Analysis of remote sensing monitoring methods for construction land at home and abroad

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Abstract. This article starts from the construction land remote sensing detection at home and abroad research situation analysis, summarizes various analysis methods, using spatial information technology in the process of urban construction land scale spatial distribution of different land use types and the spatial and temporal evolution of urban ecological environment quality evaluation, simulation, scientific development and management to provide decision support for the city, at the same time can also be used for land use planning, it provides reference for ecological and environmental governance. This can improve and enhance the level of urban planning and management, guide and control the future direction of urban development reasonably, so as to promote the coordinated development of cities.

1. Introduction

The spatial distribution of different land use types in the process of urban construction, the spatiotemporal evolution of urban ecological environment quality. It is very convenient to use spatial information technology to evaluate and simulate them, and on the basis of exploring the human ecological environment under the dominant response mechanism research, scientific development and management to provide decision support for the city, at the same time can also be used for land use planning. It provides reference for ecological and environmental governance. This can improve and enhance the level of urban planning and management, guide and control the future direction of urban development, so as to promote the coordinated development of cities.

2. Research on remote sensing monitoring of construction land expansion

To judge the speed and reasonability of urban development, it is necessary to conduct scientific monitoring on the expansion speed of construction land, urban expansion degree and urban environment change[1]. Traditional monitoring methods are time-consuming and difficult to reflect the spatial distribution characteristics and development trend of urban expansion changes. In recent years, with the development of remote sensing and geographic information system, remote sensing method has incomparable advantages, and has become an effective method and approach to monitor the dynamic change of construction land expansion, and has gradually become a trend. The following will be carried out from the information source of remote sensing monitoring and the object of monitoring research.

(1) Information sources for remote sensing monitoring of urban expansion

There are two kinds of information sources for remote sensing monitoring of construction land: aviation remote sensing and space remote sensing. In 1910, American White successfully took the first aerial photograph of Italy from an airplane, which opened the use of aerial remote sensing. Because
aerial remote sensing costs a lot of money and cannot be applied in a large number of cases, there are not many literatures on urban aerial remote sensing in China. Chen Bingxian et al. used color infrared aerial photos to monitor residential land and greening land in Nanjing built-up areas. Mei Anxin et al. took Zhenru Town in Shanghai as the research area and applied aerial photos for five years. With the support of geographic information system, they conducted dynamic monitoring research on various land changes and urban expansion processes in the research area. Chang Tongyuan et al. monitored and analyzed the urban construction area and urban construction growth rate of Hohhot urban area by using 1:50,000 color red foreign aerial films in 1987 and 1:20,000 black and white aerial films in 1995 as information sources. These studies have verified the feasibility, effectiveness and labor-saving and time-saving characteristics of aerial photography in urban monitoring. On July 23, 1972, the United States launched the first earth resource satellite, which is now called Landsat-1 (Landsat-1), which is equipped with a multi-spectral scanner, since then, remote sensing monitoring has opened the prelude to space remote sensing. Subsequently, NASA successively launched a total of 7 Land Resource Satellites [2].

Although aerial remote sensing monitoring is much more accurate and comparable than conventional statistical methods, it is very expensive. Space remote sensing data has the characteristics of wide visual Angle, multi-temporal phase and convenient information digitization and data transmission, and GIS spatial analysis technology provides core technical support for remote sensing data storage, processing and information expression, which is conducive to monitoring the speed and location of urban land expansion to the suburbs. Among the commonly used urban space remote sensing data sources, the remote sensing images such as SPOT, IKONOS and Quickbird have high spatial resolution, but they are relatively few in practical application due to their high price. Although the CBERS and HJ1-A /B satellites are free of charge, they are generally used for recent research or as supplement to other remote sensing image sources due to the late launch of satellites and the lack of early remote sensing images. In the past 30 years, the American Landsat series has acquired the longest continuous record of the earth’s land surface, so it has become the main remote sensing information source for the current urban expansion monitoring research[3-4].

(2) Research status of remote sensing monitoring of construction land at home and abroad

Overseas research status: With the development of remote sensing technology and geographic information system technology, the use of satellite remote sensing means to carry out urban monitoring has been paid attention to by scholars from all over the world. Urbanization in developed countries such as Europe and the United States had been completed successively in the 1970s, and urban development tended to be stable. Therefore, on the whole, remote sensing monitoring of urban development is not the focus of developed countries in the near future[5]. The United States is an exception. Because Americans pursue the comfortable suburban environment, the urban development pattern in the United States leads to the serious spread of suburbanization. Many scholars have done a lot of research on the monitoring of urban expansion by using satellite remote sensing technology. For example, American scholar Masek et al. carried out research on urban expansion in Washington through NDVI difference method, eliminated agricultural land change information by using spatial texture information and setting restrictive conditions, and accurately extracted urban expansion areas from 1973 to 1996. American scholars Thompson and Lozano-Garcia also conducted similar studies in Illinois, Indiana and Florida respectively. American scholar Paul innovatively proposed the method of using night satellite remote sensing images to study urban areas, which made the determination of construction land and non-construction land more accurate. Monitoring found that the expansion speed of western cities in the United States was lower than that of inland and mid-western cities. Welch extracted urban built-up area through false color composite visual interpretation of TM images, and analyzed the relationship between built-up area and population. French scholar Laurent et al. extracted urban buildings with SPOT 5 satellite remote sensing images and effectively monitored the urban expansion in Reunion Island, France. In developing countries, apart from China, remote sensing monitoring research on urban expansion is also more in India. For example, Indian scholar Taragi et al. used satellite remote sensing images to monitor the cities in Lucknow, India, and found that the cities expanded rapidly along the main road to the northeast and southwest. Indian scholar Mahesh et al. used MSS, TM and ETM+ satellite remote
sensing images to monitor the expansion of urban Ajmer in India from 1977 to 2002, and found that the growth of urban land was more than 3 times that of urban population[6-7].

Domestic research status: Since the reform and opening up, China’s urbanization level has been advancing by leaps and bounds as well as the rapid change of cities, which attracts Chinese scholars to carry out extensive research on urban expansion monitoring. Although many scholars in China have done a lot of research on urban expansion monitoring by remote sensing, there are still some deficiencies, which are mainly shown in the following aspects: 1) the economically developed cities in the southeast coastal areas are mainly studied, and the economically underdeveloped cities in the central and western regions are less studied; 2) The study of a single city is the main task, and the study of urban agglomeration within a specific administrative region is the supplementary task. There is a lack of monitoring and comparative analysis at the national macro level. There is also a lack of overall understanding of the situation of urban expansion in China and in-depth analysis and summary of the spatio-temporal characteristics of urban expansion at the macro level. It is very important to monitor the urban expansion in the eastern and central regions of China, a country with a vast territory and distinctive regional and economic development. At present, the monitoring of urban expansion mainly focuses on the longitudinal comparison of individual cities, and lacks the horizontal comparison between the eastern, central and western cities. In addition, statistical data are used in a few comparative studies on the area of urban built-up areas, which cannot accurately represent the spatial expansion and actual scope of urban built-up areas. 3) In the process of monitoring urban land expansion, the conversion of various land types before and after urban expansion is usually studied, or the built-up area is considered as a whole. There is a lack of research on the characteristics and rules of the change of green space and water body in the built-up area during the busy urban development process[8-10].

3. Methods for data analysis of construction land

(1) Transfer matrix analysis model

The transfer matrix analysis model can fully reflect the direction, characteristics and structure of regional land use type change. Its mathematical form is (1):

$$S_{i,j} = \begin{bmatrix} S_{11} & S_{12} & \cdots & S_{1n} \\ S_{21} & S_{22} & \cdots & S_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ S_{n1} & S_{n2} & \cdots & S_{nn} \end{bmatrix}$$

(1)

Where, n —— the number of earth classes;
S —— the area of map spot;
I —— the land type at the initial stage of the study;
J —— the study of the end terrestrial class.

(2) Plane barycenter model

Plane barycenter transfer mainly expresses the change of location of elements in plane space. By using the plane barycenter model to calculate the barycenter positions of each element in different periods in plane coordinates, the barycenter displacements of each period in two-dimensional space are analyzed and the changing process of the barycenter in horizontal space is revealed. The calculation model of plane barycenter is as follows (2):

$$X_k = \frac{\sum_{i=1}^{n} (A_{ki} \times X_{ki})}{A_k} \quad Y_k = \frac{\sum_{i=1}^{n} (A_{ki} \times Y_{ki})}{A_k}$$

(2)

Where, $X_k$ —— the x-coordinate value of the center of gravity of the element studied at level k; $Y_k$ —— the Y coordinate value of the center of gravity of the element studied at level k;
A\textsubscript{ki} —— the area of map spot I in the elements studied with class K;

X\textsubscript{ki} —— the average value of X coordinates within the corresponding range of map spot I in the elements studied at level K;

Y\textsubscript{ki} —— the mean value of Y coordinates within the corresponding range of map spot I in the surface parameter I studied at level k;

A\textsubscript{K} —— the total area of the surface parameters studied in class K.

(3) Transfer rate model of gravity center

The rate of barycenter migration refers to the distance that the barycenter of an element moves on the plane in unit time. The calculation model of gravity center migration rate is as follows (3) and (4):

\[
V_{k(t_2-t_1)} = \frac{B_{k(t_2)} - B_{k(t_1)}}{t_2-t_1}
\]  

\[
P_{k(t_2-t_1)} = \sqrt{\frac{(X_{k(t_2)} - X_{k(t_1)})^2 + (Y_{k(t_2)} - Y_{k(t_1)})^2}{t_2-t_1}}
\]

Where, \(V_k\) —— the migration rate of the vertical gravity center or slope gravity center of the surface parameters studied by grade K;

\(B\textsubscript{k(t_2)}, B\textsubscript{k(t_1)}\) —— the vertical or slope gravity center values of the surface parameters studied by grade K at two time periods of \(T_2\) and \(T_1\), respectively.

\(T_2, T_1\) —— the end time and start time respectively.

\(P_k\) —— the plane barycenter migration rate of surface parameters studied by class K;

\(X_k, Y_k\) —— the x and y coordinates of the gravity center of the surface parameters studied by grade k at time t, respectively.

(4) Landscape index

The modes of landscape spatial expansion are generally divided into infused expansion, marginal expansion and enclave expansion, as shown in Fig.1-Fig.3.
Landscape index can describe a quantitative expansion in a certain period of time the dynamic expansion of mode expansion as well as a variety of landscape pattern in a period of time space distribution pattern, compared with other landscape index, landscape expansion index can reflect the spatial pattern of a landscape, not only can reflect the dynamic change of landscape types in a certain time period, Two dimension in space and time. Its calculation formula is as follows(5):

\[
LEI = 100 \times \frac{A_o}{A_E - A_P}
\]

Where, LEI—— the landscape expansion index of patches; 
A_E—— the minimum bounding box area of new urban patches. 
A_P—— the area of the new urban patch itself; 
A_o—— the area of the original city patch in the minimum bounding box. 

(5) Normalized Vegetation Index (NDVI) extraction method

For Landsat TM data, the Normalized Vegetation Index (NDVI) can be expressed as(6):

\[
NDVI(x, y) = \frac{R_3(x, y) - R_4(x, y)}{R_3(x, y) + R_4(x, y)}
\]

Where, R_3—— the planetary albedo in band 3 of TM image; 
R_4—— the planetary albedo of TM image band 4 respectively. 
The variation distribution of NDVI index in the study area can be expressed as(7):

\[
NDVI_c = NDVI_n - NDVI_{n-1}
\]

Where, NDVIC—— the difference between the end of the study and the beginning of the study; 
NDVI_n—— the NDVI value at the end of the study period. 
NDVI_{n-1}—— the NDVI value at the end of the study period. 
Calculated results of kumquat can be classified into the following three types of changes according to standardization classification: With no significant change, positive change and reverse change, the overall change of vegetation cover in different time phases in the study area can be analyzed.

4. Conclusions

Part from the construction land remote sensing detection at home and abroad research situation analysis, transfer matrix analysis model were analyzed and summarized in this paper, plane, center of gravity center of gravity model migration velocity model, landscape index and normalized difference vegetation index (NDVI) to extract the use of these five methods and calculation basis, provide a reference for scholars to research the urban construction land use situation.

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