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LAND USE PATTERN LANDSCAPE INDEX ACQUISITION ALGORITHM BASED ON WIRELESS COMMUNICATION TECHNOLOGY

Changrong Peng, Xiaodong Zhang*,Haiyan Sha,Weiying Zhang
College of Art,Hebei University of Economics and Business,Shijiazhuang, 050061,China
Corresponding Author's Email:53404618@qq.com

Abstract: Design a land use pattern landscape index acquisition algorithm based on wireless communication technology to plan the improvement of the current land use situation. Based on wireless communication technology and remote sensing technology to obtain land use pattern landscape data. A suitable interpolation method is used to generate DEM landscape maps for landscape pattern characterization of different landscape types. Data processing is carried out by geometric correction and waveband combination. Fragstats software was used for the analysis and calculation of landscape pattern indices. The landscape index calculation is divided into two steps, one is the landscape pattern index selection and the other is the landscape level index selection. A study area was selected for calculation accuracy check, and it was found that the calculation accuracy was high and the algorithm was practical.
Keywords: wireless communication technology; zigbee technology; land use pattern; landsat satellite system; landscape index acquisition algorithm;

0 Introduction

Land is an important part of natural environmental resources for human survival and development, not only as a carrier of various other resources, but also as a place necessary for human to engage in social and economic activities, and moreover as a basis for sustainable social and economic development within a certain range. The process of land use not only reflects the results of the interaction, influence and constraints between the natural environment and human factors, but also reflects the nature, characteristics, properties of human-land relationship and its mechanism of action very clearly [1]. With the intensification of urbanization, the contradiction between population growth and lack of land resources in China is similar to the overall situation in the world, and even more acute than most countries. The rapid growth of population size and economic expansion and construction have become the main reasons for the shortage of land resources, and the contradiction between human and land has become increasingly prominent. The continuous development of urban-rural integration, land expansion, repeated construction, inefficient land use and ecological environment deterioration are many problems that seriously restrict the balanced development of socio-economic and ecological construction. The unreasonable spatial layout and function of land use and the serious destruction of ecological environment will affect the full play of land location advantages, reduce the sustainable use of land and ecological quality, and make it difficult to maximize the social, economic and ecological benefits of land use. A reasonable land use structure and layout is not only a reasonable arrangement of the total amount of land, but also a comprehensive consideration of land use structure, spatial layout and ecological construction.

Therefore, the study of the quantity, layout, and synergy within the land resource system has gradually become more important. The more scientific and effective way to carry out land use is by adjusting and optimizing the land use pattern to make it synergistic with the local socio-economic and ecological environment construction [2]. The study of land use patterns can be carried out through the research methods related to landscape indices. Because the landscape pattern and its change trends and causes are the result of the interaction and constraints of various external factors, and its own influence on the ecological processes and landscape edge effects within the region, it is an effective means to reveal the ecological conditions and spatial characteristics of the study area. Therefore, we design a land use pattern landscape index acquisition algorithm based on wireless communication technology to plan the improvement of land use status.

1 Designing a land use pattern landscape index acquisition algorithm based on wireless communication technology

1.1 Land use pattern landscape data acquisition

Acquisition of landscape data of land use pattern based on wireless communication technology and remote sensing technology. Remote sensing technology is used for image acquisition and wireless communication technology is used for data transmission in the process of image acquisition. The wireless communication technology used is ZigBee technology. ZigBee is a short-distance, low-power wireless communication technology based on IEEE802.15.4 protocol. In 2004, ZigBee1.0 version was launched, the current stable version is 2.0, and the latest version is ZigBee Pro. It works in the 2.4GHz free band and is characterized by short range, self-organization, low power consumption, low cost, low complexity and low data transmission rate [3]. ZigBee is currently the most widely used wireless networking method in the field of industrial automation wireless monitoring. The main embedded chip manufacturers are also constantly introducing interface chips that support this communication protocol standard, and it can also expand the communication distance by constructing the transmission mode of star, tree or mesh topology structure.

When studying the pattern of land pattern changes and patterns in the same region, selecting multi-temporal remote sensing images of the same seasonal phase is the most optimal choice that can best represent the region and also accurately and truly reflect the regional land movement attitude, which can minimize the errors arising from seasonal differences. At the same time, the resolution of the image should be high so that the accuracy of the classification can be improved. There are also certain requirements for the quality of image data, the most ideal is the image without clouds and shadows, however, in fact, remote sensing data itself is affected by subjective factors such as weather, geography and shooting time, some of the data are not the most ideal.

The appropriate data source is selected according to the actual situation, which is conducive to real-time dynamic monitoring of land use, while considering the cost and quality of the data. Landsat refers to land satellites, and in practical applications, it can accomplish various research needs of researchers by using its own access to multiple clear and different wavebands, and can achieve incomparable representative characteristics in terms of spectral resolution elsewhere, while having relatively strong relevance to the problems being explored[4]. The Landsat satellite system has been in operation for more than decades, and the research technology is relatively mature, so it is widely used in land use change research.

The remote sensing data required for the study were mainly obtained from the four phases of remote sensing images provided by the Geospatial Data Cloud website in 2002 (Landsat5), 2009 (Landsat7), 2012 (Landsat7), and 2016 (Landsat7), all with a resolution of 30 m. Other references include the 2009 and 2012 Other references include the 2009 and 2012 land use status maps and land use survey statistics.

The calibration map of the topographic map was scanned, and then the DEM data was created. The topographic map with coordinate values was corrected and resampled with a correction error of within 0.5 image elements by opening the ARCGIS software and defining its coordinates as a Gaussian-Krüger projection, and then stitching the split topographic map within the Arcgis software [5].

The digital elevation model (DEM) is a data set of planar coordinates $\left(X,Y\right)$ and their elevations $\left(Z\right)$ of regular grid points within a certain range, which mainly describes the spatial distribution of the regional geomorphology, and is formed by data acquisition (including sampling and measurement) through contour lines or similar three-dimensional models, and then data interpolation. The production of DEM data. The topographic map with coordinate values was corrected and resampled with a correction error of within 0.5 image elements by opening the ARCGIS software and defining its coordinates as a Gaussian-Krüger projection, and then stitching the split topographic map within the Arcgis software.

The topographic map processed in Arcgis software will be vectorized by contour lines in the previous step (i.e., all contour lines are outlined on the topographic map and assigned values), and then set the elevation spacing of 20m, the default interval of 1:50,000 map in the extension module of Arcgis, and then converted to raster data for use.

1.2 DEM interpolation

In the production of DEM data, different DEM interpolation algorithms are suitable for different terrain environments, and the suitability of the algorithm chosen for interpolation DEM is one of the factors that determine the accuracy of the generated DEM [6]. That is, the higher the DEM accuracy, the more suitable the selected interpolation algorithm is for the region.

The terrain area is chunked in a certain way, and each piece is individually surface-fitted and elevation interpolated according to the terrain surface characteristics, which is called spatial chunking interpolation. This simplifies the surface form of the terrain, so that each piece can be represented by a different surface, but then there is the question of how to do the chunking and how to ensure the continuity of the surfaces between the chunks. The general chunking can be done by terrain structure lines or regular areas, and the chunking size depends on the complexity of the terrain, the density and distribution of terrain sampling points; to ensure smooth connection between adjacent chunks, there should be a certain width of overlap between adjacent chunks, and another kind of smooth connection between chunks is to supplement the interpolated curved surface with certain continuity conditions. Different interpolation functions are available for different chunking units, and the commonly used interpolation number functions are linear interpolation, bilinear interpolation, polynomial interpolation, spline function, multilayer surface superposition method, etc [7].

There are three unknowns in the linear interpolation function that require three sampling points to be uniquely determined, while there are four unknowns in the bilinear interpolation function that require four known points. Linear interpolation and bilinear interpolation functions are the most commonly used methods for DEM interpolation and analysis applications based on TIN and square grid based distribution of sampled data due to their clear physical meaning and computational simplicity. Although linear interpolation is simple in calculation, the interpolation surface is continuous and not smooth, so it is suitable for the area with little fluctuation of topographic surface. The physical property of bilinear interpolation is that when Y is constant, the elevation value H is linearly related to the X coordinate; When X is a constant, the elevation value H has a linear relationship with the Y coordinate. However, the interpolation surface is still continuous and not smooth. Compared with the previous linear interpolation method, it has a higher accuracy in dealing with the large undulation of the terrain surface. The bicubic polynomial surface can provide smooth and continuous interpolation surface, but the calculation process is complex, and it is suitable for the grid value at the edge of the DEM region, and it is more suitable for the area with obvious height difference and large surface fluctuation with broken terrain [8]. Based on the quantitative analysis of actual data, linear interpolation, bilinear interpolation and bicubic polynomial interpolation are respectively used as research comparisons. In order to ensure accuracy, DEM with resolution of 30×30m is generated, and then each DEM generated is used as geomorphological map to compare the impact of the generated geomorphic classification map on the research results. Finally, the DEM generated by the proper interpolation method is used as the geomorphic map to analyze the characteristics of landscape pattern in different geomorphic areas. The process of constructing DEM in the study area with topographic map is shown in Fig.1.

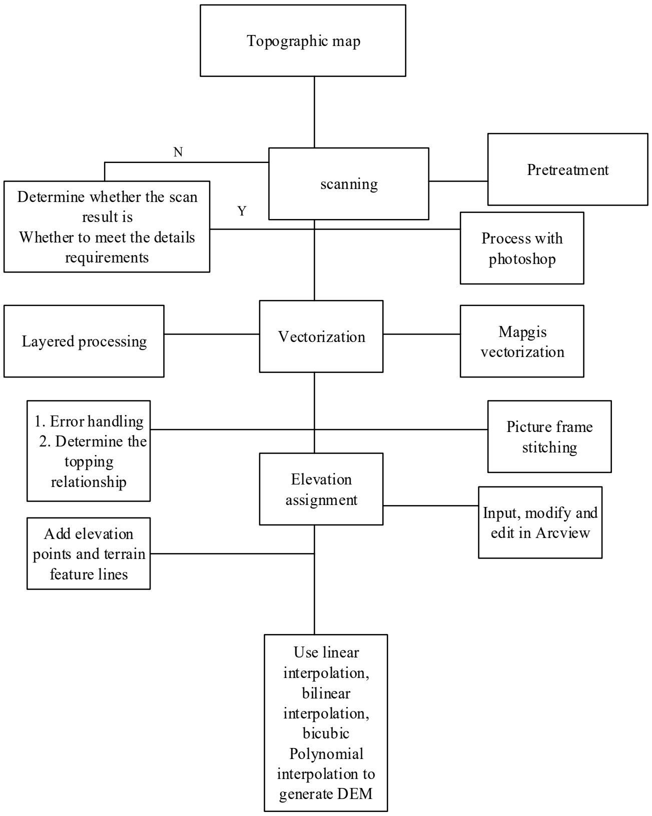

Fig. 1 Flow of constructing DEM of study area with topographic map

1.2 Data processing

First of all, geometric correction, geometric correction can correct or even eliminate the remote sensing image due to the deformation error of the sensing image, which is broadly divided into two categories: static error and geometric error caused by dynamic error. In the imaging process, the sensor will, to a certain extent, present different degrees of deformation errors when it is stationary relative to the Earth's surface, defining the errors caused by this phenomenon as static. When the remote sensing image is further imaged, the platform of the sensor will deviate from the linear relationship of the pixel non-planar of the image due to different uncontrollable factors such as its own height uncertainty and the Earth including satellites, which will have a significant impact on the results of the thesis analysis and exploration. Therefore a geometric correction process must be performed [9]. Using the 1:50,000 topographic map as the base map, based on a resolution of 30m, the same points of feature in the remote sensing image and topographic map are selected as control points all four images are sampled by quadratic polynomial, so that the number of control points is distributed as evenly as possible and also the number is guaranteed so that the error of the obtained results does not affect the analytical exploration. The final result should make the image error not more than 1 image element is the most idealized state. Dynamic error is mainly in the imaging process due to factors such as the rotation of the Earth caused by the image deformation error. The deformation error can be divided into two categories: internal error and external error.

The specific steps of geometric correction are as follows: select the two to be corrected and the standard in the ENVI software and select Map-Registration-SelectGCPs to open the geometric correction module. Select a unique location with a clear sense of hierarchy, easy to analyze and observe clearly, making it a control point for the whole impact, i.e. a center [10]. This process then needs to be repeated for the two images mentioned at the beginning, so that there is one and only one selection of control points and increasing the number of their selection in order to study a more accurate corrected image. The final corrected image is obtained by executing the Options-WarpFile command.

Then the band combination is carried out. For the method of band combination, it is necessary to choose the most optimal way to combine the bands with the least correlation between them but can clearly and hierarchically respond to the feature categories. In TM images, Band 1, Band 2 and Band 3 have high correlation, while Band 4 has relatively high independence of band information. Therefore, the common band combinations of TM are TM321 (RGB), TM432 (RGB), and TM435 (RGB) [11-12]. In fact, the differences between features are not particularly significant in the map, so it is necessary to rely on the optimal combination of bands to show the smallest possible differences, while a well-layered and saturated image can greatly improve the ease of interpretation. In the remote sensing images required for the study, the different categories of vegetation and the area covered by them need to be fully reflected, and the most important characteristics of land categories and diversity of soils and plants need to be accurately distinguished, as well as the water combination factors and the different geomorphological patterns at the surface level also need to be clearly layered, so Band4, Bands and Band3 of TM images are used for remote sensing according to the band characteristics. The image band combinations were used. The final image obtained is saturated with color and the difference of features is more obvious, which is ideal for meeting the conditions of image analysis.

Then image enhancement and cropping are performed, and the main goal of image enhancement is to make the image more suitable for a specific application than the original image by processing it. The enhancement processing of remote sensing images mainly includes spatial domain enhancement, radiation enhancement, spectral enhancement, Fourier transform and band combination [13]. When interpreting the image quality, the image information cannot be extracted completely due to the limitation of image brightness as well as saturation, and the clear identification of the features leads to the bias of the acquired data information, in order to solve this problem, the step of image enhancement is used to correct the image discrimination.

Finally, the interpretation markers can be divided into direct and indirect interpretation markers. As the name implies, direct interpretation is the interpretation information derived from the map intuitively, without the need for other experience or tools; indirect interpretation marks require the researcher to have certain knowledge of geography and familiarity with the field profile to accurately determine the data information and the pattern of change.

Image interpretation is also a key to obtain data information, which can clearly reflect the characteristics of the feature elements, and the researcher can use this feature to clarify the attributes of the elements including layout and location. At the same time, the researcher can reason out those feature elements that cannot be clearly distinguished based on common sense or experience, such as identifying the geographic category by the greenery rate and topographic features of an area [14].

The "interpretation mark" is not invariable, and it is limited by many variables. For example, the projection of different regions on the image must be different; Time is also a limiting condition. For example, the difference of soil moisture content can also affect the image characteristics of ground features. Therefore, when determining the interpretation signs, it is necessary to be clear about the geomorphic conditions in the actual area and the significant change law of geomorphic conditions in different seasons, so as to accurately define the interpretation signs and reduce the error judgment of the analysis results [15].

Invariant type and variant type are two basic approaches to discriminate criteria, and in this study maximum likelihood classification is used, which is one of the variable type methods, and maximum likelihood classification is currently the most commonly used method for remote sensing image classification [16].

1.3 Landscape pattern analysis

There are several options for the analysis software of landscape pattern, Fragstats software is used for the analysis and calculation of landscape pattern indices. Using Fragstats software several landscape indices can be calculated, and under ArcGIS 10.2 platform, the landscape pattern vector image is converted into a raster image with a grid size of 30mx30m [17]. Selected indices in the landscape type level and landscape level were analyzed in the landscape pattern analysis software Fragstats version 4.2 to provide an accurate analysis of the land use landscape types in the study area, while being able to visualize the uniqueness of each part of the structure and spatial configuration. At the present stage, the landscape pattern is divided into the patch level index, the type level index and the landscape level index [18]. Among them, the patch level index and the landscape level index are commonly applied. The patch type is mainly composed of a certain number of individual patches, and multiple patch types merge together to form a complex of landscapes.

1.4 Landscape index calculation

The landscape index is calculated in two steps, one is the landscape pattern index selection and the other is the landscape level index selection [19].

(1) Selection of landscape pattern index

Landscape pattern indices are inevitable elements that accurately and intuitively respond to landscape pattern characteristics, and according to the application scale, the research indices can be divided into three categories: patch level indices, patch type level indices, and landscape level indices; according to landscape pattern characteristics, they can be further divided into two categories: landscape structural composition and landscape spatial relationships, reflecting their obvious ecological significance [20-21]. At the landscape type level, a total of four landscape pattern indices were selected according to the research needs: patch type area, number of patches, average patch area, and maximum patch index.

(2) Selection of landscape level index

In terms of landscape level, a number of indicators were selected and the specific formula for each index was calculated as follows.

Number of patches (NP).

$$NP = N \quad (1)$$

Proportion of landscape area occupied by patches.

$$PLAND = P_i = \frac{\sum_{j=1}^{n} a_{ij}}{A}(100) \quad (2)$$

Patch density (PD).

$$PN = \frac{n_i}{A}(1000)(100) \quad (3)$$

Patch aggregation (AI):

$$AI = \left[\frac{g_{ii}}{\max \to g_{ii}}\right](100) \quad (4)$$

Shannon's Diversity Index(SHDI):

$$SHDI = -\sum_{i=1}^{m}\left(p_i Inp_i\right) \quad (5)$$

Landscape fragmentation.

$$C_i = \frac{N_i}{A_i} \quad (6)$$

If the intensity function uses $\tau_{ij}(t)$ to represent the weight of landscape index key of land use pattern between nodes i 、 j, equation (7) can represent its definition and update mode.

$$\tau_{ij}(t+1) = (1-\rho)\tau_{ij}(t) + \Delta\tau_{ij} \quad (7)$$

Among them, volatile factor ρ satisfies $0 \le \rho \le 1$. The calculation of weight increment $\Delta\tau_{ij}$ is shown in equation (8)

$$\Delta\tau_{ij} = q \cdot Interest(key) \quad (8)$$

In equation (8), q represents a normal number. The larger the weight increment $\Delta\tau_{ij}$ value is, the higher the resource interest $Interest(key)$ of users searching for land use pattern landscape index key is.

According to the above formula, in the resource search process of weight, the selection path probability function $\mathrm{p_{ij}}(t)$ can be expressed as:

$$\mathrm{p_{ij}}(t) = \frac{\left[\alpha\tau_{ij}(t)\right]\cdot\left(\beta\eta_{ij}\right)}{\sum_{k=1}^{n}\left\{\left[\alpha\tau_{ij}\right]\cdot\left(\beta\eta_{ij}\right)\right\}} \quad (9)$$

In formula (9), the weight intensity and selection diversity weight are represented by α and β respectively.

The specific symbolic meanings and index meanings in the formula are shown in Table 1.

Table 1 Specific symbol meaning and index meaning in the formula

Serial number	Name of Landscape Index	Calculation formula	Symbol Meaning	Index Meaning
1	The number of patches(NP)	(1)	N :the number of patches	The degree of landscape fragmentation
2	The proportion of patch to landscape area	(2)	a_{ij} refers to the area of patch ij , A refers to the total landscape area	When its value tends to 0, it means that this patch type becomes very rare in the landscape; when its value is equal to 100, it means that the whole landscape consists of only one type of patch
3	Patch density(PD)	(3)	n_i: Total area of category i landscape elements	Patch density is a basic index for landscape pattern analysis, and its unit is the number of patches/100 ha, which expresses the number of patches per unit area and facilitates the comparison between different size landscapes
4	Degree of plaque aggregation(AI)	(4)	g_{ii} :Number of similar neighboring patches of the corresponding landscape type	When there is no common boundary between all the pixels in a type, the type has the lowest degree of aggregation; and when the common boundary between all the pixels in the type reaches the maximum, it has the largest aggregation index
5	Shannon's Diversity Index(SHDI)	(5)	p_i :Proportion of landscape patches occupied by type i	SHDI is also a sensitive indicator when comparing and analyzing changes in diversity and heterogeneity across landscapes or across time in the same landscape
6	Landscape fragmentation	(6)	C_i is the fragmentation degree of landscape i,	It is the process by which the landscape tends to change from a single, homogeneous and continuous whole to a complex, heterogeneous and discontinuous

	N_i is the number of patches in landscape i. A_i is the total area of landscape i	mosaic of patches due to natural or human disturbances

2 Case Study

2.1 Study Area Overview

The study area is located in a city between 103°25'42 "E and 103°47" E and 30°44'54 "-31°22'9 "N. It is 54km wide from east to west and 68km long from north to south, spanning the Longmen Mountain zone in western Sichuan and the top of the Minjiang alluvial fan in Chengdu Plain. The terrain of the city is high in the northwest and low in the southeast, with 65.79% of the area of the city's hills and 34.21 of the area of the flat dam. The terrain decreases step by step from high mountains, middle mountains to low mountains and plains, with an elevation of 592-4582m and a relative elevation difference of 3900m. The terrain is high in the northwest and low in the southeast. The high mountains, middle mountains, low mountains, hills and plains are distributed in steps. The geomorphic features within the territory are roughly summarized as "five mountains, two mounds and three dikes". Mountain area accounted for 54.3%, hills accounted for 11.5%, flat dam landform accounted for 34.2%, mountain, plain, water area is roughly 6:3:1.

The city has a pleasant climate, belonging to the subtropical humid climate area, four distinct seasons, summer without heat, winter without cold, pleasant climate. The average annual temperature is 15.20C, the average temperature in January is 4.6 0C, and the average temperature in July is 24.7 0C. The average annual precipitation is 1200mm, and the average annual frost-free period is 280 days. The average annual rainfall is 1243.8mm. Dujiangyan city has complex geological structure, diverse landform types and fertile soil. The parent material of the soil is the Holocene gray and grayish purple alluvium, which is rich in mineral nutrients. The soil is mainly yellow, brown and purple mud and cold sand yellow mud.

Based on the theory of sustainable development and ecological balance, the study area is selected through the division of kilometer grid, and the land use pattern landscape data of the study area is obtained by using wireless communication technology and remote sensing technology. The landscape pattern index is selected to analyze the land landscape pattern information in the study area, and the results of the landscape index analysis are used to study and discuss the rational land use situation in the study area and put forward suggestions and measures to optimize the rational land layout in the area.

The aerial image data of the city was used for the experimental study data, as shown in Fig. 2.

Fig. 2 Aerial image data of the study area

For the study area images, the image data were segmented using a data-based approach with the support of Detiniens software. Since the process of image element seed growth is mainly determined by four parameters: scale parameter (which determines the size of the object), smoothness of the object, tightness of the object (which determines the shape of the seed growth), and spectral information (which determines the color index of the object), the data segmentation of the image was mainly referred to these four parameters. After several experiments, it was found that the data segmentation parameters were selected as shape factor 0.1, color factor 09, tightness 0.5, and smoothness 0.5, and the segmentation effect was better.

The segmentation scales of 150, 160, 200, 240, and 280 were selected for the comparison test. The five scales represent the large, medium and small types in the segmentation process, and the weights of the segmentation parameters were assigned according to the optimal parameters set at different scales, and it can be seen from the segmentation results that after the optimal segmentation parameter values are determined, there are large differences in the image objects obtained at different segmentation scales.

① When the segmentation scale is at 120, the segmentation produces too many objects with fragmented shapes, which is not suitable for obtaining the land use pattern landscape index.

② When the segmentation scale is 160, the number of objects generated by segmentation is large and the area of individual objects is small, which is not suitable for acquiring the land use pattern landscape index.

③When the segmentation scale is 200, forest land and cultivated land can produce adjacent polygons, and the object segmentation is relatively complete, so it is suitable to be selected as the best segmentation scale for the study.

④When the segmentation scale is 240, cropland and forest land with close spectral information can easily be segmented into the same object, which brings a larger error in the results.

⑤ When the segmentation scale is 280, the image object area is large and most of the feature categories are mixed with other categories, which is not very meaningful for the experiment.

Therefore, the segmentation scale of 200 was chosen as the best scale for the experiment.

2.2 Experimental results

In the experiment, due to the process of remote sensing information data acquisition, processing and analysis, various errors will inevitably occur, such as various geometric and spectral distortions caused by the unstable orbital position, solar altitude, atmosphere, topography, etc. in the process of remote sensing data acquisition. In the process of data processing for geometric correction, the inappropriate use of models or human-induced errors; in the process of data analysis, the selection of classification methods, the extraction of training samples, and the selection of various parameters will all lead to errors in the final acquisition of land use pattern landscape indices, so the accuracy evaluation is chosen to identify the reliability of the calculation results. Accuracy evaluation, as the name implies, means testing the accuracy of the calculation results by means of actual research. The error matrix was used to check the calculation accuracy. After calculation, the accuracy evaluation results of land use pattern landscape index calculation in the study area are 0.8283, 0.8256, 0.8324 and 0.835, which correspond to the four image data of segmentation, respectively, with high accuracy.

3 Conclusion

Based on the study of the algorithm of land use pattern landscape index acquisition based on wireless communication technology, it is found that the algorithm can analyze the information of land landscape pattern in the study area. In the research process, due to the shortage of time and limited energy, the collected information is not very comprehensive, some research work is not very detailed, and there are still some areas of work that need to be improved, which will be further studied in the future.

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