SHADOW EXTRACTION FROM ASTER IMAGE USING MIXED PIXEL ANALYSIS

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ABSTRACT

ASTER image has some advantages for classification such as 15 spectral bands and 15m ～ 90m spatial resolution. However, in the classification using general remote sensing image, shadow areas are often classified into water area. It is very difficult to divide shadow and water. Because reflectance characteristics of water is similar to characteristics of shadow.

Many land cover items are consisted in one pixel which is 15m spatial resolution. Nowadays, very high resolution satellite image (IKONOS, Quick Bird) and Digital Surface Model (DSM) by air borne laser scanner can also be used. In this study, mixed pixel analysis of ASTER image has carried out using IKONOS image and DSM. For mixed pixel analysis, high accurated geometric correction was required. Image matching method was applied for generating GCP datasets. IKONOS image was rectified by affine transform. After that, one pixel in ASTER image should be compared with corresponded 15×15 pixel in IKONOS image. Then, training dataset were generated for mixed pixel analysis using visual interpretation of IKONOS image. Finally, classification will be carried out based on Linear Mixture Model. Shadow extraction might be succeeded by the classification. The extracted shadow area was validated using shadow image which generated from 1m～2m spatial resolution DSM. The result showed 17.2% error was occurred in mixed pixel. It might be limitation of ASTER image for shadow extraction because of 8bit quantization data.

KEY WORD: shadow extraction, Linear Mixture Model, mixed pixel analysis ASTER, IKONOS, DSM,

1. INTRODUCTION

There are many methods of landcover Classification based on band operation or using statistics. However, it is difficult to classify shadow and water in case of high resolution satellite which spatial resolution ranges from 10m to 30m. Sometime shadow areas are classified into water area.

Landcover classification using mixed pixel analysis is one of an ideal methods. Because mixed pixel analysis is based on the model which closed to real world. Nowadays, very high spatial resolution satellite (IKONOS, QuickBird) and DSM by air borne laser scanner became very popular to use. These data can be efficient to generate training dataset. So, mixed pixel analysis can be carried out easily.

When the mixed pixel analysis applied to landcover classification, classification of shadow and water will be succeeded. After that, urban area's density can be classified by using extracted shadow data. Because urban area has big shadow by tall buildings.

2. OBJECTIVES

In this study, mixed pixel analysis will be carried out using ASTER image, IKONOS image and DSM. Linear mixture model is applied as mixed pixel analysis. The linear mixture model is derived using training dataset which generated by visual interpretation of IKONOS image. After that, landcover ratio of each category (water, vegetation, bare soil and shadow) will be estimated. The estimated landcover ratio will validated by the training dataset. Shadow extraction method will be concluded. Figure1 shows flow chart of this study.

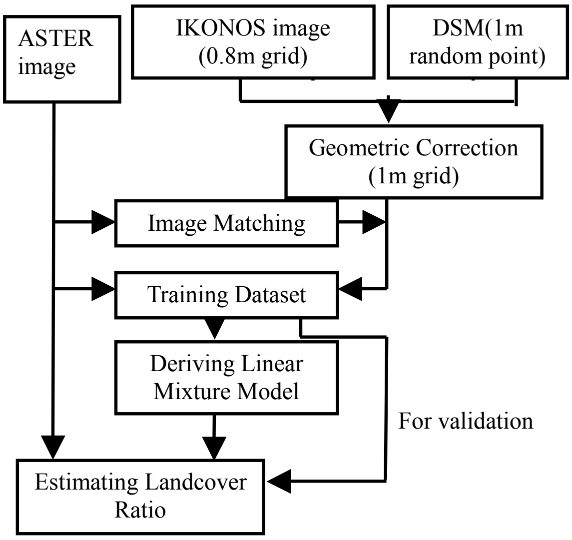

Figure1. Research flow

3 USED DATA
3-1 ASTER Image

Figure2. ASTER image

Teat area was selected Kochi city in Japan. ASTER image was used for mixed pixel analysis, which has 15 spectral bands, 8bit data, 15m～90m spatial resolution and swath width is 60km. This image acquired on 31 October 2001.

3-2 IKONOS Image

Figure3. IKONOS image

IKONOS image has 4 spectral bands, 11bit data and 0.8m spatial resolution. IKONOS image was used for generating training dataset. Swath width of IKONOS image is so narrow that two scenes were prepared in this study. The first scene includes urban area, which acquired on 19 September 2002. The second scene includes farm land and forest, which acquired on15 June 2000.

3-3 DSM

Figure4. DSM

It is difficult to extract shadow from only the IKONOS image, because acquired time is different that shadow condition is different. So digital surface model (DSM) must be prepared for simulating shadow in the ASTER image. DSM was generated by air borne laser scanner. Spatial resolution of the DSM was about 1m as random point data. And random point data were converted to raster data by bi-linear resampling.

4. GEOMETRIC CORRECTION OF IKONOS IMAGE

One pixel in ASTER image should be compared with corresponded 15×15 pixel in IKONOS image to acquire training data. So, high accurated geometric correction is needed. In this study, image matching method was applied for selecting GCP. And IKONOS image was resampled to overlay with ASTER image by affine transform. Because ASTER image should be used as original data for mixed pixel analysis. Table1 shows root mean square error which occurred in geometric correction. The error showed about 4m in X-Y direction (Table1). But it was limitation of image matching. It was judged that mixed pixel analysis might be carried out in this condition.

Table1. RMS error

number of GCP	8
RSM error	0.27m
Total RMS error	2.14m

5. GEOMETRIC CORRECTION OF DSM

DSM should be overlaid with IKONOS image to simulate shadow condition. Image matching between height data and multi spectral data was so difficult that GCPs were selected by visual interpretation. Geometric correction was used affine transform. Table2 shows root mean square error which occurred in geometric correction. The error shows less than 1m and GCPs could be gotten in enough precision.

Table2. RMS error

Direction	RMS error
x	4.02m
y	3.71m

6. SHADOW IMAGE GENERATION FROM DSM

Shadow condition of ASTER image and IKONOS image was difference. Because aquired time was different. Therefore, Shadow image must be generated from DSM on same condition of the ASTER image (figure5). When training data were acquired, this shadow image was compared with IKONOS image.

Figure5. Shadow image

7. ASTER IMAGE CLASSIFICATIN BY LINER MIXTURE MODEL

7-1. Linear Mixture Model

Originally, many land cover items consisted in one pixel. Nowadays, some models of mixed pixel analysis were suggested. In this study, linear mixture model was applied. Digital number of ASTER image is expressed with land cover ratio of each category and the coefficient. Four categories were set in the linear mixture model as follows:

$$DN_i=(C_{wi}*R_w+C_{vi}*R_v+C_{bi}*R_{bi}+C_{si}*R_i) \quad (1.1)$$

$$R_{wi}+R_{vi}+R_{bi}+R_{si}=1$$

i : Band 1,2,3,10

R: Landcover ratio in each category R_w (water), R_v (vegetation), R_b (bare soil), R_s (shadow)

C: mixture coefficient C_w (water), C_v (vegetation), C_b (bare soil), C_s (shadow)

7-2. Training Data Preparation

Firstly, one pixel of ASTER image was compared with corresponded 15x15 pixels of IKONOS image. Corresponded 15x15 pixels of IKONOS image was classified into four categories by visual interpretation. As training data, pure pixel and mixed pixel were selected.

Table3 shows number of pixel in the ASTER image for training data. The most mixed pixels were consisted with combination of two categories.

Generally shadow areas are often classified into water area. Therefore, many training data of mixed pixel which included water were selected. Total 137 training data were acquired. In each training data, each landcover ratio was calculated.

Table3. Number of training dataset

Training data	Number of pixel
No Shadow Mixed Pixel	12
Shadow Mixed Pixel	20
Shadow Pure Pixel	25
Sea Pure Pixel	20
River Pure Pixel	20
Vegetation Pure Pixel	20
Bare Soil Pure Pixel	20

7-3.Mixed Pixel Analysis

Table4 shows correlation coefficient between digital number of each band in ASTER image and each land cover ratio. The band 1, 2, 3 and 10 are indicated over 0.9. Then these bands can be used for linear mixture model. Spatial resolution of band 10 is 30m. However influence of the spatial resolution might be slight because landcover ratio will be almost same. In each band, coefficients of linear mixture model were calculated by using least square method using training data. Table5 shows list of the coefficient in each band.

Table4. Correlation between digital number and landcover ratio

Band Name	Correlation Coefficient	Band Name	Correlation Coefficient
Band1	0.913	Band9	0.889
Band2	0.923	Band10	0.911
Band3	0.912	Band11	0.320
Band5	0.895	Band12	0.413
Band6	0.865	Band13	0.363
Band7	0.869	Band14	0.438
Band8	0.884	Band15	0.363

Table5. List of coefficient in linear mixture model

	Water (C_w)	Vegetation (C_v)	Baresoil (C_b)	Shadow (C_s)
Band1	0.2285	0.2323	0.3837	0.2032
Band2	0.1040	0.1252	0.2812	0.1106
Band3	0.0636	0.3388	0.1936	0.0955
Band10	0.0566	0.0775	0.1348	0.0787

7-4. Classification By Using Linear Mixture Model

Now, four polynomial equations were setup. There are four land cover ratio as unknown coefficients. So, when digital number in each band is known, four land cover ratio will be derived by solving the polynomial equations. However, solving the polynomial equations is very difficult. Because solution will be unstable by high correlation of digital number in each band.

In this study, optimum value searching using one by one approximate calculation is applied to derive land cover ratio with following conditions.

$$0<R_{wi}<1,\ 0< R_{vi} <1,\ 0<R_{bi} <1,\ 0<R_{si}<1 \quad (1.2)$$

Every combination of each land cover ratio is input the polynomial equation to solve the equations. Calculated digital numbers are derived from the input value of land cover ratio. By comparison between the calculated digital number and original digital number, the nearest digital number can be searched. The combination of land cover ratio was changed 0.02 steps width in the iteration. It was enough precision.

8. RESULT

Figure 6～9 shows each land cover ratio by linear mixture model. Brightness in the images according to land cover ratio. In figure9, a brightness was reversed because to understand easily. Figure10 shows color composite using each landcover ratio. Red is bare soil, blue is water, green is vegetation. The composite image shows reliable result.

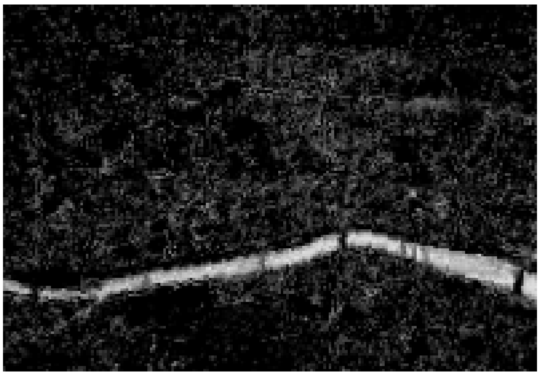

Figure6. Result of Water image

Figure7. Result of vegetation image

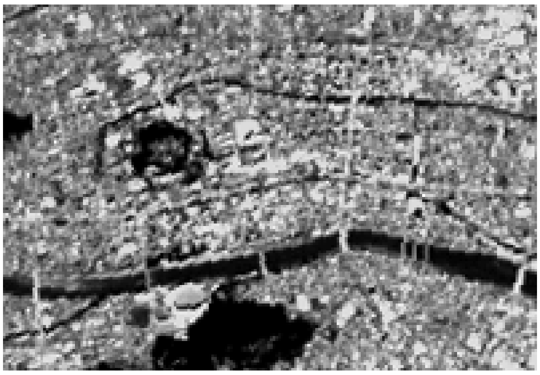

Figure8. Result of bare soil image

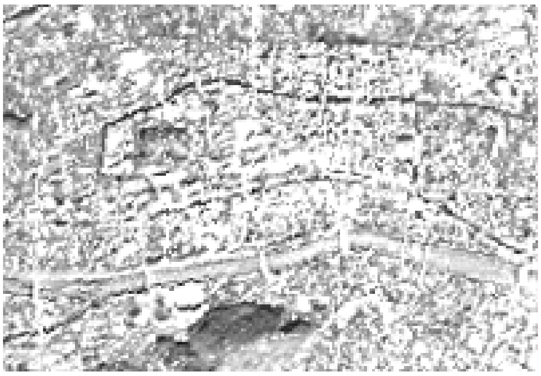

Figure9. Result of shadow image

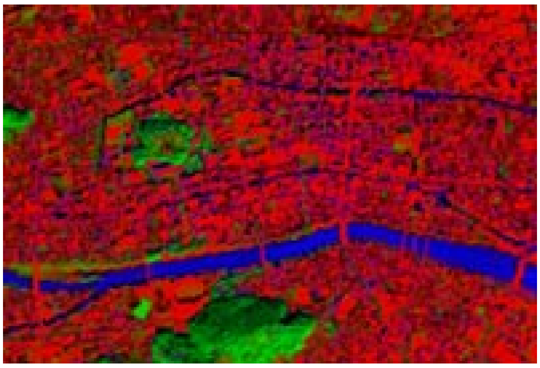

Figure10. Result of ASTER image classification

9. CONCLUSIONS

Analytical results were evaluated by visual interpretation. It could get good result in bare soil and vegetation. But, there are some miss-classification in water and shadow. And Small river was classified into shadow. It was difficult to judge shadow area or water by visual interpretation in original ASTER image. Quantitative evaluation was done using training dataset. Calculated each land cover ratio was compared with land cover ratio in training dataset. When the category which indicated maximum landcover ratio became same to land cover in training data, the calculation result was defined as correct in this study.

Table6. Evaluation of classification

	Number of Data	Number of Correct answer	Ratio of Correct answer
Mixed pixel	32	14	43.7%
Pure pixel	105	102	97.5%

Table7. Evaluation of shadow extraction

	Number of Data	Average of Absolute Error
Shadow pixel in training data	45	17.2%
No shadow pixel in training data	92	2.9%

Table6 shows ratio of correct pixel classification. Ratio of correct pixel showed less than 50%. But, category of component of mixed pixel became same. Category contained in one pixel could be classified correctly. But, precision of land cover ratio became lower. This reason might come from accuracy of training dataset. Because acquisition data of ASTER image was different from IKONIOS.

Therefore, condition of land cover was slightly changed. When higher accurate training dataset are prepared, classification result will became higher precision.

Table7 shows evaluation of shadow extraction. Extracted shadow by linear mixture model was compared with training dataset of shadow, by average of absolute error. No shadow pixel showed better than shadow pixel. But, there were many pixels which classified into shadow in water. Shadow extraction in mixed pixel was difficult. In shadow area or water area, digital number indicates very low. ASTER image has 8bit data. 8bit data might not be enough quantization to divide shadow and water.

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