Paper presented at the 22nd Asian Conference on Remote Sensing, 5 - 9 November 2001, Singapore.

IDENTIFICATION OF URBAN CHARACTERISTIC USING IKONOS HIGH RESOLUTION SATELLITE IMAGE

Ching-Yi Kuo*
*Miss, Department of Land Management,
Feng-Chia University, Taichung,
Tel: 886-4-24516669 Fax: 886-4-24519278
Email:julia@gis.fcu.edu.tw
TAIWAN.

Tien-Yin Chou**
**Prof., Geographic Information Systems Research Center of
Feng-Chia University, Taichung,.
Email:jimmy@gis.fcu.edu.tw
TAIWAN

Re-Yang Lee***
***Office of the National Science & Technology Program for
Hazards Mitigation, Taipei,.
Email:rylee@naphm.ntu.edu.tw
TAIWAN

Keywords: Urban Characteristic? High Resolution Satellite Image

ABSTRACT: Land use patterns are fragile and sophisticated in Taiwan. In order to rapidly derive detail information of land use/land cover, it is necessary to employ remote sensing techniques because of its broad area coverage and fast data acquirement. The purposes of this research are to use high-resolution satellite images, such as IKONOS, to obtain urban land use information, and to apply fuzzy algorithms technique for assessing the accuracy of classification. During the course of this research, we develop a semi-auto urban land use classification model using the high-resolution satellite images. Due to the lack of detailed Digital Terrain Model (DTM) database for image registration and rectification, the ground control points are derived from field GPS measurements and one to one thousand GIS map of experimental sites. This research demonstrates that the high spatial resolution images can offer more detail urban land characteristics than the traditional low spatial resolution satellite images.

1. INTRODUCTION

As we know, land use information is very important for management and planning activities in urban areas. Traditional land surveying methods, such as field surveys or using aerial photography, are costly and time-consuming. In order to rapidly derive detail land use information in broad areas, it is necessary to use remote sensing techniques. Most of the studies relating to urban mapping aim to identify interpretation techniques, which account for the urban complexity in relation to the data spatial resolution. This is because this factor affects the essential use of remotely sensed data in urban studies (Barnsely and Barr 1996). Examples in using Landsat MSS and TM data or Landsat sensor with SPOT HRV data in urban classifications are reported in various studies. However, their results were not encouraging regarding class specificity and accuracy. It is due to the coarse spatial resolution of the imagery.

Within these few years fine spatial resolution satellite sensor imagery become widely available. Such as the IKONOS satellite imagery, several new satellite sensors are being developed capable of generating imagery with spatial resolutions as fine as 1-m in panchromatic mode (Pan) and 4-m in multi-spectral mode (MS). Many details such as buildings, roads, trees, grass and other component elements of urban scenes can be clearly identified from this high-resolution satellite images (HRSI). Pixel-based methods of image classification cannot work successfully using such imagery, because they assign each pixel to one of the land-cover classes solely on the basis of its spectral reflectance properties.

Urban landscapes are composed of diverse materials (concrete, asphalt, metal, plastic, glass, shingles, water, grass, shrubs, trees, and soil) arranged by humans in complex ways by building housing, transportation systems, utilities, commercial buildings, and recreational landscapes (Welch, 1982). Land use patterns in Taiwan, however, are more fragile and sophisticated. The purposes of this research are to use high-resolution satellite images, such as IKONOS, to obtain urban land use information, and to apply fuzzy algorithms technique for assessing the accuracy of classification.

2.METHODOLGY

Many approaches have been made to identify the urban land-use information. This study uses a spatial reclassification technique that represents a simple way to examine the spatial variation in land cover in remotely sensed images. In this study, we performed the classification to infer urban land use in two stages. First, we labeled each pixel by one land cover class using a pixel based clustering algorithm. Then, the labeled pixels were grouped into discrete land use categories on the basis of their frequency of occurrence and spatial arrangement within a kernel. This procedure to infer land use from the spatial arrangement of land cover was first suggested by Wharton (1982) and improved by Barnesley and Barr (1996). The basic assumption underlying this approach is that individual categories of land use classes are characteristic spatial mixtures of spectrally distinct land cover classes (Barnsley and Barr, 1992). And these classification techniques were proved to be useful for the classification of residential density classes on HRSI.

We tested this technique using a sub-scene extracted from an IKONOS multi-spectral image of north Taiwan. Due to the lack of detailed Digital Terrain Model (DTM) database for image registration and rectification, the ground control points are derived from field GPS measurements and one to one thousand GIS map of experimental sites.

2.1 Pre-classification

The image was radiometric-corrected. A supervised classification with the maximum-likelihood algorithm was used first to obtain the land-cover map. Training sites were extracted manually with the aid of 1/5,000 aerial photography imagery. They were then digitized on the screen and divided into two groups for training and test the accuracy of classification.

2.2 Post-classification

The second stage calculated the frequency and spatial arrangement of different land cover types within each n- by n- pixel region by convolving a simple, rectangular kernel with the classified image. Figure 1 illustrates an adjacency-event matrix in a 3- by 3-pixel window. The pairs of adjacent pixels were connected along an edge or by a vertex within the square kernel. Each pair of pixels produces a single adjacency event, so that the order of the labels is not significant.

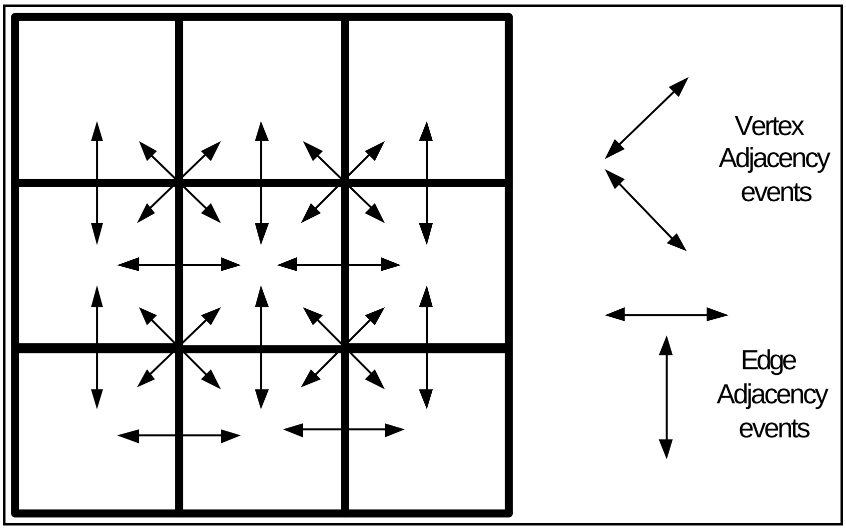

Figure 1. Adjacency events in a 3- by 3-pixel window.

The class label associated with each pixel defines the nature of the "adjacency event" by this kernel. In this stage the adjacency-event matrix is calculated for each new position of the kernel is compared with each of the template matrices and the land use category defined by the template matrix which best match the current adjacency-event matrix is assigned to the central pixel of the kernel. The land use category for a given pixel is determined by comparing its adjacency-event matrix with those derived from representative sample areas of the candidate land-use categories. An overview of this technique is given in Barnsley and Barr (1996).

3.EXPERIMENTAL RESULTS

3.1 Result of Pre-classification

The first stage in this study is to produce an initial land-cover map from the remotely sensed image. In order to get the greatest control over both the number and the nature of the classes defined, we used the supervised maximum-likelihood algorithm. Under this aspect, seven land-cover classes have been identified in the study area: ‘crop’, ‘grass’, ‘large structure’, ‘small structure’, ‘soil’, ‘tree’, ‘water’. Figure 2 illustrates the classification maps derived from the application of the supervised maximum-likelihood algorithm. Table 1 shows the confusion matrix for per-pixel land-cover classification.

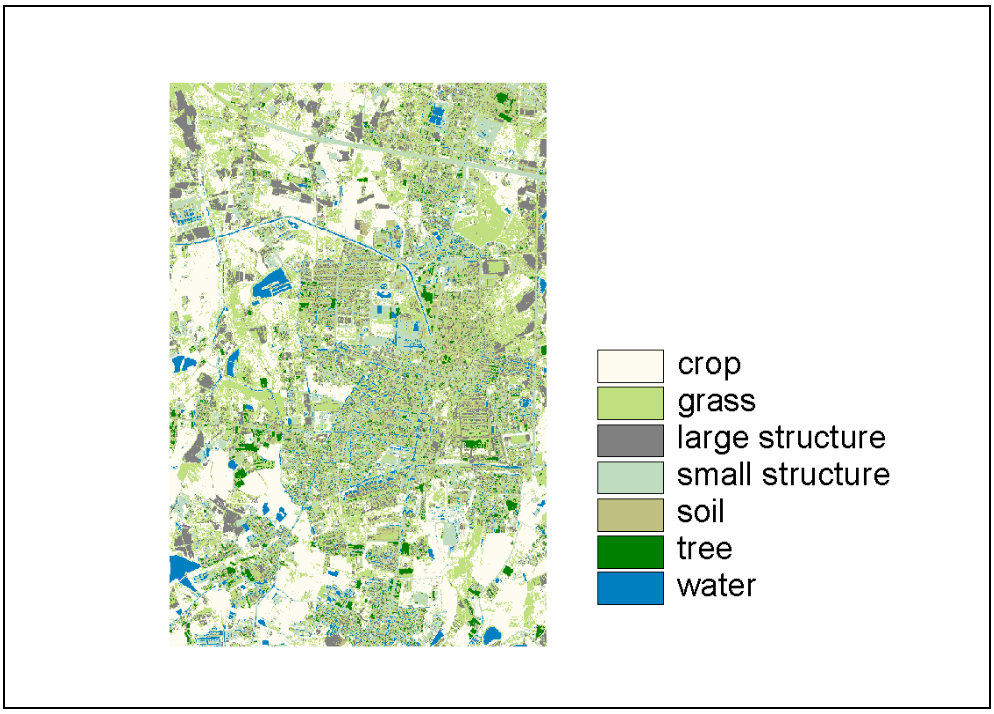

Figure 2. Classification maps resulted from the application of the Supervised maximum-likelihood algorithm.

The results of the initial classification are rather broad nature of the land-cover classes. And the classification accuracy is a very high level : overall accuracy = 88.28 percent; Kappa coefficient = 85.45 percent.

Table 1. Confusion matrix for per-pixel land-cover classification.

Land-cover type	Crop	Grass	Large structure	Small structure	Soil	Tree	water
Crop	162	11	0	0	0	0	0
Grass	45	74	0	0	0	0	0
Large structure	0	0	92	0	0	0	0
Small structure	0	0	0	42	0	0	0
Soil	0	0	0	11	56	0	0
Tree	0	0	0	0	0	32	0
water	0	0	0	0	0	0	47
Total test pixels	207	85	92	53	56	32	47

Average Accuracy	92.08%	Overall Accuracy	88.28%	Kappa Coefficient (*100)	85.45%

3.2 Results of Post-classification

After deriving a satisfactory land-cover classification, the labeled pixels were grouped into six land use categories : 'Arable Crop', 'Industrial', 'Low Density Residential', 'Medium Density Residential', 'Soil', 'Water'. In this study, a 7- by 7-pixel kernel was selected to examine the land-use categories. Figure 3 illustrates the land use map produced using post-classification with a 7- by 7-pixel kernel. Table 2 displays the confusion matrix for land-use reclassification.

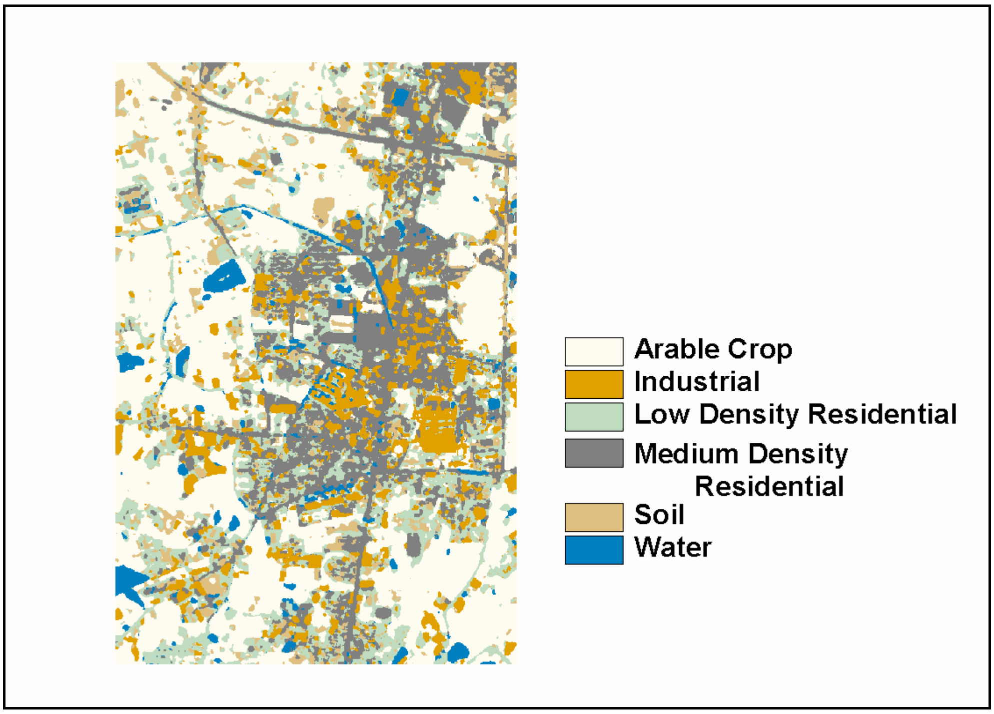

Figure 3. Reclassification maps resulted from the application of adjacency-event matrix algorithm.

The results of the reclassification are rather broad nature of the land-cover classes. And the classification accuracy is a very high level : overall accuracy = 86.75 percent; Kappa coefficient = 84.08 percent.

Table 2. Confusion matrix for land-use reclassification.

Land-cover type	Arable Crop	Industrial	Low Density Residential	Medium Density Residential	Soil	Water
Arable Crop	729	0	0	0	22	0
Industrial	0	488	37	0	0	0
Low Density Residential	0	37	198	32	0	0
Medium Density Residential	0	0	0	67	0	0
Soil	133	0	0	0	142	0
Water	0	0	0	0	0	85
Total test pixels	862	525	235	99	164	85

Average Accuracy	86.0%	Overall Accuracy	86.75%	Kappa Coefficient (*100)	84.08%

4.CONCLUSIONS

Nowadays the analysis of information about urban areas from remotely sensed images is essentially accomplished by photo-interpretation with the aid of ground surveys. The improvement of this spatial resolution now taking place has awakened the interest of people working in urban areas (urban planners, cartographers, urban geographers, etc). In this paper, the experimental results displayed the potential of reclassification techniques for land use mapping in a very small study areas using IKONOS imagery. We will proceed with larger areas to improve the accuracy of classification in the future.

REFERENCE

Barnsley, M. J. and Barr, S. L., 1996. Inferring urban land use from satellity sensor using kernel-based spatial reclasification,. Photogrammertric Engineering and Remote Sensing.

Kontoes, C.C., Raptis, V., Lautner, M. and Oberstadler R., 2000. The potential of kernel classification techniques for land use mapping in urban areas using 5m-spatial resolution IRS-1C imagery, International Journal of Remote Sensing, 16, 3145-3151.

Welch, R., 1980. Monitoring Urban Population and Energy Utilization Patterns from Satellite Data, Remote Sensing of Environment, 9:1-9.

Wharton, S.W., 1982, A context-based land use classification algorithm for high resolution remotely sensed data , Journal of Applied Photographic Engineering, 8:46-50.