Optimization Strategy of Cultural Space in Old Urban Communities

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Abstract: With the development and popularization of the sharing economy in cities, the city's appearance and lifestyle have changed with each passing day, and the service functions of some old communities can no longer meet the current people's living needs. It is of practical significance for the sustainable and coordinated development of the city to study the strategies and methods of optimizing the functional space of the old community, optimize the cultural space of the old urban community and establish the shared service function. Aiming at the spatial information demand in urban development decision-making, this paper studies the theory, method and application of urban spatial dynamic data mining, and applies particle swarm optimization (PSO) to the optimization of cultural spatial layout of old urban communities with performance constraints, and discusses the method and application of urban land use spatial structure prediction. The example results verify the feasibility and effectiveness of the algorithm. The optimization of cultural space in old urban communities combined with PSO algorithm can obtain reasonable, feasible and scientific spatial optimization results, and the operation efficiency is obviously improved. It is particularly important to formulate and improve the laws and regulations of community development, formulate scientific and reasonable community planning, and attach importance to the inheritance and innovation of community culture. Using PSO can efficiently complete the layout optimization design of community cultural space.
Keywords: Old community; Cultural space; Layout optimization

1. INTRODUCTION

After the reform and opening up, China began the process of transforming from a planned economic system to a market economic system. Great changes have taken place in urban socio-economic conditions and the ideological values and spiritual and cultural life of urban residents. These factors have had a profound impact on China's urban social space (X.-Y. Zhou et al., 2017).

With the development and popularization of the sharing economy in the city, the urban appearance and lifestyle have changed with each passing day, and the service functions of some old communities can no longer meet the current living needs of people (Wang & Han, 2021). Due to the economic transition and social transformation, urban social problems and

social contradictions have become increasingly prominent, and the research on urban social space has been paid more and more attention by academia and government departments. Many problems in urban development have a strong timeliness, as well as the constraints of geographical spatial distribution, which shows the multidimensional compound of time, space and characteristic quantities (Church & Li, 2016). Community is the basic unit of urban social space and plays an increasingly important role in urban social and economic development and spatial optimization (Li et al., 2016). Strengthening the guidance, adjustment and optimization of urban community spatial organization is an urgent task to promote the development of urban communities in China. It is of practical significance for the sustainable and coordinated development of cities to study the strategies and methods of optimizing the functional space of old communities, optimize the cultural space of old communities, and establish shared service functions.

With the large-scale real estate development and urban expansion, residential areas spread from the old city to the new city, significantly changing the existing urban spatial structure, and at the same time driving the migration of population in urban inner space (Wang et al., 2017). It is the polar nucleus and radiation source of regional development, and the overall economic and social development of the region can not be separated from the drive of the city. Due to the rapid development of earth observation technology, database technology and network technology in the field of spatial information technology in recent years, all kinds of spatial data increase exponentially (Mariani et al., 2012).

The dual population movement within the region and the city, projected on the urban community, is the time-space change of the community residents' structure, which not only brings the pressure of the urban community residents, but also reshapes the urban community function and social spatial structure, causing a series of community problems, especially in the old communities (Samarghandi et al., 2010). Urban spatial data mining (USDM) refers to the application of spatial data mining (SDM) theory, method and technology in urban areas, and includes the newly developed spatial data mining theory, method and technology according to the characteristics of urban areas (Derakhshan Asl & Wong, 2017). In this paper, taking the spatial information demand in urban development decision as the goal, guided by the theories of geographic information science and urban geography, the theory, method and application of urban spatial dynamic data mining are studied. Combining with PSO, the cultural spatial layout of old urban communities is optimized, and the method and

application of urban land use spatial structure prediction are discussed. From the economic point of view, urban area is the polar core and radiation source of regional economic and social development, with highly concentrated economic and social resources, very active economic and social activities, and dramatic changes in urban landscape (Cheng & Lien, 2012).

The continuous deepening of urbanization and the improvement of residents' quality of life have aroused the attention of urban planning professionals to living space. The focus of urbanization development with people as the core has begun to shift from the field of urban production to the fields related to residents' daily life (Walsh, 2012). The increasingly abundant urban spatial data has exceeded the ability of scientists to deal with to a certain extent. The need to discover knowledge from these massive data makes the urban spatial distribution data mining method inevitable (Cronin-de-Chavez et al., 2019). Urban space is both the noumenon of urban culture and the carrier of urban culture. As a micro element of the city, community space is not only the carrier of residents' daily life, but also the crystallization of urban culture (Rabbani et al., 2012). The rest of the article is arranged as follows: The second section is literature review, which analyzes the related research of spatial layout and USDM, summarizes its contributions and shortcomings, and puts forward the optimization strategy of cultural space in old urban communities. The third section is methodology, which constructs the optimization model of community cultural spatial layout from two aspects: USDM and PSO. The fourth section is the experimental analysis, which verifies the efficiency and effectiveness of PSO in this paper. The fifth section is the summary of the full text, expounding the effectiveness of the optimization algorithm of cultural space in old urban communities, and proposing the future development direction.

2. Related Work

In the analysis of social structure and spatial structure in traditional settlements, Zhang analyzed the transformation of social structure and spatial structure, the social structure of people at the settlement level and the family social structure at the architectural level (Zhang et al., 2010). Guitart, etc. think that the main body of social structure is the crowd, and its main content is the behavior and organization of the crowd's life, including the behavior of living in compact communities, and it also further

involves the institutional consciousness and belief at the cultural and spiritual levels (Guitart et al., 2012). In the analysis of spatial structure and function of See urban open space, it defines urban open space, studies and analyzes the spatial distribution pattern of urban open space and the structural mode of urban open space layout (See et al., 2015). Wu et al. think that in cities, its open space system has the functions of culture, landscape, protection, control and economy (Wu et al., 2018). Hasenbein and other scholars have explored and studied the theoretical basis, method system, technical framework and application prospect of spatial data mining (Lu et al., 2016). Sommer et al. studied the calculation model of the distribution axis equation of spatial point set, but he did not consider the weight effect of the attribute characteristics of point set on the distribution axis.

In addition, the general situation when the distribution axis is a curve also needs further study (Sommer et al., 2015). Zhao proposed a spatio-temporal segmentation clustering model based on mutual information principle (Zhao et al., 2016). Zhou established a remote sensing image classification method by using neural network technology. However, these spatial clustering and classification methods do not consider the location coordinates and spatial relations of spatial entities.

For entities or regional units within a class, they can only describe their similarity in attributes, but cannot reflect their proximity in locations. In essence, they are still attribute-based data mining methods (T. Zhou et al., 2017). In the soil classification rules established by Bai et al., the position coordinates are introduced into the conditional attributes, so that the classification rules have a certain correspondence with the coordinates (Bai et al., 2015; Chong & Osorio, 2018).

3. Methodology

Since the reform and opening up, great changes have taken place in Chinese cities. China's original urban-rural dual structure has been loosened and transformed in the process of accelerating urbanization. The developed coastal areas, big cities and megacities have attracted a large number of rural population in the central and western regions, and these people need to be accepted by urban communities in the future development. Strengthening the guidance, adjustment and optimization of urban community spatial organization is an urgent task to promote the development of urban communities in China. Spatial dynamic prediction

and spatial dynamic simulation are the main means of spatial dynamic data mining, and spatial dynamic prediction focuses on obtaining dynamic laws from historical data, which has the characteristics of data mining.

Under the theme of sustainable development, it is not only an important topic in the field of land use, but also a very urgent task to rationally use the limited cultural space of old communities and promote the sustainable use of land resources by combining modern intelligent algorithms to optimize the layout of cultural space of old communities and promote the spatial distribution of cultural space of old communities to change from scattered to rational aggregation.

3.1 USDM

Dialectical materialism thinks that space is actually a form of material existence, and its existence is inseparable from the movement of material, so the essence of space is infinite. It is not an existing existence, but a form of material movement, so the space extending at any point will be endless. The space view of subjective and objective integration holds that space is not actually an objective form of material existence, but also the result of people's re-creation of the understanding of objective things, so it is historic, social and practical. Sociological investigation of urban space is not to examine the impact of purely objective spatial phenomena on life, nor to recognize space from a purely subjective attitude, nor to discuss the relationship between material and space, so we should choose the space concept of subjective and objective integration. The forecasting method based on spatial data mining focuses on extracting the implicit spatial dynamic evolution law from historical data, and then taking the present situation as the starting point to predict the changes of urban spatial state in the future. The key and difficulty of spatial dynamic prediction is the excavation and expression of spatial dynamic evolution law. For relational database, it is abstracted as vertical attribute and horizontal tuple.

Spatial data mining system can be roughly divided into three layers. The first layer is the data source, which refers to the use of indexes, query optimization and other functions provided by spatial database or data warehouse management system to obtain and refine the data related to the problem domain, or directly use the data stored in spatial data cube. The second layer is the miner, which uses various data mining methods in spatial data mining system to analyze the extracted data. Generally, it adopts interactive mode, and the user selects the appropriate data mining method according to the type of problem and the type and scale of data. The third layer is the user interface, which uses visual tools to reflect the

acquired information and discovered knowledge to users in a way that is convenient for users to understand and observe. The basic implementation process of spatial data mining is shown in Figure 1.

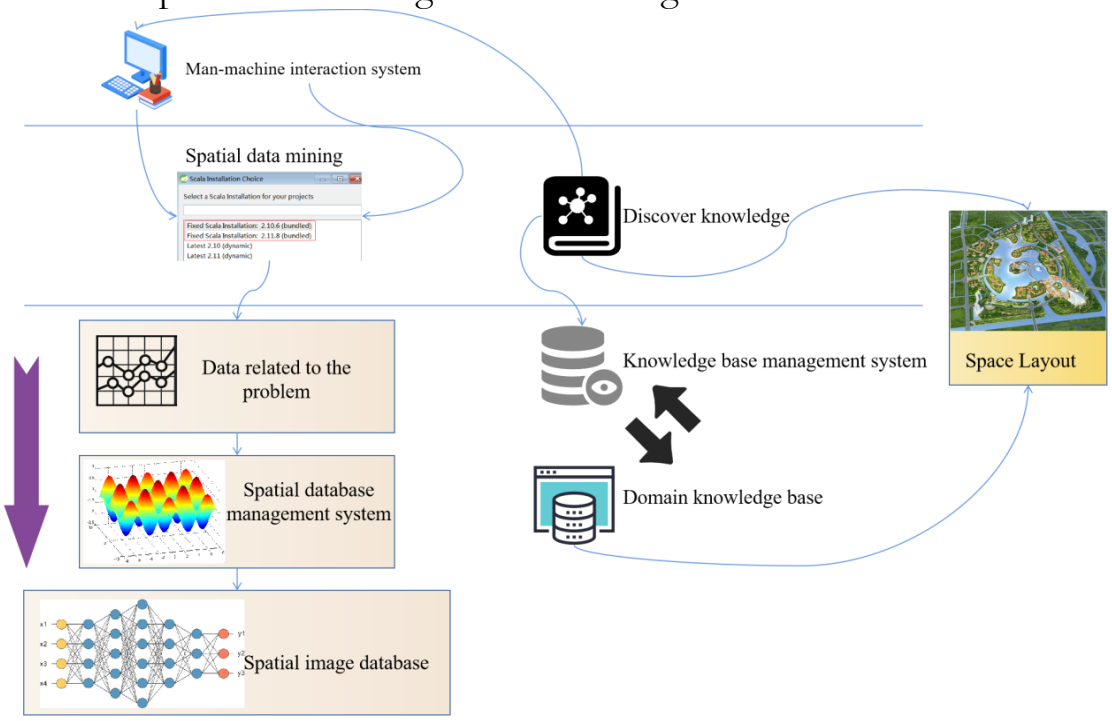

Figure 1: Implementation process of spatial data mining

Analyze and evaluate the knowledge discovered by users, and provide the knowledge for spatial decision support, or store the useful knowledge in the domain knowledge base. In the whole process of data mining, users can control every step. In the whole process of data mining, a good human-computer interaction user interface is the basis of data mining and satisfactory results. According to the needs of specific knowledge discovery, the relational tables of a basic database can be summarized according to the values of certain attributes, resulting in relational tables of different conceptual levels from micro to macro. Each macro-tuple of the summarized relational table corresponds to multiple tuples in the basic relational table. The macro-tuple is the base of the knowledge discovery state space of the corresponding conceptual level and is the initial knowledge template.

Build a state transition frequency table. Scan each element in the entire cultural space for moments t_1 and t_2, respectively, for elements C_{ij} for moments t_1. Detect its combined status code, and check the code value table to obtain its code value serial number u. Detect the status code v of the element C_{ij} at the moment t_2 to count and calculate:

$$s(u,v)=s(u,v)+1 \quad (1)$$

The two-dimensional array s is called the state frequency table, and this array should be cleared in advance. Establish a state transition probability table and a state transition probability matrix. Normalize the state frequency table:

$$p(u,v)=\frac{s(u,v)}{\sum_{w=1}^{l} s(u,w)}, \forall u; v=1,2,\ldots,l \quad (2)$$

l is the number of space states. At this point there are:

$$\sum_{v=1}^{l} p(u,v)=1, \forall u \quad (3)$$

Urban spatial classification includes supervised classification and unsupervised classification. Supervision requires training samples, and the number and center of categories are clear. Unsupervised classification, also known as clustering, divides the spatial units according to the principle of closest similarity within a class and most dissimilarity between classes. The number and center of classes are uncertain in advance.

The biggest feature of tentative spatial classification is the irreplaceability of indexes, that is, the index values corresponding to the units within a class are similar, and the index values between classes are obviously different. In spatial analysis and data mining, we are faced with a variety of spatial elements with different sources, different times and different types. Only by pre-processing the required data according to a unified spatial unit framework and guiding the attribute data of each element layer entity into a unified spatial unit network can we carry out multi-element comprehensive analysis or single-element spatial dynamic analysis.

3.2 Optimization of cultural space layout in old urban communities based on PSO

In order to explain the data model of the problem, firstly, the vector format of the current situation map is converted into grid data, and the grid (35m×35m) is used as the evaluation unit of spatial pattern optimization, and the current situation area is divided into N rows and M columns of grid units, that is, there are N×M land units in total.

The number of cultural space optimization units of K old communities in the research area is set. Cell (i_0, j_0) is the initial cell, and cell (i', j') belongs to cells in the neighborhood of cell (i, j). L_{ij,i_0j_0} is the spatial distance of cell (i, j) from the initial cell (i_0, j_0). Z is the total relocation distance (km), AI

is the aggregation index (%), and G_{ij} is the number of units of the same type adjacent to the old community cultural space unit (i, j).

$\max G_{ij}$ is the maximum number of old community cultural space units (i, j) that may be adjacent to units of the same type. The land suitability of each evaluation unit (i, j) is Q_{ij}, and the total suitability is Q_u.

The following objectives are selected as the optimization objective function.

Minimum total migration distance objective function:

$$\min Z = \sum_{i=1}^{N}\sum_{j=1}^{M} L_{ij,i_0j_0} \tag{4}$$

Maximum aggregation degree objective function:

$$MaxAI = \left(\sum_{i=1}^{N}\sum_{j=1}^{M}\frac{G_{ij}}{\max G_{ij}}\right)\cdot 100 \tag{5}$$

Maximum suitability function:

$$MaxQ_u = \sum_{i=1}^{N}\sum_{j=1}^{M} Q_{ij} \tag{6}$$

After optimization, there are at least 2 units of the same type in the neighborhood of the old community cultural space unit (i, j):

$$G_{ij} \geq 2 \tag{7}$$

The area after optimization should be equal to the area before optimization. Assuming that the initial total area of the old community cultural space is S_0, and the total area of the optimized old community cultural space is S_1, there are:

$$S_1 = S_0 \tag{8}$$

Urban spatial structure refers to the internal relationship between various elements and units of urban space, which is essentially an organic organization of human body. Spatial structure analysis is the basic method in the practice of urban planning and design.

The concept of urban spatial cultural structure interprets urban space from the cultural dimension, calls for cherishing the culture in space, and aims to extract the cultural meaning from the spatial representation, identify and repair the internal cultural structure through diachronic and synchronic analysis, and realize the overall improvement of the cultural quality of urban space through systematic design means. Combining with PSO, this section realizes the optimization design of cultural space layout of old urban communities.

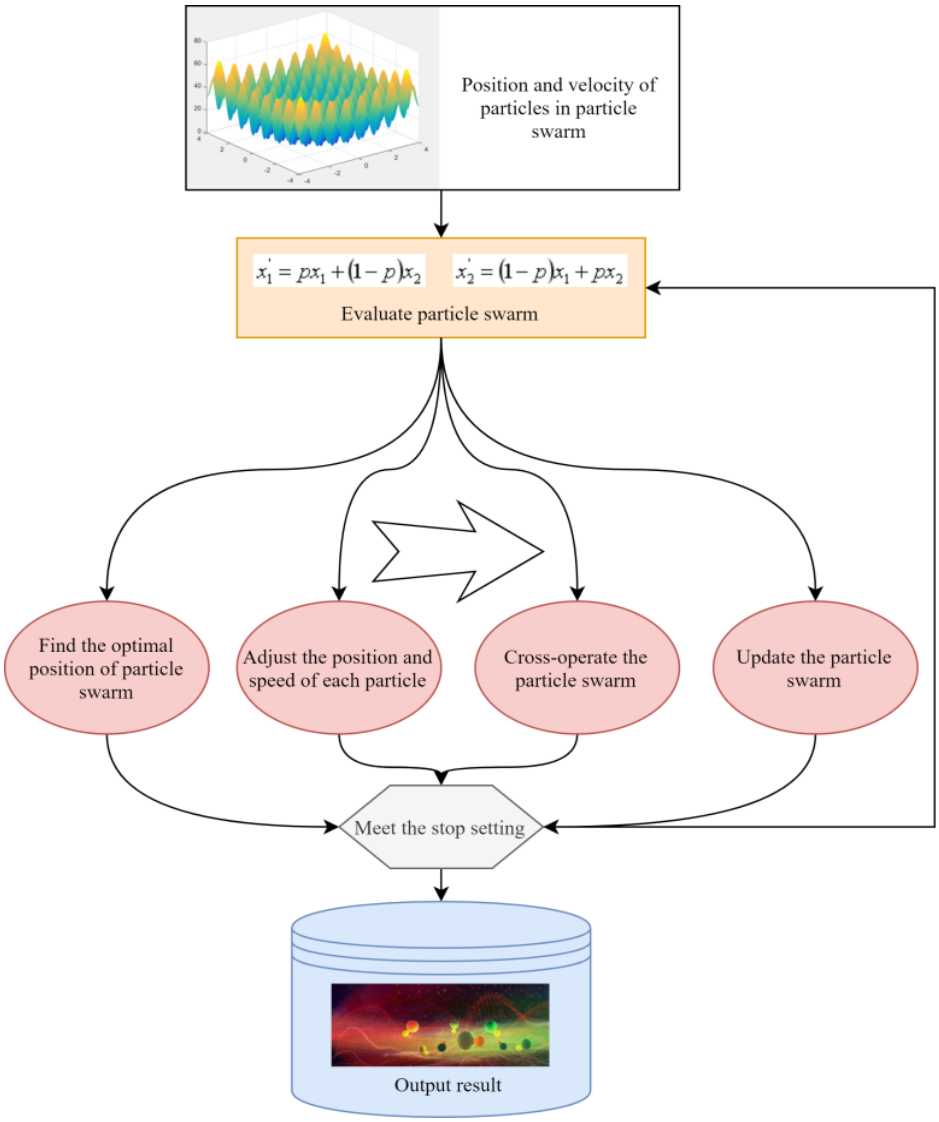

Figure 2: Particle swarm search process

Particle swarm search process is shown in Figure 2. On the basis of PSO, this algorithm adds some operators of genetic algorithm, which can give a hybrid probability to the particles in the particle swarm. This hybrid probability is determined by the user and has nothing to do with the fitness value of the particles. In each iteration, each particle is hybridized according to the hybridization probability to generate the same number of offspring particles. After the parent particles cross, the fitness value of the offspring particles is compared with that of the parent particles. If the fitness value is higher than that of the parent particles, it will be replaced, otherwise, it will not be replaced. The position of the child particle can be obtained by arithmetic weighting of the position of the parent particle:

$$x_1' = px_1 + (1-p)x_2 \tag{9}$$

$$x_2^{'} = (1-p)x_1 + px_2 \tag{10}$$

Among them, x_1, x_2 is two D-dimensional parent particles; $x_1^{'}, x_2^{'}$ is the D-dimensional child particle generated by cross; p is a D-dimensional random vector that obeys a uniform distribution, and each component in p is in $[0,1]$. For the spatial layout of old community cultural space, we should consider not only the change of the fitness value of the objective function, but also the choice of the gathering direction of old community cultural space. If only the optimization strategy of the standard PSO algorithm is used, the cultural spatial layout of the old community may move closer or gather in one direction. With the rise of mass media and the comprehensive construction of cultural facilities, residents' enthusiasm for participating in cultural activities has been continuously improved. Under the influence of the change of urban residents' consumption structure and the increase of leisure time, culture has not only been limited to the "elite culture" consumed and enjoyed by a few people with status and economic strength. Culture is not only a basic human right widely recognized by the national society, but also an important soft power to promote national rejuvenation, strengthen national cohesion and build a harmonious society. Those "popular cultures" that are close to the grassroots and closely related to the daily cultural needs of residents have become the mainstream. From the perspective of content composition, the urban spatial cultural structure is a spatial cultural unit formed by the aggregation of spatial cultural elements, and a collection of cultural functions and cultural values formed by the combination of spatial cultural units. A good cultural structure of urban space should not only have the cultural heritage of urban space, but also the creation of contemporary spatial culture, which should be presented through excellent spatial organization. In the tide of globalization and modernization, the sustainable change of urban spatial cultural structure is an important starting point to protect urban characteristics.

4. Result Analysis and Discussion

A large number of neurons collectively learn the patterns in the data to be analyzed through training, and form nonlinear functions that describe complex nonlinear systems, which are suitable for mining classification knowledge from nonlinear spatial systems with complex environmental information, fuzzy background knowledge and unclear reasoning rules. It has an important and far-reaching impact on computer science, artificial

intelligence and information technology, and can be used for classification, clustering and feature mining in spatial data mining. In the course of social development, there are basic forms that connect social contents, and the job of sociology is to peel off these social contents to study social forms. As an abstract spatial entity, the movement of urban agglomeration can be regarded as a time-space process of point-like entities, and there must be inherent regularity. Table 1 shows the comparison of the layout results of different spatial regional patterns in the cultural space optimization areas of old urban communities, and selects F1, Recall and Precision for evaluation.

Block radius	F1(%)	Recall(%)	Precision(%)
R=50	75.46	68.24	91.01
R=90	80.17	88.56	75.33
R=130	80.11	91.45	71.78
R=200	62.25	71.47	55.28

Table 1 Detection results of different block sizes

In spatial data mining, the data mining task is expressed as a search problem, and the optimal solution rule satisfying the fitness value is obtained by using the spatial search ability of PSO. Many problems in data mining, such as the acquisition of knowledge such as classification, clustering and prediction, can be expressed or converted into optimization problems, which can be solved by PSO. The overall data volume of the training model and the performance of the model after spatial optimization are considered comprehensively. Figure 3 shows the running time comparison results between the algorithm in this paper and the method in reference [13].

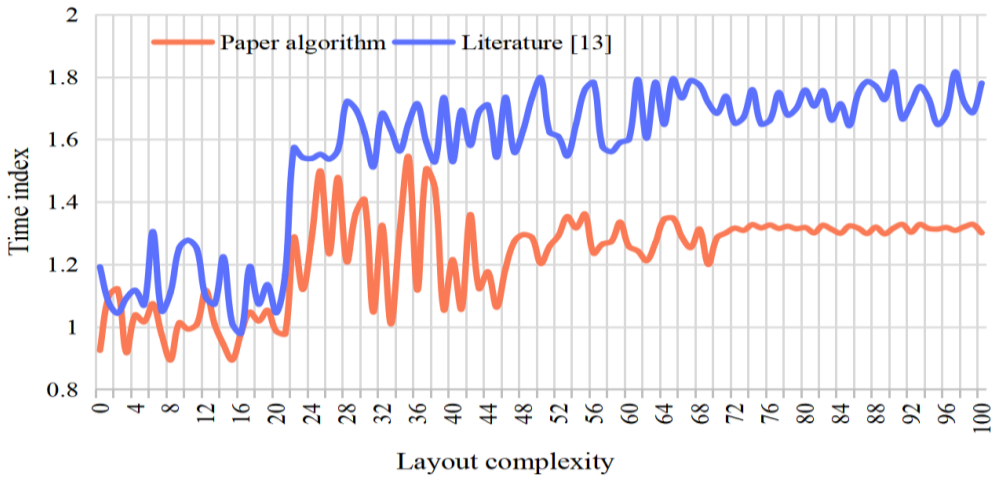

Figure 3: Algorithm calculation time comparison

Self-organization and independent cultural life of residents reflect residents' subjective initiative in community cultural life. In this paper, the daily cultural life of community residents with a certain scale and the stable combination of community public space are taken as the judgment basis of community cultural activity space, and the space places with popular and cultural activities in the community are marked. The convergence comparison results between the method in literature [13] and PSO algorithm are shown in Figure 4.

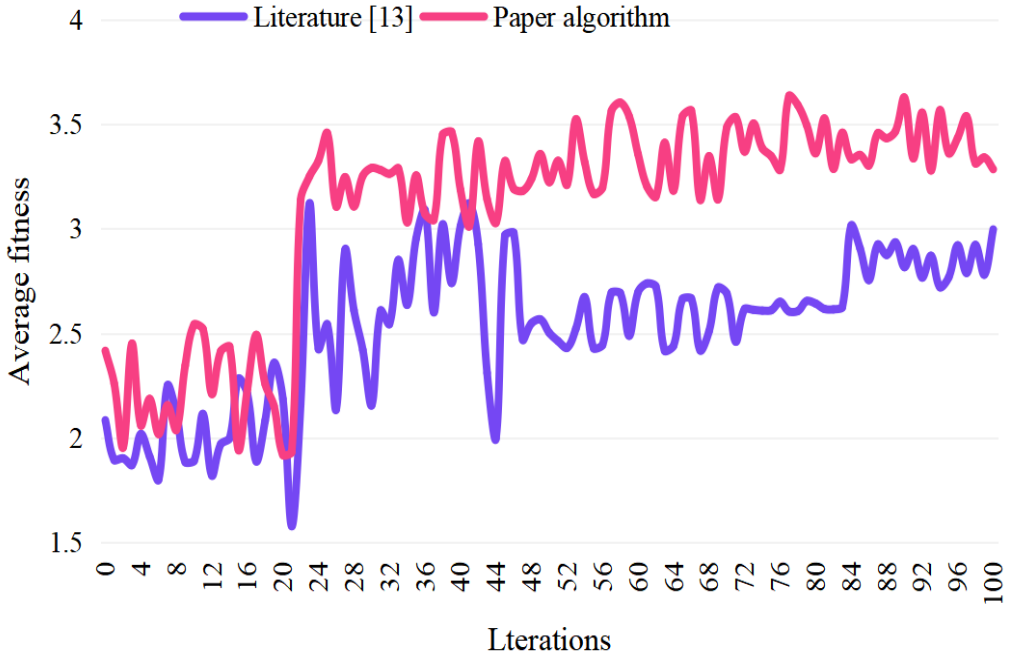

Figure 4: Convergence comparison results

The results show that compared with the standard literature [13] algorithm, PSO algorithm can obtain more reasonable, feasible and scientific spatial optimization results, and its operation efficiency is obviously improved, which can provide a scientific basis for the spatial planning of old community cultural space. In theory, general layout can form orthogonal layout, but because of the existence of local optimum, it is basically impossible to form orthogonal layout at last. The results show that it is feasible and effective to assume that the rectangular layout is finally orthogonal at the beginning. Eight posture strings are randomly generated to form the initial population. By calculating the fitness value of each individual (the inverse of the sum of squares of residuals), three individuals with larger fitness values are selected to participate in the cross calculation. One of the three new individuals is randomly selected for mutation operation, and three individuals with larger fitness values are still reserved

to participate in the next round of calculation. The parameters of the prediction model obtained by genetic calculation of X coordinate and Y coordinate data are shown in Table 2.

Model	1	2	3	4	5	6	7	8	Residual
X	114.569	5.782	0.745	11.653	6.695	2.346	/	/	3421.65
Y	33.699	3.694	0.971	3.134	10.065	3.217	3.031	9.885	13590.44

Table 2: Parameter estimation of the community space barycentric coordinate prediction model

A lot of computing work needs the support of computer system. All kinds of spatial dynamic data mining algorithms have their own complexity, and the increase of data volume aggravates the increase of calculation amount when the model runs, so a lot of calculation work obviously cannot be separated from the support of computer system. In order to explore the complex behavior of the city, the model often needs to be run repeatedly under different parameters to explore the potential law of urban development. For the purpose of providing decision support information for urban development, the system can provide many functions such as dynamic simulation of urban land use structure, continuous spatial field prediction of spatial autocorrelation and simulation of center of gravity movement of urban agglomeration. Compare the rate of return and accuracy of the algorithm for spatial pattern optimization, as shown in Figure 5 and Figure 6.

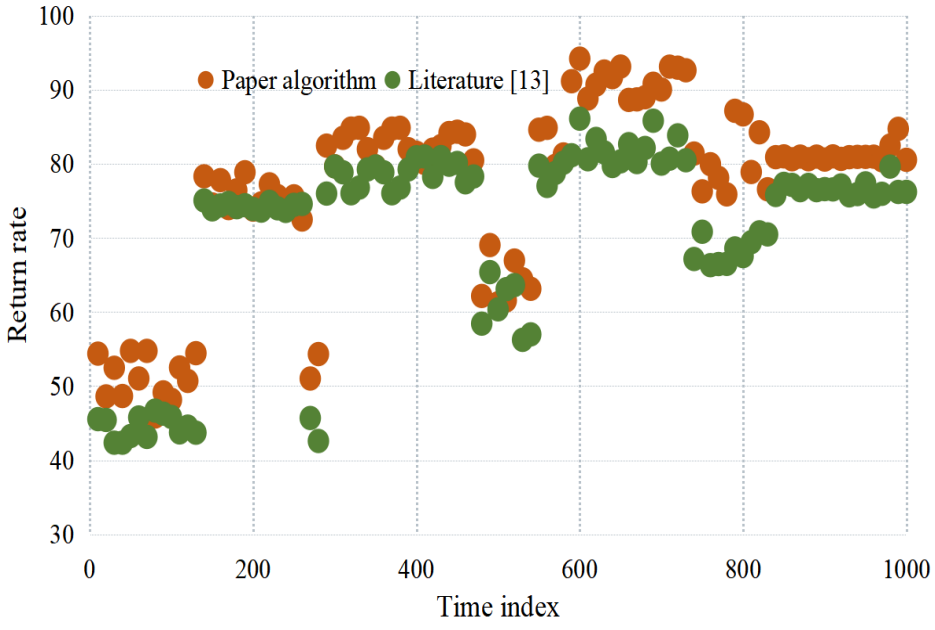

Figure 5: Comparison of returns on spatial pattern optimization

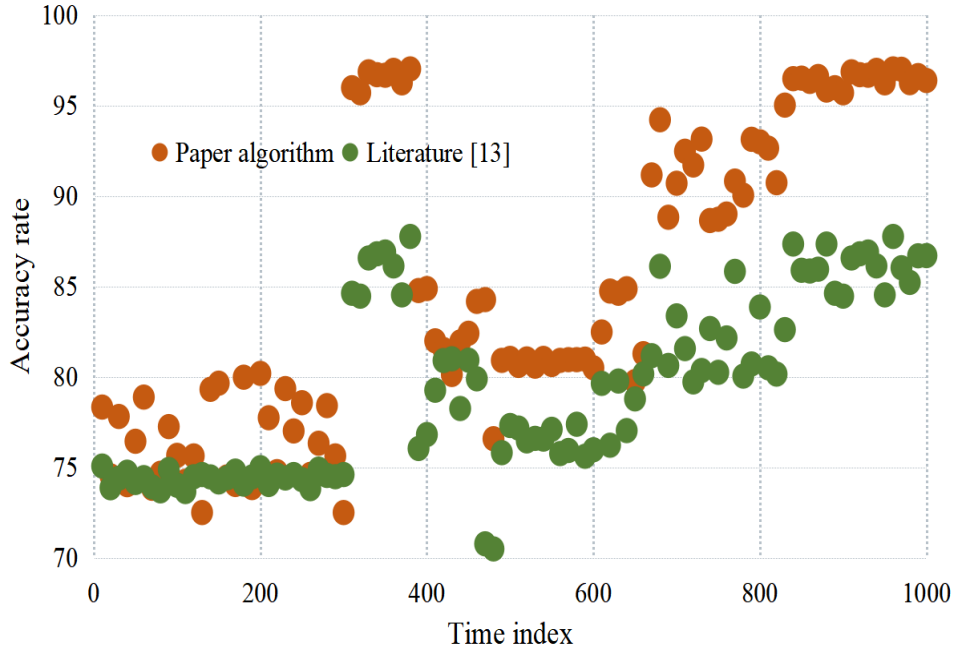

Figure 6: Comparison of accuracy rates of spatial pattern optimization

From the subjective test results, it can be seen that the accuracy of this algorithm in optimizing the spatial pattern of community culture is higher. Figure 7 shows the curve of the optimal solution of particle swarm optimization.

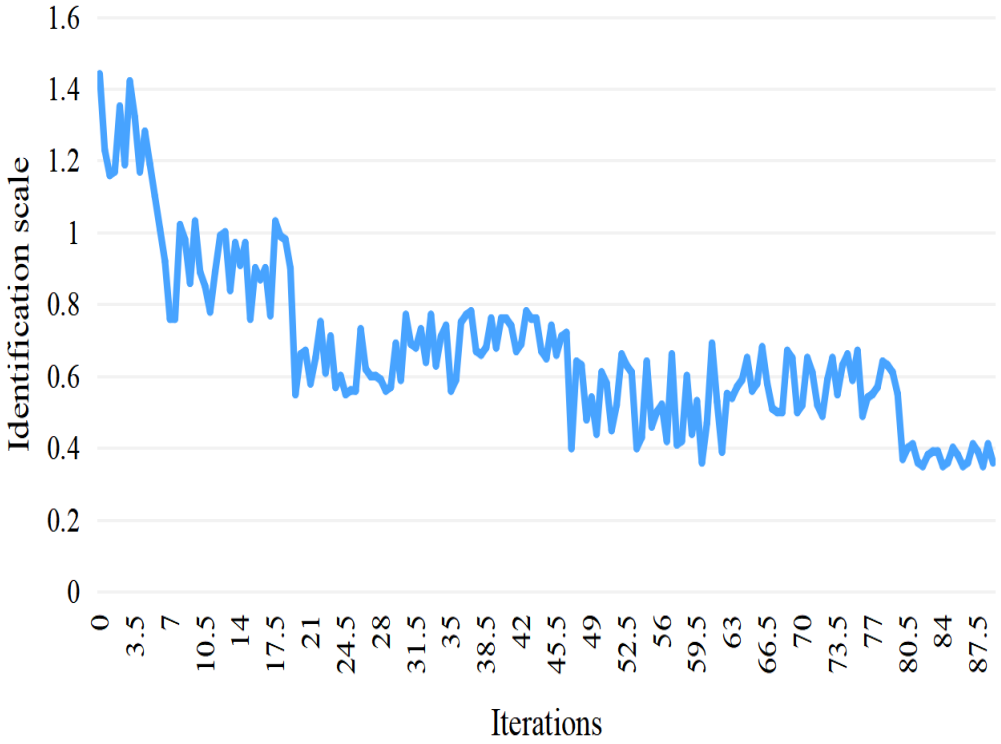

Figure 7: Variation curve of optimal solution of particle swarm

It can be seen from Figure 7 that the whole layout optimization solution process is smooth and rapid, and can quickly approach the optimal solution. This shows that particle swarm optimization algorithm can solve the optimization problem of cultural space in old urban communities. By evaluating the suitability of land units for different use types, we can make clear the suitability of land for each use type and the quantity, quality and structural characteristics of the suitability, and reveal the restrictive factors that affect the determination of use types and their restrictive degrees, thus providing the basis for the overall land use planning. From the type and distribution of community cultural activity space, neighborhood space is the closest activity space to residents' living space. Although it has not been planned and constructed in a unified way, it has formed the place closest to residents' daily life under the joint promotion of specific natural and cultural conditions in the community. Cultural activities will not be restricted by spatial function positioning and corresponding facilities and services.

5. Conclusions

At present, urban planning and community planning often emphasize the pursuit of quantification and optimization, the preference for performance and efficacy, and the expression of material desire and possession, while ignoring people's spiritual needs, which makes people increasingly become non-spiritual living beings. Community is a community of people with a certain spatial scope, but in essence, community is not a regional concept, but a social concept. Although community planning should pay attention to the layout of material space, it should pay more attention to the social needs of different groups of people and try to meet people's multi-level spiritual needs.

This paper analyzes the spatial structure of cultural space in old urban communities according to its geographical attributes, and establishes a mathematical model for optimal layout design of cultural space in old urban communities and a parametric description of cultural space in old urban communities. PSO is applied to the optimization of cultural spatial layout of old urban communities with performance constraints, and the method and application of urban land use spatial structure prediction are discussed. The results show that the PSO algorithm can obtain a reasonable, feasible and scientific spatial optimal layout result, and its operation efficiency is obviously improved, which can provide a scientific basis for the spatial

planning of old community cultural space.

In fact, the spatial planning and gathering direction selection of old community culture is not only the spatial optimization layout, but also the area optimization, combined with the farmers' wishes, family economic level, government policies and other constraints. Therefore, how to improve the optimal layout of the old community land and further strengthen the operation and processing ability of the algorithm is an urgent problem to be solved in the next step

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Bio-profile

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