RETRACTED ARTICLE: Spatial structure system of land use along urban rail transit based on GIS spatial clustering

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ABSTRACT

During the past 30 years of reform and opening up, the level of urbanization in our country has made considerable progress, and more cities have had development conditions of the rail transit. In order to solve various problems caused by urbanization and optimize the allocation of urban resources, in this paper, the significance of spatial planning in big cities was analyzed from the perspective of land space utilization along with the rail transit. Based on GIS spatial clustering mining technology and combined with the basic characteristics of geographic information system, a GIS spatial mining search model that can solve the spatial land use was proposed. Then, by combining the clustering algorithm of some association rules, the land planning and utilization along the urban rail transit were calculated. The actual case was taken to establish the grid elements along with the rail transit, and the GIS spatial clustering algorithm was used to verify the model. The results show that GIS spatial clustering algorithm can effectively verify and calculate urban rail transit land planning programs.

Introduction

The speed of urbanization in our country has attracted worldwide attention. However, with the rapid development of urban rail transit, the speed of urbanization development is far greater than the speed of infrastructure construction of the urban rail transit, and this will result in that the uncoordinated problems of the development of the two are exposed. The urban problems in the development of big cities in China have become more and more serious, and the scientific development of rail transit has become a problem that people have to face and solve (K M L & Jayasree, 2013). Urban rail transit not only involves the planning of transportation network lines but also involves the land use and planning along with the rail transit. Therefore, the urban planning and construction of rail transit are a continuous process of repetition and construction. If the project construction process is not carefully planned, then the management of rail transit will come (Li et al., 2015). In the construction of urban rail transit, the most important issue is the overall development of rail transit, and then is the development correlation programming of rail transit. The cognitive grasp on the direction of urban development and the positioning and upgrading of urban centers are the problems that must be considered in the future, here, the land use space utilization along rail transit is involved. As long as the land along the line is scientifically and rationally used, the development of the planning and construction of rail transit can be coordinated (Gao, J J et al., 2014). In short, improving land utilization along the rail transit is the ultimate goal of development.

Data acquisition and storage realized by computer processing technology is currently an effective way to solve the information-based knowledge and technology. This is because a lot of data growth has gone far beyond human analytical capabilities. Then, for the great potential value of the effective information existing in a large number of data, there is an urgent need for a technique and method of data mining and clustering analysis about how to use the potential information value of the data (J Gao et al., 2013). Spatial data mining is a knowledge-based problem-solving technique. After digging and obtaining the available valid information from the data and providing it to the spatial decision-making system, more accurate data knowledge can be obtained. Then, after the spatial decision-making system possesses the data knowledge, the designed algorithm is used for calculation, so as to help people understand the valid information of the data more clearly (Zulu L C et al., 2014). As a decision system of data knowledge, spatial data mining technology can be widely used in the fields of GIS and remote sensing. GIS is a platform for spatial analysis and geographical data computing, which can accurately analyze the spatial distribution and morphology (Kaundinya D P, et al., 2013). GIS data storage and analysis functions are fully used, and a large...
number of geospatial data are collected as smart data. Spatial data clustering analysis is the basis of GIS query and analysis technology. At the stage of knowledge discovery, an intelligent GIS system is established, and a GIS decision-making system of cluster analysis space is formed.

A survey of the Utilization of Geographic Information Technology Based on Spatial Geographic Data

**Concept grid division technology**

The technical basis of the spatial clustering algorithm is to define and divide the concept grid, so as to make better use of the algorithm to mine the data. In this paper, based on the basic model of GIS spatial data mining and the algorithm of clustering analysis, a calculation method of spatial association rules will be proposed. The basic concept is a progressive way of human progress and language expression, which can be classified as ideological units of connotation and grouping in philosophical system (Siordia, 2013). In view of the basic meaning of the philosophical system, the concept of form can carry out the discovery and sorting display of basic problems. In the basic problems of formal concept, the connotation is named as the basic attributes set of research objects, so that the concept philosophy is introduced into the visualized problem expression. Concept lattice is the core data characteristic of concept form, it essentially reflects the effective correlation between objects and attributes, which shows the generalization characteristic relation between basic research concepts and proves the characteristic correlation degree between basic concepts. The process of data mining is to make the knowledge contained in the data become a basic utilization concept. The formation of concept requires Hasse diagram to form a concise generalization characteristic relation (A S et al., 2013). When the data is visualized, the concept lattice can prepare for the data analysis, and the application of the knowledge-based data tool can achieve the use target in the knowledge engineering.

The definition of the concept lattice is to generalize the basic idea into a node; then, the expression form of the concept is formed, which is called the form concept. When a lattice concept is used for data mining, the concept lattice needs to be converted to the formal background of the object (Gupta et al., 2015). The initialization phase is defined as a combination of three elements, \( T = (O, D, R) \), among them, \( O \) represents the object set of an instance, \( D \) represents the attribute set. The basic relationship between formal concepts can be formed through the relationship between concepts, and the expression is:

\[
H_1 = (O_1, D_1) \quad \text{and} \quad H_2 = (O_2, D_2)
\]

In the formula, \( O_1 \subseteq O_2, D_1 \supseteq D_2 \), \( H_2 \) is the super concept of \( H_1 \). After the generalization work and the previous generation of nodes extends outward, the node connotation of the previous generation is the connotation subset of the next generation of node, that is, many objects can be contained. The attributes of the research object will continue to decrease, and the concept set formed by the formal background will form a complete lattice (Roth et al., 2016).

The basic principles of data mining need to be completed through the following steps: the first step is the basic preparation work for spatial data, the second step is to create the connection form, the third step is to build the concept lattice, and the fourth step is the spatial association rules extraction method. After spatial computation and data transformation, the non-spatial attribute fusion of the special objects is carried out to the reference layer and related layers, and the spatial predicate connection table that can be studied and used is formed (J Gao et al., 2013).

Spatial predicate connection table is an expression method of the data table form that can achieve spatial data correlation, and then the spatial associated thing type data expression form is described. The research method of this article has the association rule mining form, and the basic structure of the concept lattice is formed based on the formal background. In the formation process of the concept lattice, a Hasse diagram is formed (Bermingham et al., 2013). According to the association rules generation basic algorithm of the concept, the connotation automation generation redundant association rules are adopted. The first is to find frequent concept nodes to summarize non-null subsets. If the selected subset is a subset of one of the parent node, then the subset can be deleted. After the first step is processed, for the remaining subset of connotations of each frequent node, if there is another subset that is a true subset, then the subset is deleted. The set after connotation reduction can generate two different rules, one of the rules is 100% of the complete rules, and the calculation form is:

\[
\{ g \rightarrow (f/g) \mid f \in FC, g \in G, g \neq f \}
\]

In the formula, \( FC \) is the node connotation set of the frequent concept, \( f \) is the connotation set of a frequent node. This computational rule is a set generated by combining the connotation of frequently used conceptual nodes and compression. Another type of confidence level may be less than 100%. The calculated expression is:

\[
\{ g \rightarrow (f_2 - g), g \in G \}
\]

This rule represents the conceptual node formation process of two parent–child relationships with strong correlation. The above method can be used to form an association basic rule with the least confidence. Figure 1
shows a spatial association rule data mining process. By combining the spatial mining model of geographic information data, an effective data association mining rule can be obtained.

**Spatial data clustering technology based on GIS**

Clustering analysis is a kind of “irregular” supervised data learning and use way, then, the classification of similarity of the attributes is carried out according to certain characteristics. The field of research and design is more extensive, including data mining, statistics, biological information fields and so on (Sung et al., 2014). Spatial clustering analysis technology is the wide application of spatial database. It can not only discover meaningful clustering analysis structure from the spatial database but also accomplish the division work in similar areas. Spatial clustering data mining is a relatively frontier research method. There are many computing methods that can be used. In this paper, the GIS application clustering space algorithm is applied to carry out cluster calculation to the geography and building along with the urban rail transit (Zhu, 2014).

Spatial clustering analysis is an analytical method that can deal with many dimensions, it finds out the region of the measured space distance for different distance sizes and carries out the similarity matching for the “cluster” space objects (J Gao et al., 2013). Spatial clustering is an extension and expansion of cluster analysis. The process of general clustering analysis is shown in **Figure 2**. In the use process of the clustering algorithm in this paper, the frequently used documents are used as feature attributes. And after a certain number of frequent words are extracted, the coordinates in the images are labeled to describe the pixel feature points of the image.

Among them, the calculation of similarity is the main work of clustering analysis data, and the definition of cluster is the basis of similarity calculation. At present, a relatively wide range of similarity measure functions is used to describe and measure the space distance of two data objects (Gao, J J et al., 2014). The difference degree of scale variables of the interval is a continuous distance. The closer the distance is, the larger the computing similarity point between the objects is. Among them, the Euclidean distance calculation method is shown as follows:

\[
d(i, j) = \sqrt{\sum_{k=1}^{m} (x_{ik} - x_{jk})^2}
\]

In the formula, \( i = (x_{i1}, x_{i2}, \ldots, x_{im}) \) and \( j = (x_{j1}, x_{j2}, \ldots, x_{jm}) \) is the multidimensional data object of two objects.

The total number of binary variables is counted. Binary variables have the same weight, and the binary value table in **Table 1** can be used to describe and reflect the state that the variable values of two objects may appear. \( a \) represents the basic quantity of attributes that the object value is “1”, \( b \) represents the number of attributes that the objects are “1” and “0”,

![Figure 1](image1.png)

![Figure 2](image2.png)
and \( c \) represents the basic number of attributes that the object values are "0" and "1". The sum of \( a, b, c, d \) is the total number of attributes of the research object.

The value of a binary variable is that in a symmetric case, the value of an object variable is "1" or "0", which is equivalent and has the same weight (Wang et al., 2013). At this time, the calculation expression of the difference degree of the object is:

\[
    d(i,j) = \frac{b + c}{a + b + c + d}
\]

(5)

However, in the process of many practical processing problems, the binary research objects are not symmetrical (Chen, 2013). The calculation expression of the difference degree of two research objects is:

\[
    d(i,j) = \frac{b + c}{a + b + c}
\]

(6)

In the clustering analysis algorithm used in this paper, a density clustering algorithm is adopted, the collected data are abstracted into data points, and the clustering calculation is carried out according to the density of the data gathering area. The definition has the data point \( p_1, p_2, \ldots \) of which \( p_1 = q, p_n = p \) met. For \( i \in \{1, 2, \ldots, n-1\} \), the density from the data point \( p_{i+1} \) to the data point \( p_i \) can be calculated directly, then, the density of data point \( p \) and data point \( q \) can be calculated, as shown in Figure 3.

According to the existing GIS system, the vector data structure can be calculated and the basic points, lines and surfaces of the space entity can be described. In the spatial clustering calculation, the spatial entities use a certain point to describe, and then, the basic area is formed after clustering (Zhao et al., 2014). GIS abstracts clustering samples as an arc between points and points. After being bound by some constraints, the network structure is formed through the connection of points, as shown in Figure 4.

The subject of the geographic information system description is the spatial object. For clustering objects, the spatial objects are all spatial samples, and it is more accurate to use points and lines to perform description (Zhao et al., 2014). The points in the layer are used to describe the points of the spatial sample, and meanwhile, the properties need to guarantee a certain relationship. Table 2 shows the spatial attribute of the sample points to be clustered. The GIS geospatial attributes that need to be described include population, land price and some non-spatial base attributes.

### Table 2. Attributes of samples to be clustered.

| FID | 0  | 1  | 2  | 3  | 4  | 5  |
|-----|----|----|----|----|----|----|
| Shap| Point | Point | Point | Point | Point | Point |
| Entrance | Q0 | Q1 | Q2 | Q3 | Q4 | Q5 |
| Land price | P0 | P1 | P2 | P3 | P4 | P5 |

#### Optimization Method of Urban Traffic Space Along the Line Based on GIS Spatial Clustering

In this paper, a city in southwest China was selected as a case of land use along with urban rail transit. By combining the above GIS spatial clustering analysis technology analyzed, a certain planning strategy was taken for the utilization of space along with the urban rail transit. The first was to give the basic situation of the city. The target city is the capital city in the
The landform is mainly based on mountains, as well as the hills and basins. As China’s southwestern city is an important central city in southwest China, it can be positioned as a key eco-tourism and cultural city. The total output value of the city in recent 3 years is about 300 billion yuan, and the annual growth rate is about 12%, the total population is about 4.7 million, and the level of urbanization is about 75%. As capital city is an important transportation hub and important industrial and tourism city, with the constant improvement of people’s living standards, the proportion of urbanization is increasing continuously. According to incomplete statistics, in recent 5 years, the city’s vehicle market has increased from 300,000 to 1 million. Figure 5 shows the city’s motor vehicle growth trend analysis diagram.

At present, the methods for dealing with the problem of two-dimensional space obstacle in the clustering analysis algorithm are mainly divided into general type and special type. The general algorithm is to adopt the preprocessing method to deal with the space obstacle before the operation. The special method is an algorithm processing step which is implemented for the individual clustering algorithm, and it is generally integrated with the clustering algorithm. In this paper, the CPDG calculation method will be used to complete the spatial barrier crossing of the clustering algorithm. It can be confirmed from the existing literature that CPDG can completely solve the problem of clustering analysis algorithm based on grid density.

In the idea of spatial clustering algorithm based on grid density, the grid and density are two very important concepts. Among them, the grid division is the basic unit for dealing with the problem. After the process of object allocation, the clustering algorithm will directly face the grid, rather than directly facing the research object. Density is the basic standard of grid processing. According to study the characteristics of the geographical environment, the grid density degree is given to form a special cluster. However, the following two kinds of problems often need to be solved in the spatial clustering algorithm: the first problem is the transformation and identification form after the space encounters the obstacle, and the second problem is that the transformed space obstacle can’t be crossed in the clustering algorithm.

Here, CPDG is used to solve the above two problems. After the space gridding, in view of different forms of obstacles for line and surface, the general expression of space obstacle is transformed into a series of grids to form a continuous change area. The influence of low-density region on spatial clustering is similar to the influence of obstacles on clustering algorithm. Therefore, the spatial obstacle after gridding is transformed into low-density region, and in the two-dimensional space, the grid density clustering region forms a continuous non-leapfrogging region. The main meaning of the gridding of linear obstacles is to form a grid of discounted forms. At both ends of the curve, there may be an intersection point (X, Y) between a certain margin line and the above curve. Assuming S is the basic length of the grid, and N is a constant (integer), the following conditions are satisfied:

\[ X = N \cdot S \]  
\[ Y = N \cdot S, f(x) \neq 0 \]  

Spatial clustering division needs to solve the problem of polygons obstacle gridding division. For any type of polygon obstacle, all the grid vertices are searched within the smallest outer rectangle, that is, a polygon obstacle can be formed. The principle of gridding processing is shown as follows: (1) Supposing that the grid vertices are on the polygon, then, the processing isn’t made. (2) Assuming that the vertices of the grid are outside the polygons, then, no processing is done. (3) The grid vertices are in the polygon; then, four vertices are associated and they are classified as obstacle grid, and the density is zero. After determining the basic principle of polygon grid obstacle, the topological relations of the polygons in space will be confirmed. In this paper, the traditional ray focus method is adopted to determine the topological relations between the grid vertices and the polygon obstacles. The main idea of this method is to emit a ray randomly at the left and right sides of the free space; then, the intersection point of the first polygon is encountered, and the second intersection point is encountered after entering the interior, next, leaving the polygon. However, there are also many special cases, as shown in Figure 6. The (a) ray in Figure 6 intersects with the vertex of the polygon, while the (b) ray in Figure 6 does not intersect with the vertex of the polygon, which can’t be involved in the calculation. (c), (d) in Figure 6 coincide with one edge.
of a polygon, and the influence of this side can be ignored.

For the point control on a polygon, an example of the grid obstacle method in the two-dimensional space shown in Figure 7 is given. The left is an independent linear obstacle and the right is a polygon obstacle. After the obstacle grid division is completed, the clustering algorithm begins to cluster. In CPDG, the implementation process of two-dimensional space obstacle grid algorithm is the core part, which deals with the continuous low-density area of obstacles in space, and realizes the obstacle constraint of spatial clustering. No matter how does the processing method, the core part of the algorithm is basically unchanged. And the main difference is to deal with the regional connectivity problem of the spatial algorithm.

**Calculation Results and Optimization Scheme**

The land use along the urban rail transit is mainly for two basic tasks. The first is traffic demand planning, and the other is demand forecasting and land for construction of urban rail transit. The above two works can be applied to the GIS system for design and planning. In the comparative research method of general transportation planning land, four stages of demand forecasting method are adopted. The first is to divide the land planning along with the urban rail transit into several traffic zones and predict all the forecasting and all traffic areas. The trip generation methods include trip probability or regression model methods. The traffic mode planning of the trip is divided into the distributed traffic mode among each traffic district so that the basic model assignment is carried out in each traffic network. The non-aggregation model has had good spatial transfer, which has been used well in the actual traffic planning. The calculation expression of the sharing rate of a non-aggregation model in a space combination trip mode is shown as follows:

\[
P_i = \frac{\exp(U_i)}{\sum_{j=1}^{N} \exp(U_j)}
\]

\[
U_i = \alpha_i T_i + \beta_i C_i + \gamma_i
\]

In the formula, \(U_i\) indicates the use efficiency represented by the trip mode, \(T_i, C_i\) indicates the service time and cost, \(\alpha_i, \beta_i, \gamma_i\) are the calculation parameters to be determined, \(N\) indicates the number of the trip mode.

The land planning and use of rail traffic are restricted and influenced by many factors. In the process of planning, the basic factors of the passenger flow should be taken into consideration for the use of land, and the factors such as the economy, human and operating...
conditions are comprehensively analyzed. Because many factors can’t be quantified, the network design can only be added to the design and construction process of urban rail transit to carry out qualitative analysis. The current land planning of rail transportation is mainly based on experience, but the land planning can be effectively combined with experience after the promotion of quantitative analysis in the future. On the intuitive interface of GIS, the rail transit line can be preliminarily planned through objective constraints and some basic principles, and several initialized traffic plans can be drawn up. The quantitative analysis is completed by GIS. Finally, the spatial clustering algorithm is used to evaluate the planning scheme. Assuming that the objective function is:

$$\min \{a \cdot C + b \cdot P + c \cdot OD\} \quad (11)$$

In the formula, $C$ is the cost of the urban rail transit, $P$ is the number of population covered along with the traffic, $OD$ is the traffic land distribution amount, $a, b, c$ and are calculation constants.

According to the land use along the urban rail transit indicated by GIS, the prediction object area is given and divided into several traffic operation districts, and furthermore, a demand prediction is carried out to the predicted traffic planning area. The first phase of the traffic volume of trip is the single economic indicator of land planning. According to the influence model of multiple factors, based on the GIS urban rail transit basis, a standard space entity figure of the traffic area is set up. Attribute information needs to establish demand data. Then, according to the economic indicators along with the urban rail transit, the relationship between land use area, population and land use category is established. In addition, a traffic area is used as the research object of case analysis, and the basic graph of the traffic area with input query is built based on the relevant attribute information of GIS query.

The gravity model is embedded into the spatial clustering algorithm so that the spatial clustering algorithm can achieve the traffic distribution prediction under the gravity model, and then the land use planning along the urban rail transit can be clarified. Supposing that the traffic volume between traffic area $i$ and traffic area $j$ is directly proportional to the amount of traffic attracted and inversely proportional to the distance to the residential area. Therefore, the traffic calculation formula for the land use along the urban rail transit is:

$$t_{ij} = k \cdot \frac{G_{i} \cdot A_{j}^{\beta}}{R_{ij}^{\gamma}} \quad (12)$$

In the formula, $t_{ij}$ is the amount of distribution in the traffic area, $G_{i}$ indicates the production quantity of traffic area $i$, $A_{j}^{\beta}$ is the number of the traffic attraction of traffic area $j$, and $R_{ij}^{\gamma}$ is traveling impedance coefficient in traffic area.

Through GIS spatial clustering algorithm, the land use model of urban rail planning line is calculated. Then, the first approximations and the second approximations of the spatial clustering algorithm are calculated by inputting the computational generation and combining the traffic distance of the traffic gravity center of GIS, as shown in Table 3.

### Conclusions

With the development of urbanization in China, the spatial structure and functional structure have a far-reaching impact on the development of urban rail transit. It is urgent for China to develop and plan the land for constructing the rail transit along the line, so as to alleviate the traffic congestion caused by the urbanization development as much as possible. In this paper, a basic strategy of land use optimization along rail transit was proposed. Firstly, the spatial data mining and geographic information system (GIS) were discussed deeply, thus hoping to transform the transaction processing-type data into spatial data through a certain transformation. Then, a GIS mining feasibility data processing technology of the spatial clustering method was proposed. After combining with the GIS spatial data mining geographic information system, the spatial clustering algorithm was simpler, and the problem of geographic information system analysis was also simpler.

Taking a provincial capital city in southwest China as an example, the effect of GIS spatial clustering algorithm on land structure utilization along the urban rail transit was discussed by combining the GIS spatial clustering analysis technology proposed in this paper and integrating the land use planning strategy along with the urban rail transit. The calculation results show that the GIS clustering algorithm proposed in this paper has better effect on the land space utilization along with the urban rail transit in the core city, which can achieve better results and provide excellent theoretical data for land use strategy of the urban rail transit.
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