images in time series. The objective in this study is to investigate accuracy of spectral umixing when spectral signature of an image applied to other images in a time series.

ASTER images acquired in January, March and October, were used. And land cover information obtained from IKONOS image acquired in September. Mixed pixel analysis of ASTER acquired on October was carried out with the land cover information. After that, spectral signatures of endmembers were calculated from the mixed pixel analysis. The spectral signature applied to ASTER acquired on January and March (Figure 1). Then spectral unmixing results of them were evaluated.

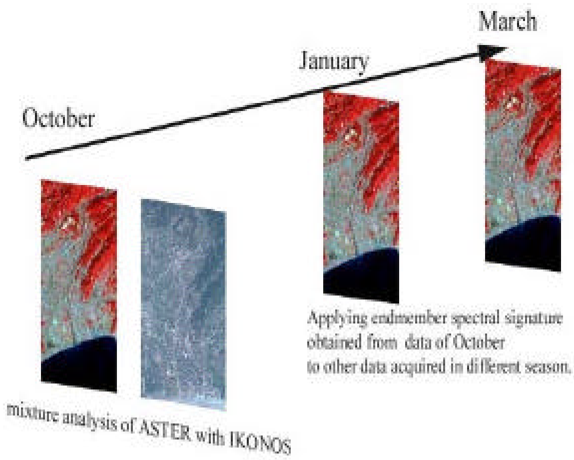

Fig 1. Applying spectral signature from land cover known data to land cover unknown data in a time sires

2. Data Used

Three ASTER images acquired on January, March and October were used. Table 1 shows the detail of ASTER image used in this study. The ASTER image acquired in January is darker than other images. Because solar elevation angle is larger than others.

In contrast with ASTER image acquired on January, solar zenith angle of ASTER image acquired on March is similar to solar zenith angle of ASTER image acquired on October. To obtain land cover information, IKONOS acquired on September was used.

Table1. ASTER data used

Date of acquisition	Solar azimuth angle (degree)	Solar zenith angle (degree)
October, 2000	163	50
January, 2001	160	60
March, 2001	149	44

3. Geometric rectification

To keep the original condition of ASTER, IKONOS images were geometrically rectified according to the ASTER with affine transform. Template matching method was used to obtain accurate GCP points. Table 2 shows the result of rectification.

Table 2. Geometric rectification result

Number of GCP template	RMS error in column	RMS error in Row
8	4.02m	3.71m

4. Methodology

The spectral signatures of endmembers of ASTER acquired on October were obtained using land cover information of the IKONOS.

When endmember spectral signatures of an image were applied to other images, One of major difficulties in is brightness different due to solar zenith angle and atmospheric condition.

To correct solar zenith angle and atmospheric condition, brightness in each image should be adjusted in same condition by using gain and offset. Figure 2 shows the flow char of this experiments procedure.

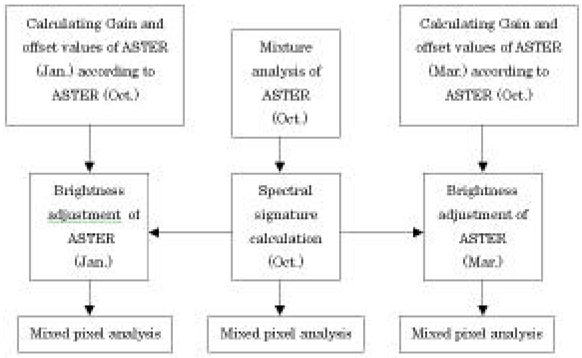

Fig 2. Experiment procedure

5. Mixed pixel Analysis

For mixed pixel analysis of the ASTER images, the linear mixture modeling method was used. To calculate spectral signature, 1pixel of ASTER was compared to 15 pixels by 15 pixels of IKONOS. Then the proportions of endmenbers were counted (Figure 3). After that the correlation between proportion of endmembers and pixel numbers in each band of ASTER were calculated. In this study, Band 1, 2, 3 and 10 are selected because they showed correlation coefficient indicated over 0.9.

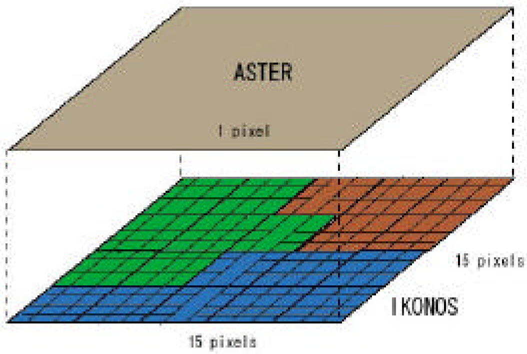

Fig 3. Spectral unmixing ASTER with IKONOS

Eq1 is the spectral unmixing equation in this study. And four endmembers, shadow, bare soil including urban, water were considered in this study. Summation of the area ratio of endmembers become one (Eq 2).

$$DN_i = \left(C_{wi} * R_w + C_{vi} * R_v + C_{b\_ui} * R_{b\_ui} + C_{si} * R_s\right)$$

Eq1)

$$R_{wi} + R_{vi} + R_{b\_ui} + R_{si} = 1$$

Eq2)

i :Band (12,3,10)

R: Ratio of landcovers in IKONOS,

R_w (water), R_v (vegetation),

R_{u_b} (bare soil, urban), R_s (shadow)

C: spectral signature of i*th* endmenmber,

C_w (water), C_v (vegetation),

C_{u_b} (bare soil, urban), C_s (shadow)

Totally 124 training data were used for the calculation. Table3 shows the number of training data in this study.

Table3. The number of training data in each category

Category	Total
Mixed pixel	18
Shadow	26
Soil, urban	20
Vegetation	20
Water (river)	20
Water (sea)	20

Spectral signatures of each endembers were calculated using least square method. Table 4 shows the calculation result of spectral signature of each endmember in each band.

Table 4. Spectral signature of each endmember

	Water (C_w)	Vegetation (C_v)	Soil Urban (C_{u_s})	Shadow (C_s)
Band1	0.2270	0.2224	0.3798	0.2030
Band2	0.1023	0.1142	0.2770	0.1096
Band 3	0.0680	0.3511	0.1999	0.0959
Band 10	0.0565	0.0729	0.1328	0.0778

After the calculation of spectral signature, the ratios of each landcover were calculated from digital number of ASTER images.

In the calculation of the ratio of landcover, Inversion of spectral signature of endmember vector to calculate the proportion of land cover was not works well. Because each bands are highly correlated. So In this study, iterative calculation method was used.

Four polynomial equations which have four unknown ratio of landcover, were established. DN of images were input to the four equations. Then expected landcovers were input until optimized proportions of landcovers were obtained.

After that the amount of difference of area between training data and calculated ratio of landcovers was quantified with following equation.

Spectral unmixing Errors =

$$\frac{\sum_{i=1}^{N} \sqrt{\sum_{x=water}^{shadow} (A_{xi} - B_{xi})^2}}{N}$$

Eq3)

A: area of endmember training data

B: area of calculated endemember

x: category (water, vegetation, bare soil _urban, shadow)

N: total number of training data in each category

Table 5 shows the evaluation resultof spectral unmxing of ASTER acquired in October.

Table 5. The result of spectral unmxing of ASTER acquired in October (unit: m^2)

Category	Spectral umixing Errors in 225 m^2 (October)
Mixed pixel	143
Shadow	19
Urban	18
Vegetation	14
Water	33

6 Mixed pixel analysis of data acquired in different season with gain offset adjustment

Brightness of image is unique in each scene due to solar zenith angle and atmospheric condition. The brightness in the image acquired on January is much different from images acquired on October and March.

For the calculation of gain and offset, only brightness of pure land cover in the training data was used. Because it is one of reliable way for mixed pixel analysis by some try and error. Table 8 shows the result of mixture analysis of the gain and offset adjusted image acquired on January. In the result the error distance of urban and vegetation show 15 and 14 m^2. This result is not poor because the geometric rectification error is approximately 4m.

On the other hand, error distance of shadow and water show 122 and 124 m^2. This result was poor. Especially, this error is occurred in steep slope where shaded area. If topographical adjustment of this data is possible spectral unmixing of shadow will be improved. As decreasing shadow area which classified into water area, the result of water will be become improved. Table 9 shows the result of the result of mixture analysis of the gain offset adjusted image acquired on March. In the result, the spectral unmixing results of endmembers are better than the result of the image acquired on January. Because its zenith angle is almost same as zenith angel of the image acquired on October.

Table 8. The result of mixture analysis of the gain offset adjusted image acquired on January (unit: m^2)

Category	Spectral umixing Errors in 225 m^2 (January)	Error difference from October
Mixed pixel	172	29
Shadow	141	122
Urban	33	15
Vegetation	28	14
Water	157	124

Table 9. The result of mixture analysis of the gain offset adjusted image acquired on March (unit: m^2)

Category	Spectral umixing Errors in 225 m^2 (March)	Error difference from October
Mixed pixel	150	7
Shadow	63	44
Urban	29	11
Vegetation	36	22
Water	42	9

8 Conclusions

In this study, the mixed pixel anaysis of time series remotely sensed data were carried out by using the spectral signature of endmembers which was obtained from IKONOS image. The spectral signatures of endmembers could be applied to different seasonal images. Although test data has different zenith have different zenith angle, the spectral unmixing results of urban and vegetation were reliable by using gain and offset adjustment. The unmixing result of shadow and water were poor, but if topographical adjustment of those kinds of data is possible, the result will be improved.

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