The study of Combination Texture Information and Knowledge Base Classification for Urban Paddy Area Extraction—Using High Resolution Satellite Image

Tien-Yin Chou
100 Wenhwa Rd., Seatwen, Taichung, Taiwan, R.O.C.
jimmy@gis.fcu.edu.tw

Tsu-Chiang Lei
100 Wenhwa Rd., Seatwen, Taichung, Taiwan, R.O.C.
eric@gis.fcu.edu.tw

Yan-Hung Chen
100 Wenhwa Rd., Seatwen, Taichung, Taiwan, R.O.C.
snailh@gis.fcu.edu.tw

Abstract: This research uses high-resolution satellite images as a source of collecting farmland information. For effectively extract the paddy area, we use texture information and different classify methods to assist the satellite image classification. First, using maximum likelihood classifier to extract paddy information form images. The results show that the User Accuracy and Procedure Accuracy of the paddy area can increase from 80.60% to 95.45% and 84.38% to 95.45%. Second, establishing a paddy Knowledge Base and using Knowledge Base Classifier to extract paddy area, and result shows the User Accuracy and Producer Accuracy to be 92.16% and 90.06%. Finally, The result shows we can effectively contribute to the paddy field information extraction from high-resolution satellite images.

Keywords: Texture Analysis、Knowledge Base、Image Classification、Paddy extraction

1. Introduction

In Taiwan, rice cultivation survey is a major project for agriculture department. A traditional survey was used aero-photo (1/5000 scale) to check if it is a paddy field by using texture to match the corresponding cultivating field map. This method is very time-consuming and strenuous, so some researchers have adopted SPOT satellite images and GIS information to study the paddy area extraction (H. Y. Chen, and T. Y. Chou, 1999; M. S. Deng, 1997; I. H. Chen, 1998). Otherwise, The paddy area in Taiwan features small area cultivation but the SPOT image space resolution (12.5m) insufficient effective to extract paddy area information. Therefore, this study uses high-resolution satellite images (QuickBird image, space resolution 3m) to conduct related paddy field application analysis and with the assistance of Texture Analysis, we hopes to increase the accuracy of high-resolution satellite image paddy fields extraction.

2. Field of Research

1) Study area

This research focuses on the area shown in Figure 1, which is the Pei Tun Section of Taichung City, Taiwan.

2) Time period

The images and information used in this research were taken on the following dates.

a. QuickBird image: 10/17/2002.

b. Aero-Photo: September 2002.

c. Cultivating Field Map: Phase 2 cultivation, 2002.

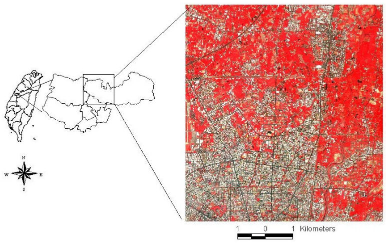


Fig. 1. Region of study

3. Study Flow

The study flow is shown in Figure 2.

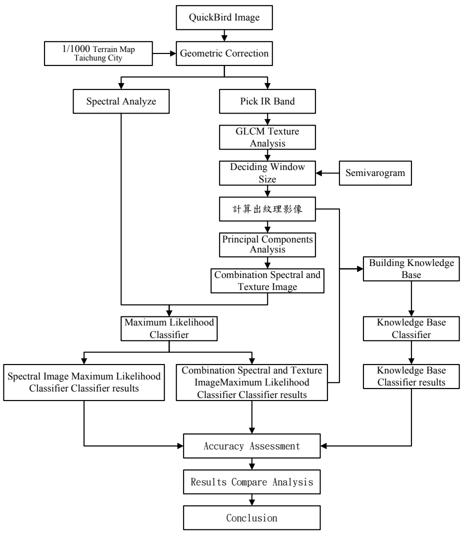


Fig. 2. Study Flow

4. Research Method

1) GLCM Texture Analysis

GLCM is a two-dimensional statistic method. It can use the different size of the moving window to obtain different information on the satellite images and record the frequency of each possible set of gray level value (Haralick, 1973). Haralick (1973) once suggested fourteen kinds of texture statistics to quantify GLCM matrix. This research only uses five most frequently used ones and they are: (1) Contrast; (2) Dissimilarity; (3) Energy; (4) Entropy; (5) Homogeneity.

2) Semi-variogram

Semi-variogram represents the spatial variation of observed information and is the kernel of Kriging Methodology. As for how to get a semi-variogram, due to the fact that general Kriging Methodology assumes that $E[Z(x)] = E[Z(x+h)]$, we can get a semi-variogram through the Eq. (1) (Fig. 3)

$$\gamma(h) = \frac{1}{2n(h)}\sum_{i=1}^{n(h)}[Z(x_i) - Z(x_i + h)]^2 \qquad (1)$$

$Z(x)$ and $Z(x+h)$ represent any two random variable values. n is the pair number; h is the relative distance; c(h) is the covariance function; and r(h) is the variogram.

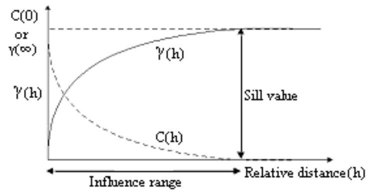


Fig. 3. Test Semi-variogram graph

3) Knowledge Base Classifier Establishment

There are several ways of obtaining knowledge and writing information into the knowledge base system. The most frequently used and applicable rule in the satellite image classification is: If "a certain condition is established", then "a certain result will be inferred." The structure of the knowledge base can be illustrated as Hypotheses, Rules, and Sources (F. J. Chien, 2001).

5. Research Achievement and Discussion

1) Spectral classification results

This research used supervised maximum likelihood classifier (MLH) to categorize images obtained by spectral image and get 7 categories. They are road, water, forest, grass, barren, paddy, and residential. The extract result shows in table 1.

Table 1: A comparison on the precision of image classifiers.

Information Type	*Producer Accuracy*	*User Accuracy*
Spectral classifier	80.60%	84.38%
Spectral and Texture Classifier	95.45%	95.45%
Knowledge base classifier	92.16%	90.06%

2) Semi-Variogram to decide texture window size

This research uses the semi-variogram to decide texture moving window size, through sampling and the assistance of GS+ software, the result shows in Figure 4. It shows the suitable window size is about 7 by 7.

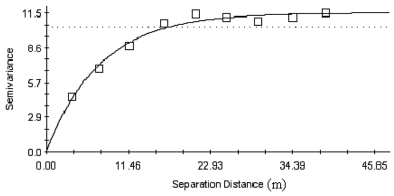


Fig. 4. Texture suitable window size analyze result

3) Combine the spectral and texture information classification results

This research choosen the PC1 and PC2 information (eigenvalue 97.38%) from Principal Components Analysis (PCA) on the five texture indexes (7 by 7 window) and combines the texture and spectral information for further classify analysis. The result shows in table1.

4) Knowledge Base Structure and Classification Results

This study is according assistance information to establish the paddy Knowledge Base. The Knowledge Base consists of the paddy information shown in Figure 5.

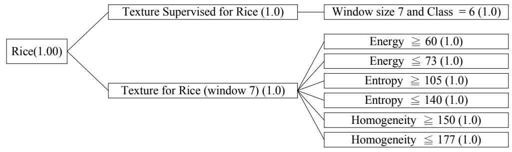


Fig. 5. Paddy field knowledge base structure

5) Image Classification Result Analysis

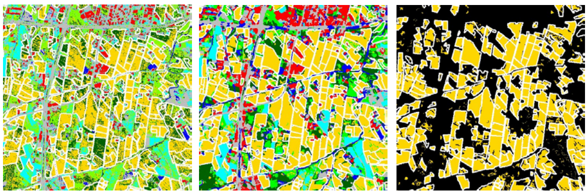
Image classification result shown in Table 1. It shows that through the assistance of the texture information, the interpretation accuracy on the paddy area can be effectively enhanced. Also, through comparing the interpreted area of spectral images and the texture assistance image with the cultivating field map are issued by the Council of Agriculture, the paddy field area can be effectively extracted (Table 2). Although there is some disparity in the area interpreted, we thought that is inevitable. Reasons include the following: (1) not all images can be interpreted with 100% rate. (2) Cultivating field map data issued by Council of Agriculture whose interpretation involves a certain degree of human errors.

Table 2: Paddy area estimate chart (measure unit：hectare)

Information type	*Interpreted area*
Spectral classifier	689.65
Spectral and Texture classifier	666.90
Knowledge base classifier	657.86
2002 2-stage paddy cultivation cultivating field map	622.08

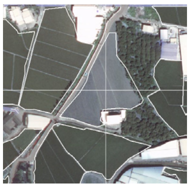
Through comparing two different data classifier results, we find that with the assistance of the texture information, it is possible to enhance the cultivating field completeness of the image interpretation. Figure 6 (a) is the spectral data classification result. The paddy cultivating field interpreted from the image contains various kind of noise information. Figure 6 (b) is the classification result of spectral and texture combination information. When using this to examine the interpreted cultivating field result, a complete cultivating field map can be sought. Figure 6 (c) is the knowledge base classifier result, it have a similar result with (b).

This research, with the assistance of the texture information, can detect the errors in the cultivating field map. The land cover in Figure 7 (a) is proven to be a grass through aero-photos, but cultivating field map is still definition as the paddy field. In the spectral data classification result was failed to detect the error. However, assistance by the texture information, both the MLH or Knowledge Base classifier can effectively take the error.

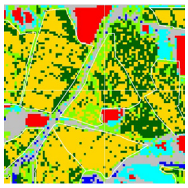


(a) spectral data (b) spectral + texture data (c) knowledge base data

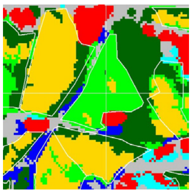
Fig. 6. Different data classification results



(a) Aero-photography



(b) Spectral classifier



(c) Spectral + Texture classifier

(d) Knowledge base classifier

Fig. 7. Cultivating field map error detection result

6. Conclusion

This research uses the supervised maximum likelihood classifier and the knowledge base classifier on the QuickBird image to conduct interpretation on the paddy area. The conclusions are as follows:

1. The high-resolution satellite image assistance by the texture information can effective to extract the paddy area and increase the extract accuracy. The producer accuracy can increase from 80.60% to 95.45%, and the user accuracy increase from 84.38% to 95.45%.
2. High-resolution satellite image assistance by the texture information, no matter using the MLH or Knowledge Base method can obtain similar result. And can effective to detect the error in the cultivating field map.

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