THE RESEARCH OF THE DYNAMIC MONITORING TECHNIQUE FOR LAND USE BASED ON REMOTE SENSING IMAGERY

Shao Yong-she*, Zhang Shao-ming , Dou Jian-fang , Jia Sheng-ju

Department of Surveying and Geo-informatics of Tongji University, Shanghai, China,200092

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ABSTRACT:

For the past few years, the dynamic monitoring technique for land use based on high resolution remote sensing imagery is at the stage of key techniques research and system development in China. The paper regards the system of the dynamic monitoring for land use of the GuangDong province as an example, and expounds detailedly the key techniques and the process obtaining the change polygon. In the paper, a brief introduction about the constituent of the dynamic monitoring system is firstly given. Then, the area change detection techniques, classification methods, the alterative area and attributes acquisition are discussed in detail. Lastly, the paper describes the operation flowline and primary function, and analyzes the application perspective of the system and the problems that will be improved in the future.

1. INTRODUCTION

The research of the change monitoring using remote sensing imagery began in the 1960s later. Dynamic change monitoring can be used to agriculture, forestry, water conservancy, and land resources surveying. For the time being, the remote sensing change monitoring technology is mostly used in land cover investigation, land use surveying, forest cover investigation, water area surveying and so on in China. Since 2000, China has carried out the census in land use, and established the National Land Use Database (Shen Xiao-le et al, 2007). Nevertheless, with the sustaining and rapid growth of national economy, as well as the less and less arable land, dynamic monitoring and reasonable planning of the land use play a very important role in ensuring the sustaining and healthy development of the national economy.

In China, the monitoring of land use information generally experienced the following three stages. The first stage is the initial artificial investigation stage, which the change information is entirely completed by the artificial investigation, and is in low efficiency and a long life cycle; the second is dynamic monitoring stage and regards the aerial photos as information sources, which mainly monitors the change by means of visual interpretation and image processing, and is very expensive and in a longer cycle; the third stage regards remote sensing satellite imagery as the main data sources, and combines the dynamic monitoring technology of remote sensing imagery so as to implement dynamic monitoring of land use, which is being in the stage of key technologies research and application at present(Di Feng-ping et al, 2008).

In this paper, we take the dynamic monitoring system of land use in Guangdong for an example, expound the key technologies and processes of the subsystem acquiring change polygon in detail, and introduce the operation flowline and the primary functions of the system.

2. THE SYSTEM OF LAND USE CHANGE PLOYGON DETECTION

Change monitoring of land use mainly determines the change orientation, distribution, extent, categories and area size for land use and land cover at a certain period of time. The change detection, classification, regional extraction and edge tracking technology, which fit to the remote sensing imagery, are used to acquire change polygon of land use based on the constitution of changing information and characteristics. After the attributes of change polygon are ascertained, the land-use database will be updated. Therefore, the polygon acquisition becomes one of the key technologies in the dynamic monitoring of land use. The major component of acquiring change polygon of land use includes change detection, polygon extraction, classification, attribute information acquisition and edition, which is shown in Figure 1.

3. PLOYGON DETECTION AND ATTRIBUTE INFORMATION ACQUISITION

3.1 Change Polygon Detection

Change polygon detection is one of the key technologies for dynamic monitoring of land use. A variety of methods can improve the reliability of change detection of remote sensing imagery (Zhang Ji-xian et al, 2005). Therefore, the module of the change detection system mainly includes image differential method, principal component analysis (PCA) and correlation analysis (CA) (Gatsis, I. et al, 2006). Image differential method is a kind of the simple methods for change detection, but the results depend on the image quality.

PCA transforms a set of correlated variables into a group of independent and orthogonal variables, which is the linear combination of input variables so as to eliminate redundancy

* Corresponding author. Tel.: 86-21-65981710. E-mail address: Shaoysh@sina.com

among images (Kilic, S. et al, 2006). This method firstly calculates a standard transformation matrix. Then, the new image, namely principal component data, is obtained from the input image based on the transformation matrix. At last, the results of change detection may be acquired using image difference method.

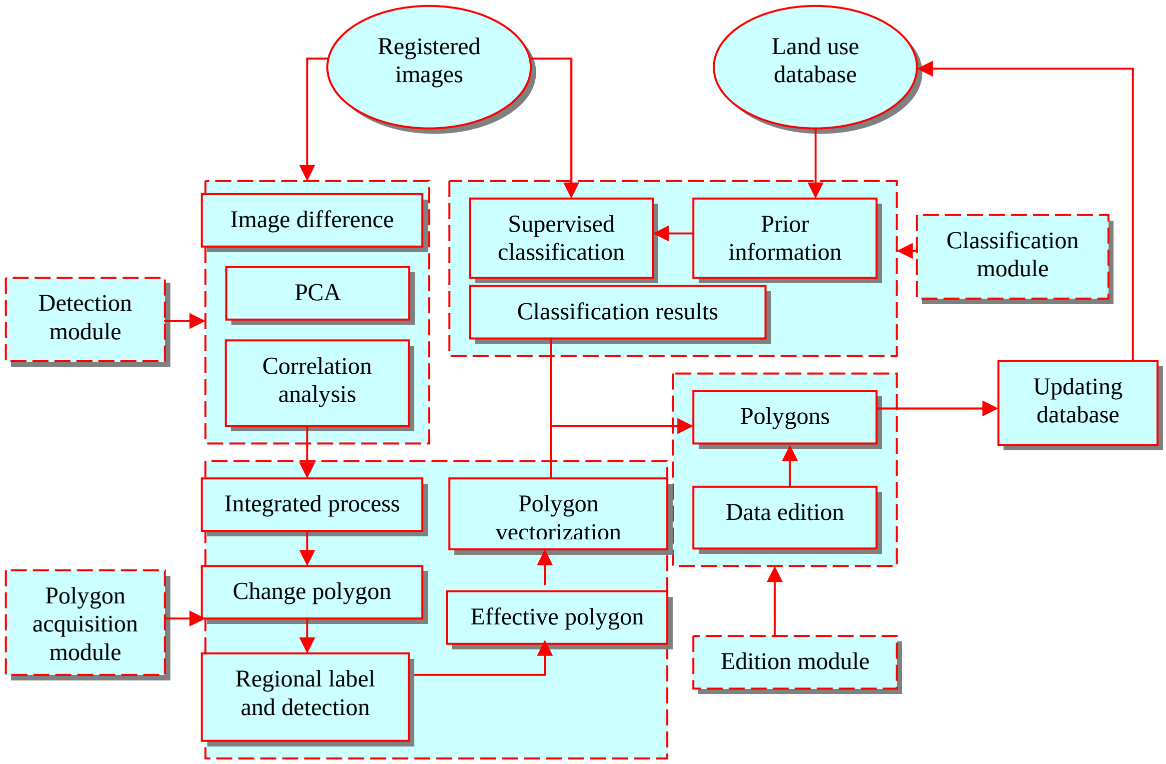

Figure 1. The constitution of the change polygon system

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Suppose a vector of n dimension image $X=[x_1,x_2,\cdots,x_n]^T$, which is performed using a linear transformation. Namely,

$$\boldsymbol{Y}=\boldsymbol{Q}^{\mathrm{T}}\boldsymbol{X} \tag{1}$$

Where, $\mathbf{Q}=[\mathbf{Q}_1,\mathbf{Q}_2,\cdots,\mathbf{Q}_n]$ is an orthogonal matrix. The covariance matrix is:

$$\boldsymbol{C}_X=\varepsilon\{[(\boldsymbol{X}-\mathrm{E}(\boldsymbol{X})][(\boldsymbol{X}-\mathrm{E}(\boldsymbol{X})]^{\mathrm{T}}\} \tag{2}$$

Because C_X is a real and symmetric matrix, an orthogonal matrix $\boldsymbol{Q}=[\boldsymbol{Q}_1,\boldsymbol{Q}_2,\cdots,\boldsymbol{Q}_M]$ consequentially exists, and makes $Q^T C_X Q$ become a diagonal matrix. That is:

$$\boldsymbol{Q}^{\mathrm{T}}\boldsymbol{C}_X\boldsymbol{Q}=\begin{bmatrix}\lambda_1 & & & 0\\ & \lambda_2 & & \\ & & \ddots & \\ 0 & & & \lambda_M\end{bmatrix} \tag{3}$$

Solve the eigenvalues $\lambda_1,\lambda_1,\cdots,\lambda_M$ of the image matrix C_X, and calculate the correspond eigenvectors $\mathbf{Q}$. After the orthogonal transformation is performed on original image, the principal component $\boldsymbol{Y}=[\boldsymbol{Y}_1,\boldsymbol{Y}_2,\cdots,\boldsymbol{Y}_M]^{\mathrm{T}}$ is obtained. The change detection may be used to the second components because the change targets are mainly displayed in the second components transformed.

Canonical correlation analysis is a kind of the statistical analysis methods that analyzes the linear relationship between two random variables (Chen Lei et al, 2007). The idea means that canonical transformation is applied to the image using the different linear combination transformation, in which a transformation of the largest correlation coefficient can be found. In fact, the method can be converted to the problem of solving eigenvalues and eigenvectors.

Suppose that the covariance of the random variable $[X \quad Y]$ is Σ, and $U=a^T X$ $V=b^T Y$. Σ may be separated and written as:

$$Var=\begin{bmatrix}\Sigma_{11} & \Sigma_{12}\\ \Sigma_{21} & \Sigma_{22}\end{bmatrix} \tag{4}$$

Canonical correlation analysis means that the linear transformation is performed to the random variable $[X \quad Y]$, and make the coefficient vectors a and b of $U=a^T X$ and $V=b^T Y$ meet:

$$\left.\begin{aligned} a^T \textstyle\sum_{11} a &= 1 \\ b^T \textstyle\sum_{22} b &= 1 \\ Cor\{U,V\} &= a^T \textstyle\sum_{12} b = \max \end{aligned}\right\} \quad (5)$$

In fact, the problem can be described as solving the values a and b that can make $a^T \sum_{12} b$ be maximum under the condition of $a^T \sum_{11} a = 1$ and $b^T \sum_{22} b = 1$, which may use Lagrang solution. After a and b are solved, two group of random variables are transformed so as to obtain the detection results from the difference vectors.

3.2 Classification and attribute information acquisition

After the prior information is obtained from land use database, the attributes of the change polygon is acquired by the supervised classification of image. Classification is done by the supervised classification based on fuzzy subordinate level (Wang Jian et al, 2006). Firstly, the land use information of the detected region is gotten from the land use database. Then, the image can be classified according to the information of land use categories and the prior spectral information. At last, the polygon attributes may be achieved from the database.

The fuzzy subordinate level function of the classification is determined by Bayesian formula. That is:

$$\mu_{\omega i}(x) = \frac{P(\omega_i)P(X \mid \omega_i)}{\sum_{j=1}^{n} P(\omega_j)P(X \mid \omega_j)} \quad (6)$$

Where, $P(\omega_i)$ and $P(X \mid \omega_i)$ respectively represents the prior probability and conditional probability of the category ω_i. In the case of normal distribution, the conditional probability is determined by following formula:

$$P(X \mid \omega_i) = \frac{1}{(2\pi)^{1/2} \mid \sum_i \mid^{1/2}} e^{\left[-\frac{1}{2}(X-V_i)^T \sum_i^{-1}(X-V_i)\right]} \quad (7)$$

Where, V_i and $\sum_i$ respectively represents the fuzzy mean value vector and fuzzy variance matrix of the different category.

The fuzzy subordinate levels of the initial sample pixels are given according to experience and statistical analysis results, and make up of the matrix called fuzzy matrix. If the number of samples is n, and the amount of samples pixel is m, then the fuzzy segmentation matrix can be expressed as:

$$\begin{bmatrix} \mu_1(X_1) & \mu_1(X_2) & \cdots & \mu_1(X_m) \\ \mu_2(X_1) & \mu_2(X_2) & \cdots & \mu_2(X_m) \\ \cdots & \cdots & \cdots & \cdots \\ \mu_n(X_1) & \mu_n(X_2) & \cdots & \mu_n(X_m) \end{bmatrix} \quad (8)$$

Where, $\mu_i(X_j)$ is the subordinate degree of the pixel X_j to the category i.

All kinds of the fuzzy mean vectors and fuzzy covariance matrixes can be obtained according to the fuzzy segmentation matrix. Each pixel is ultimately classified by its subordinate degree through the iterative calculation. On the one hand, the polygons edges are vectorized to update the vector information of the land use database, on the other hand, the attribute information is achieved from the land use prior information.

4. PLOYGON DETECTION AND ATTRIBUTE INFORMATION ACQUISITION

The system may implement the land use database updating based on the orthoimages captivated at a different time, as well as the polygon print, and the report forms of the attribute information output. The primary operation flowline is shown in Figure 2.

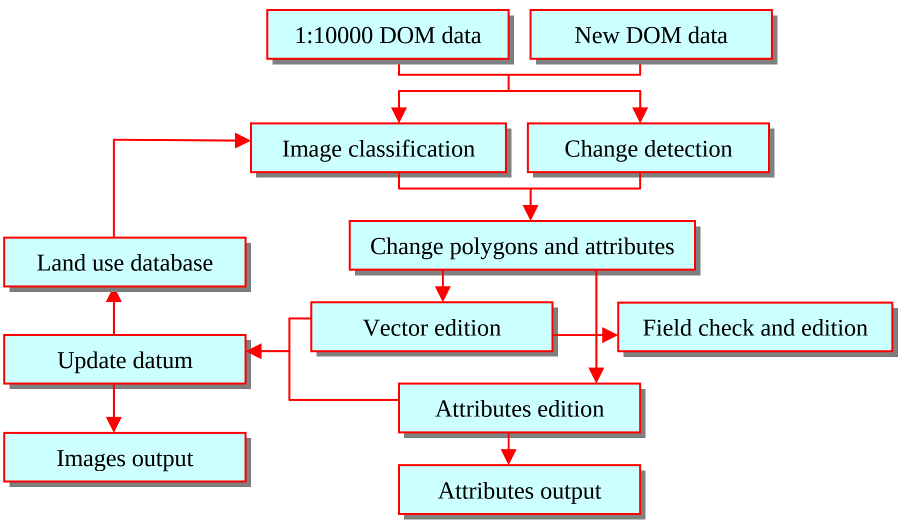
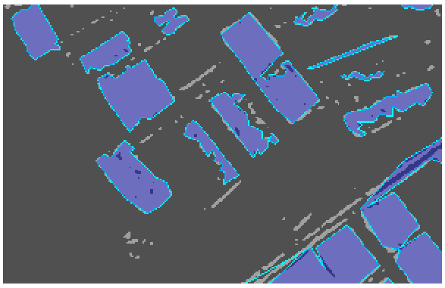


Figure 2. Operation flowline of the dynamic monitoring for land use

The main functions of the land use dynamic monitoring system include change polygon monitoring, the attribute acquisition with the image classification, contrast examination of draw curtain, change polygon vectorization, vectors and attributes edition, dynamic projection of the image, the maps and attributes output and so on. Figure 3 shows some functions of this system.

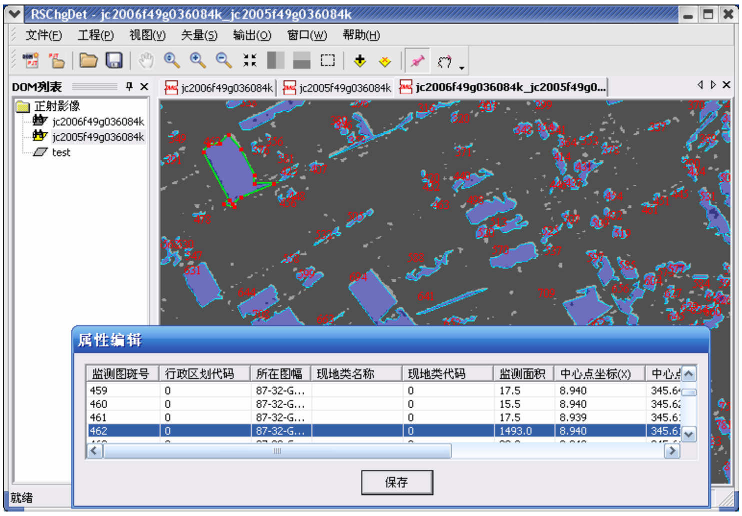
a) The primal DOM image

b) The DOM image detected



c) The Change detection result

d) Contrast check of draw curtain



e）The vectors and attributes edition

Figure 3. The main functions of the system

5. CONCLUSIONS

The land-use dynamic monitoring system of Guangdong Province is mainly built for the production, so the system designing focuses on the algorithms practicality and functions. Due to the influence of the resolution of remote sensing image and other factors, the accuracy of change polygon is different. In order to meet the actual application, the limit values may be adjusted for the change polygon detected in the system. The automatic detection of the change polygon is regarded as a kind of the supplemental measures for land use dynamic monitoring so as to improve the production efficiency. The system has gained preliminary application in the production, and be expected to obtain more reliable and more accurate change polygon with the improvement of the data source, detection methods, classification technology, which can promote the automatic implementation of land-use dynamic monitoring.

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