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Research on the siting of rural public cultural space based on path-clustering algorithm: A case study of Yumin Township, Yushu City, Jilin Province, China

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Abstract: Cultural revitalization is the foundation of rural revitalization. Rural public cultural space is an important place for rural residents to participate in cultural life and an important carrier for the occurrence, inheritance and development of rural culture. Within the town area, public cultural spaces are divided into three types based on the service scope of the public cultural space: "single-village decentralized", "single-village concentration" and "multi-village concentration". This paper focuses on the analysis of the siting of "multi-village concentration" public cultural spaces using a path-clustering algorithm. First, the path clustering algorithm is written, and then its parameters, initial clustering centers and number of clusters, are analyzed for their effect on the clustering results. Two parameters, WCSPD and MPDWC, are proposed to evaluate the results of the algorithm. Then, taking Yumin Township of Jilin Province as an example, the villages in the township are clustered with travel distance as the main influencing factor. It is ensured that the path distance from the central village in each cluster to other villages is no greater than the set travel distance. Finally, the public cultural space is constructed in the central village to serve all villages in the cluster. This study points out that when the set travel distance is 5 km, the villages within Yumin Township are divided into 8 clusters, which means that 8 public cultural spaces are needed. When the travel distance is set at 6 km, 6 public cultural spaces are needed.

Keywords: cultural revitalization; rural public cultural space; path-clustering algorithm; site

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1. Introduction

1.1. Background

At present, most cities in China have entered the stage of stock development, while the development of the countryside is somewhat lagging behind. Under the background of rural revitalization, an increasing number of people from different fields have started to devote themselves to the construction of the countryside. However, many problems have emerged in these rural development efforts, such as ignoring the individuality of the villages, not respecting the history, culture and natural conditions, and adopting a uniform model to deal with different villages. The reason for these problems is the neglect of rural culture. The essence of Chinese culture is vernacular culture, and the roots of Chinese culture are in the countryside [1]. Therefore, in the construction of villages, it is necessary to focus on strengthening the construction of rural culture. The revitalization of rural culture is an inevitable requirement to realize rural revitalization. The production and development of culture cannot be achieved without space as the material carrier. Rural public cultural space is an important place for the occurrence and transmission of rural culture and carries the spiritual life of farmers. Public cultural space is very important for

strengthening rural cultural construction [2] and is an important material space carrier for rural cultural revitalization.

As time goes by, an increasing number of scholars in China are paying attention to the important role of public cultural space in rural cultural construction work. Zhang P Q et al. [3] proposed that in the context of rural revitalization, the construction of rural public cultural space should meet the needs of rural residents for a better life. Chen B et al. [4] analyzed the impact of accelerated urbanization on rural public cultural space in China and studied the methods and models for reconstructing rural public cultural space. Ma Y Q[5] proposed cultivating traditional public cultural spaces in villages into new public cultural spaces by means of transformation or innovation. However, in these studies, not only do they lack scientific and quantitative analysis methods, but most of them only develop some theoretical guidance strategies, which cannot be implemented to the practical level.

1.2. Related works

Many scholars have conducted studies on the distribution of public service facilities. The main research directions can be summarized into two. One is to rationalize and optimize the distribution of public service space to enhance efficiency. Wang X C et al. [6] took Wuhan city as an example and tried to use machine learning algorithms for the planning and siting of elderly facilities based on POI data. The purpose is to make the overall layout of elderly facilities better and the resource allocation more reasonable. Sevtsuk A et al. [7] introduce a version of the Huff retail expenditure model, where retail demand depends on households' access to retail centers. Examines the issue of merchandise retail centers in cities and explores how adjusting the location and size of commercial centers can maximize overall visitation. Tong H [8] studied the location and route planning problems of ship logistics distribution centers and explored efficient and low-cost distribution center location and route planning solutions.

The second research direction focuses on solving the existing problems by optimizing the distribution of public service space. Aliniai K et al. [9] conducted a study on the mismatch between the development of cities and public parking lots. The present study aims to find the most suitable sites for public parking lots in one of the most crowded cities of western Iran. Wang Z B et al. [10] studied the existing spatial distribution of various types of medical facilities. Based on the current spatial distribution of existing medical facilities, an optimization strategy is proposed to develop an emergency response plan for health emergencies. In summary, such studies are mostly focused on urban space, and few of them take rural space as the main object of study. Therefore, this study applies machine learning algorithms to the study of rural public cultural space distribution. It aims to propose a set of reasonable and efficient methods for selecting sites for rural public cultural spaces to achieve a reasonable distribution of cultural space resources.

1.3. Our study

In this study, Yumin Township, Jilin Province, was used as the research object. The siting problem of public cultural spaces is taken as the main research topic. When a public cultural space needs to serve multiple villages, the travel distance of villagers is used as the constraint factor. Then, the clustering algorithm is used to divide the villages within the township into groups. Villages within the same group share one public cultural space, which can avoid wasting resources while meeting villagers' needs for cultural space. In the cluster analysis, considering the practical situation, people's travel distance cannot be simply represented by the Euclidean distance between two points. Therefore, we write the path-clustering algorithm that uses the shortest path distance between points as the unit of measure to complete the clustering of villages in our study.

This paper is organized as follows: Section 2 provides an interpretation of the concept of public cultural space and its specific meaning in the Chinese rural context; Section 3

mainly describes the clustering algorithm written using the shortest path distance as the metric distance; Section 4 focuses on how the algorithm is applied to the clustering of villages; Section 5 discusses the novelty of this study and its potential applications, as well as the limitations of this study and future research directions. Finally, Section 6 summarizes the main conclusions of this paper.

2. The concept of rural public cultural space

2.1. Public Cultural Space

Public cultural space is an integrated concept with theories related to "public space" and "cultural space", which involves multidisciplinary fields such as sociology and cultural studies [11]. It is a spiritual and material community that carries cultural activities. The "public space" is generally considered to be the middle ground between the state and society, the place where public cultural activities are consciously carried out by the citizen class. The concept of "cultural space" first appeared in the study of The production of space [12] by French scholar Lefebvre H. In this book, he mentions that space is a product of society, a process of life production, which has the property of triple dialectical interaction of perception, conception and reproduction. Later, the concept of "cultural space" was further expanded to refer to a physical or social space. It encompasses a set of behaviors and patterns of life associated with a particular group of people who occupy this space [13]. Public cultural space, as an integrator of two concepts, was initially defined in an urban context. In the book The fall of public man, Sennett R mentioned the description of public cultural space as "Urban amenities were diffused out from a small elite circle to a broader spectrum of society, so that even the laboring classes began to adopt some of the habits of sociability, like promenades in parks, which were formerly the exclusive province of the elite, walking in their private gardens or 'giving' an evening at theater"[14]. Therefore, in the context of urban culture, some public cultural spaces, such as squares, theatres, museums and art galleries, are not only physical spaces or places but also contain the meaning of 'public','shared' and 'cultural'. It has the significance of redefining modern urban life and human relations.

2.2. The concept of public cultural space in the Chinese rural context

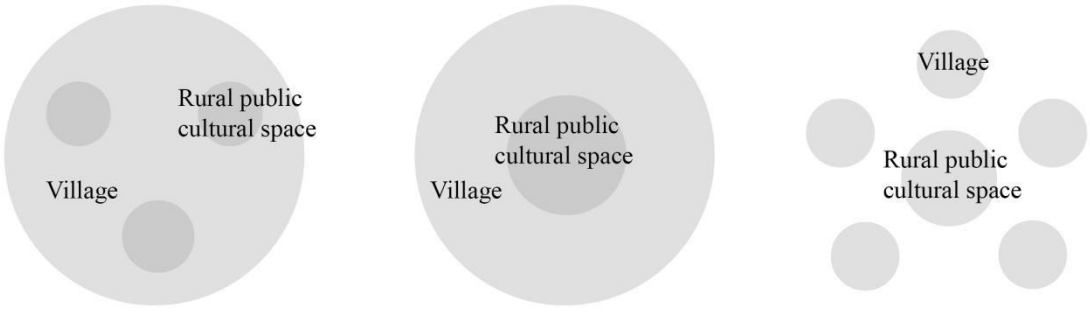
In the rural context, different scholars have tried to define public cultural space. Li X Y [15] proposed that rural public cultural space is a complex that carries regional culture and has social, economic and productive characteristics. At the same time, it also has the function of cultural edification and is the main carrier of rural cultural heritage. According to Zheng Z [16], rural public cultural space is a kind of community with both cultural and spatial properties, which is a spiritual and material construction of human social activities. In this study, rural public cultural space refers to a holistic concept that includes cultural activities and cultural resources and is the spatial carrier in which rural cultural life occurs. As a spatial carrier, rural public cultural space mainly refers to the space where many people can participate in cultural activities and which is not privately owned. In the construction of public cultural space, there are many aspects, and this paper focuses on the location of public cultural space. In this issue, we need to consider the spatial properties of the public cultural space. It should be more public, a place where farmers can freely access, interact and participate in public affairs.

2.3. Types of Rural Public Cultural Spaces

In the existing studies on rural public cultural spaces, most scholars have classified public cultural spaces. For example, Chen J[17] divided the modern rural public cultural space into living culture public space, traditional culture ritual space and folk art exhibition space. Chen Y et al. [18] divided rural public cultural spaces into traditional rural

public cultural spaces and new rural public cultural spaces according to the order of historical development. Traditional rural public cultural spaces include ancestral shrines, theatres and other spatial places with traditional history and culture. The new public cultural spaces are generally government-led or villagers' self-organized spaces for holding modern public cultural activities. These include rural museums, cultural and sports rooms, electronic reading rooms and cultural squares with fitness and recreational functions. Cao H L[19] classified public cultural spaces into two types, "administratively embedded" and "endogenous to the village", according to the different formation mechanisms. Luo J et al. [20] took Zhulian Village in Liuyang City as an example and classified public cultural spaces into three types: productive, living, and organizational. Some scholars have also classified public cultural spaces by their spatial morphological characteristics. For example, Zhu R X et al. [21] classified public cultural space into point-like space, linear space and surface-like space based on spatial form.

In this paper, based on the correspondence between public cultural spaces and villages, public cultural spaces are divided into three types: "single-village decentralized", "single-village concentration" and "multi-village concentration" (Figure 1). The "multi-village concentration" type of public cultural space refers to one rural public cultural space serving multiple villages, such as libraries, cultural stations and other cultural and educational public cultural spaces. The "single-village concentration" type of public cultural space refers to one public cultural space serving one village, such as a small square or a cultural compound. The "single-village decentralized" type refers to multiple public cultural spaces serving one village. These are generally living public cultural spaces. Such as the open space outside the courtyard, used for villagers to chat or for some simple productive activities. This paper focuses on the "multi-village concentration" type of public cultural space. In constructing this type of public cultural space, it is necessary to divide the villages into clusters and to establish a public cultural space in each cluster. Therefore, how to divide the group and set up the public cultural space in which village in the group is the focus of this study. We determine a constrained travel path distance based on the accessibility of the space of the actual path distance and the villagers' willingness to travel. Then, we divide all the villages in the township into clusters by the shortest path distance and determine the central villages for establishing public cultural spaces. The distance from the central village to any village in the group is guaranteed to be no greater than the set travel path distance.



(**a**) (**b**) (**c**)

Figure 1. Schematic diagram of the relationship between three types of rural public cultural spaces and villages. (**a**) single-village decentralized; (**b**) single-village concentration; (**c**) multi-village concentration

3. Path-clustering Algorithm

A clustering algorithm partitions a dataset into different classes or clusters according to specific criteria so that data objects within the same cluster are as similar as possible. It can also be understood as dividing data with similar attributes into one cluster, while data

not in the same cluster are as different as possible. Typical cluster models include connectivity models, centroid models, distribution models, etc. In this study, the K-means [22] method is used as a partitioned clustering method. It requires specifying the number of clusters and the initial clustering centers in advance and dividing the data according to the similarity of eigenvalues by iterative iterations. In the K-means algorithm, the Euclidean distance is generally used as the similarity measure between clusters. However, the clustering classification based on Euclidean distance cannot meet the needs of this study. One cannot use the straight line distance from point to point as the basis of travel but is more based on the path distance between points. Therefore, we need to write the clustering algorithm using the path distance as the similarity measure, which is the path-clustering algorithm.

3.1. Process overview of the path-clustering algorithm

The general k-means clustering algorithm proceeds as follows: Given a set of observations (x1, x2..., xn), where each observation is a d-dimensional real vector, k-means clustering aims to partition the n observations into k (≤ n) sets S = {S1, S2..., Sk} to minimize the within-cluster sum of squares (WCSS) (i.e., variance). Formally, the objective is shown in Equation (1).

$$\arg\min_{S} \sum_{i=1}^{k} \sum_{\mathbf{x} \in S_i} \|\mathrm{x} - \mu_i\|^2 \quad (1)$$

where μ_i is the mean of points in Si

$$\arg\min_{S} \sum_{i=1}^{k} \sum_{\mathbf{x} \in S_i} Dis(\mathrm{x}, \mu_i) \quad (2)$$

where μ_i is the point with the smallest sum of distances to all other points;

$Dis(\mathrm{x},u_i)$ means the shortest path distance between x and u_i;

However, in the path-clustering algorithm, the objective is to minimize the sum of the shortest path distances from points in different clusters to the centroid (ui). First specify the value of K[23] and its initial cluster centroid, and then run the algorithm in its two steps alternately as follows:

Assignment step: The first step is to find the shortest path distance between each point and the initial cluster center and then assign each point to the cluster center closest to it. The clustering centers and the object points assigned to them form a cluster St (Equation (3)).

Update step: For each cluster obtained in the previous step, find again the point that has the smallest sum of path distances to other points. This point is then used as the center of the clusters to redivide the new clusters, and the cycle continues in this way. The algorithm is stopped when the centroids of the clusters are all coincident with the centroids of the previous step (Equation (4)).

$$S_i^{(t)} = \left\{ x_p : \left\| x_p - m_i^{(t)} \right\|^2 \le \left\| x_p - m_j^{(t)} \right\|^2 \forall j, 1 \le j \le k \right\} \quad (3)$$

$$m_i^{(t+1)} = u_i^{(t)} \quad (4)$$

3.2. The shortest path distance between points

In finding the shortest path distance between points, there are two main methods: the Dijkstra algorithm [24] and the Floyd algorithm [25]. This study uses a Floyd algorithm to find the shortest path distance between any two points. The algorithm logic is that for any pair of vertices U and V, see if there exists a vertex W such that the sum of the path distance from U to W plus W to V is shorter than the path distance directly from U to V.

If so, update the shortest distance between the two points U and V. The logic of the algorithm is demonstrated in the path diagram shown in Figure 2. First, the distance value from each point to all other points in the graph is calculated and saved in the form of a matrix. If two points are connected by a line, the length of the line is recorded as the distance value between the two points. If there is no line between the two points, the distance between the two points is recorded as infinity. Once the initial distance values from each point to all other points are available, the shortest path distance between the points can be calculated in a loop based on these values. First, point A is chosen as the middle point, which does not make the distance between the other two vertices shorter; then, the distance matrix is not updated. The distance matrix is updated when Dis[A][D]>Dis[A][B]+Dis[B][D], Dis[A][E]>Dis[A][B]+Dis[B][E], and Dis[C][E]>Dis[C][B]+Dis[B][E] with point B as the midpoint. When C is the midpoint, the distance matrix is also kept constant. When D is the midpoint, Dis[C][E]>Dis[C][D]+Dis[D][E], Dis[A][F]>Dis[A][D]+Dis[D][F], Dis[B][F]>Dis[B][D]+Dis[D][F], and Dis[C][F]>Dis[C][D]+Dis[D][F]. Update the distance matrix, and then follow this method to loop and continue to update the distance matrix with E and F as the midpoints. Finally, the distance matrix of the shortest path distance between all points is obtained (Figure 3).

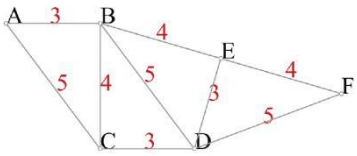


Figure 2. Path diagram-1

	A	B	C	D	E	F
A	0	3	5	∞	∞	∞
B	3	0	4	5	4	∞
C	5	4	0	3	∞	∞
D	∞	5	3	0	3	5
E	∞	4	∞	3	0	4
F	∞	∞	∞	5	4	0

(**a**)

	A	B	C	D	E	F
A	0	3	5	8	7	∞
B	3	0	4	5	4	∞
C	5	4	0	3	8	∞
D	8	5	3	0	3	5
E	7	4	8	3	0	4
F	∞	∞	∞	5	4	0

B as the vertex (**b**)

	A	B	C	D	E	F
A	0	3	5	8	7	13
B	3	0	4	5	4	10
C	5	4	0	3	6	8
D	8	5	3	0	3	5
E	7	4	6	3	0	4
F	13	10	8	5	4	0

D as the vertex (**c**)

	A	B	C	D	E	F
A	0	3	5	8	7	11
B	3	0	4	5	4	8
C	5	4	0	3	8	8
D	8	5	3	0	3	5
E	7	4	8	3	0	4
F	11	8	8	5	4	0

E as the vertex (**d**)

Figure 3. Transformation of distance matrix. (**a**) Initial distance matrix; (**b**) Distance matrix after B as midpoint; (**c**) Distance matrix after D as midpoint; (**d**) Distance matrix after E as midpoint

3.3. Initialization methods

In the K-means clustering algorithm, the common initialization methods are forgy and random partition[26]. The starting means in the Forgy technique are determined by randomly selecting k observations from the dataset. The random partition technique initially randomly allocates a cluster to each observation and then goes to the update stage, therefore determining the initial mean to be the centroid of the cluster's randomly allocated points. In this study, the centroids of the clusters are specified randomly in the initialization phase using the Forgy technique. Taking the path diagram in Figure 4 as an example, we choose the number of clusters as 5 and calculate the within-cluster sum of path-distance (WCSPD) between each result. The WCSPD value represents the sum of the distance values from the points in all clusters to the centroid of the clustering result (Equation (5)), and the smaller its value is, the better the clustering result. By comparing the

WCSPD values, it is possible to compare the variability between the clustering results corresponding to different initialized clustering centers. As seen from the following nine clustering results (Figure 5), their clustering results are relatively close to each other in terms of WCSPD values. The results show that the more discrete the choice of their initial clustering centroids, the better their final results.

$$WCSPD = \sum_{i=1}^{k} \sum_{\mathbf{x} \in S_i} Dis(\mathrm{x}, \mu_i) \quad (5)$$

where μ_i is the point with the smallest sum of distances to all other points；

$Dis(\mathrm{x},u_i)$ means the shortest path distance between x and u_i ；

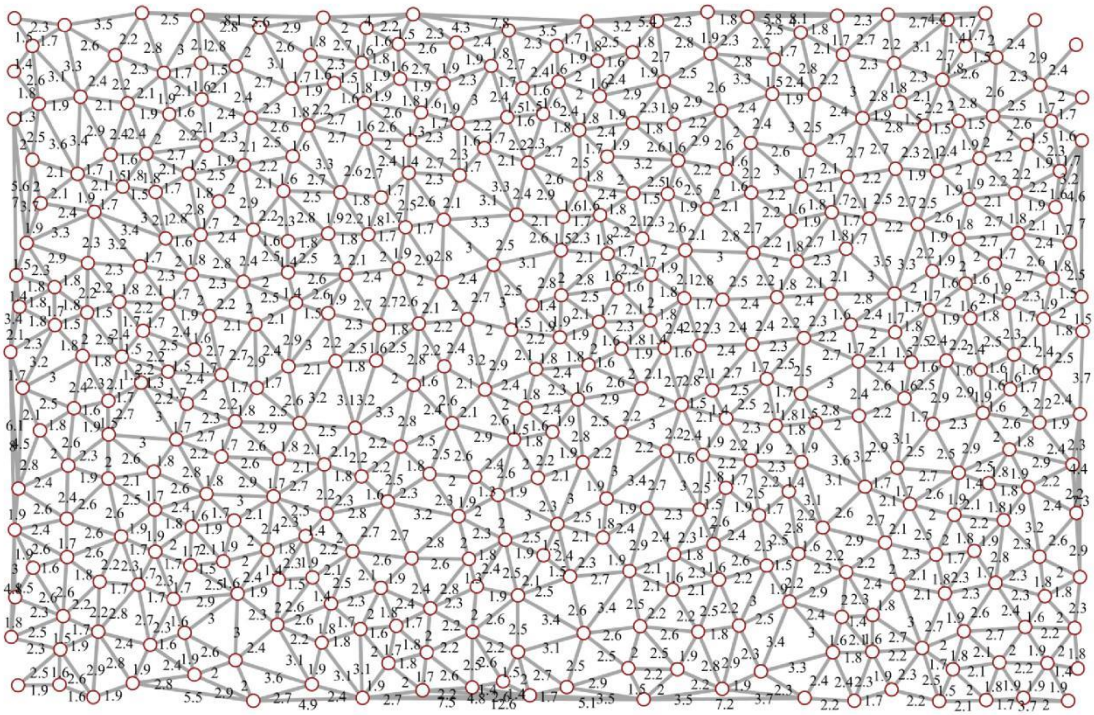


Figure 4. Path diagram-2

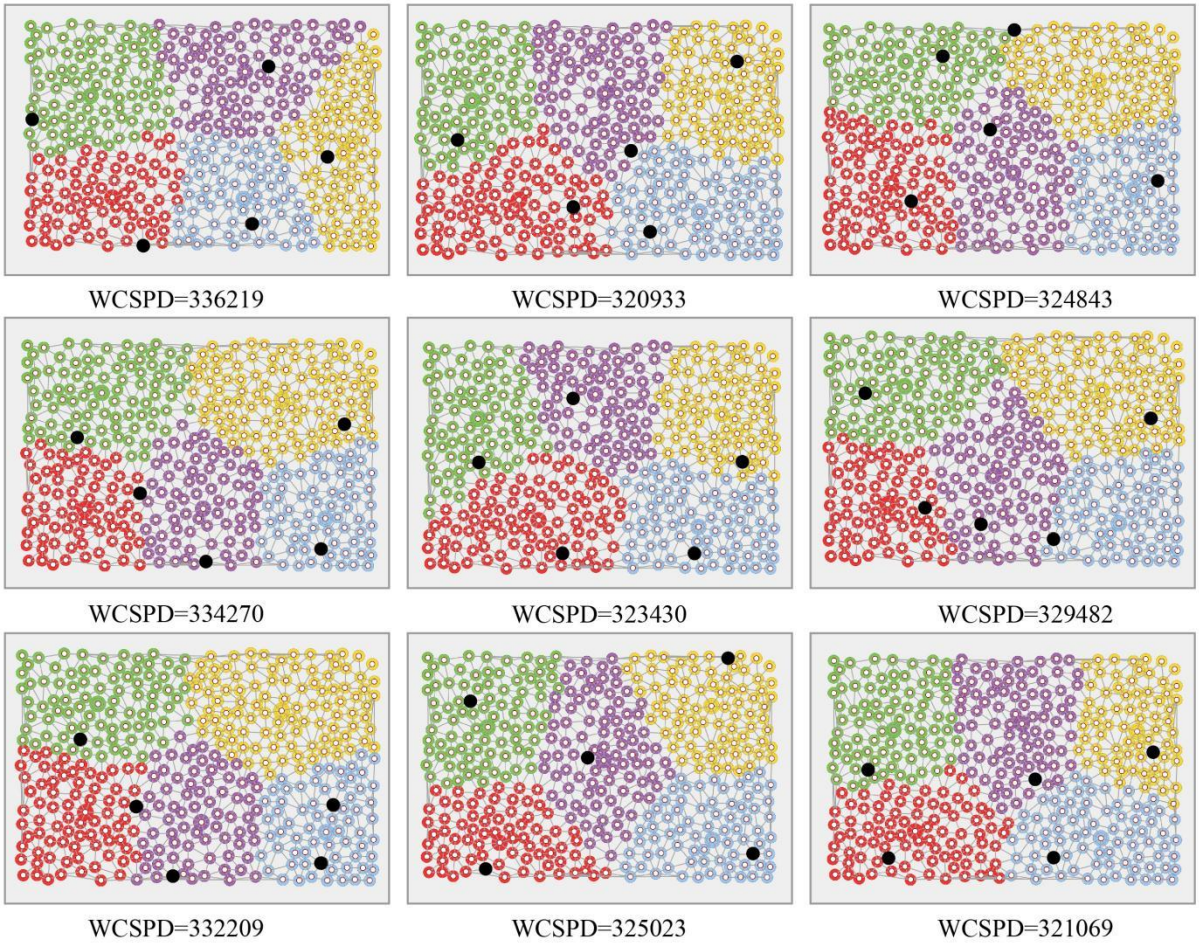


Figure 5. The WCSPD values are obtained from the clustering results corresponding to different initial clustering centers. The black points are the initial clustering centers.

3.4. K value: Number of Clusters

In the study of this paper, the results of clustering need to ensure that the maximum value of the path distance from the points in all clusters to the centroid does not exceed the set travel distance. In other words, the maximum value of the path distance within-cluster (MPDWC) needs to be less than the set value. Therefore, the number of clusters is specified by the set travel path distance value. Again, using the path diagram in Figure 4 as an example, the MPDWC values of the clustering results corresponding to different K values (number of clusters) in this path diagram are plotted as a line graph. From the results (Figure 6), it can be found that the MPDWC values decrease as the K values increase. Therefore, once we obtain the limited travel path distance value, we can choose a suitable K value.

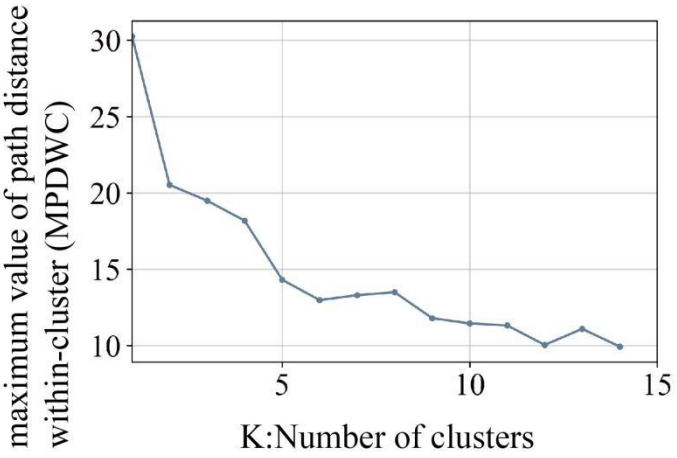


Figure 6. The line graph of the MPDWC values corresponding to different k values.

4. Applying the Path-clustering Algorithm to Site Selection Analysis of Rural Public Cultural Spaces in Yumin Township

4.1. Yumin Township

Yumin Township is located in the northern part of Yushu city, Jilin Province, in the hinterland of the Songliao Plain. It is adjacent to Daling Township in the east, Taian Township in the south, Hongxing Township in the west, and Lalin River in the north, with a total area of approximately 151 square kilometers. The plan of Yumin Township (Figure 7) is approximately rectangular, with a wide width from north to south and a narrow width from east to west. The villages within the township are relatively evenly distributed. Before the clustering analysis of villages in Yumin Township, the path diagram of the township needs to be manually depicted based on the satellite map (Figure 8).



Figure 7. Satellite map of Yumin Township.

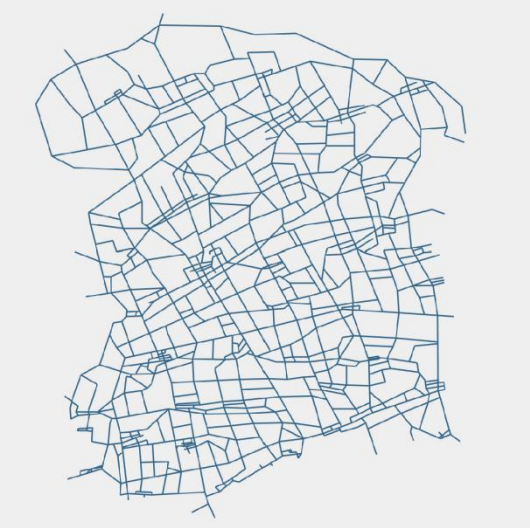


Figure 8. Path diagram of Yumin Township.

4.2. Clustering Analysis

Since the ultimate goal of the algorithm is to cluster the villages, it is not necessary to perform cluster analysis on all the point data in the path map. The point with the smallest sum of path distances to other points in the village was selected as the representative, and a total of 44 points were selected to represent 44 villages (Figure 9). Then, the shortest path distance matrix between each point is found. However, it is worth noting that the initial stage of the algorithm will find the distance between all the folding points and turning points in the path map, which is converted into a distance matrix. Therefore, this distance matrix needs to be filtered to obtain the shortest path distance matrix between each point of village in preparation for the cluster analysis (Figure 10).

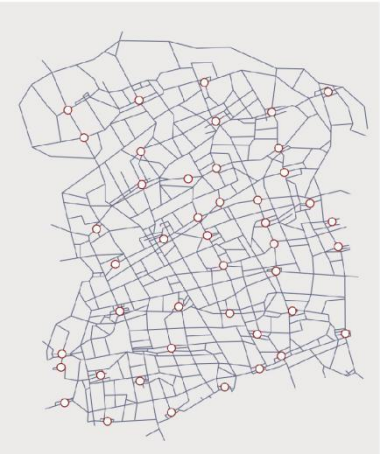


Figure 9. Path diagram of all points representing villages.

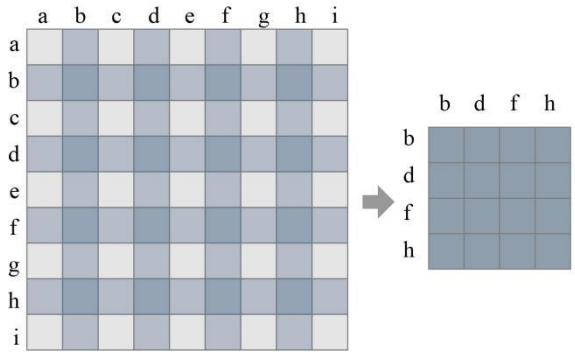


Figure 10. Transformation of distance matrix.

First, a line graph of the variation in MPDWC values with K values is plotted (Figure 11). Then, the K values are selected according to the set shortest path distance for the trip. In the analysis of village clustering in Yumin Township, we chose two different shortest path distances for travel, which were 5 km and 6 km. From Figure 11, we can see that when the travel path distance is set to 5 km, the K value is set to 8. When the travel path distance is set to 6 km, the K value is set to 6.

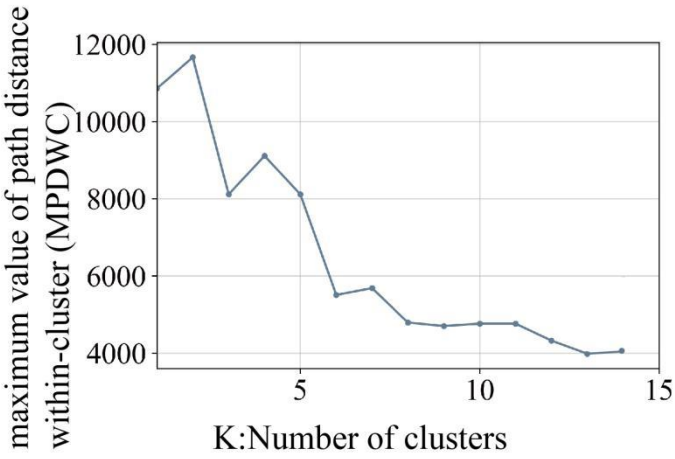


Figure 11. The line graph of the MPDWC values corresponding to different k values.

4.3. Clustering results

Figure 12 shows the clustering results corresponding to three different initial clustering centers with k values of 8. From the clustering results, we can see that the villages in Yumin Township are divided into 8 groups, which means that 8 multi-village concentration-type public cultural spaces need to be set up. The number of villages in each cluster varies from a maximum of 8 to a minimum of 3. Therefore, the scale of the public cultural space they need to set up varies and needs to be set specifically according to the number of villages they serve. The three clustering results also have different MPDWC values, but the differences are not very large, and all are less than the set travel distance of 5 km. Figure 13 shows the clustering results corresponding to three different initial clustering centers with k values of 6. The villages in Yumin Township are divided into 6 clusters, which means that 6 multi-village concentration-type public cultural spaces need to be set up. The number of villages in each cluster has a maximum of 11 and a minimum of 3. There are clustering results whose MPDWC will exceed 6 km, so the clustering results need to be filtered.

In summary, there is variability in the clustering results for different initial clustering centers. The final purpose of cluster analysis is to divide villages into groups, and the villages corresponding to the final cluster centroids are used as villages for establishing public cultural spaces. Therefore, the goodness of its clustering result is not only judged by the WCSPD or MPDWC values but also depends on whether the village of the center point of the final clustering is suitable as a village for setting up public cultural space. If its scale is too small, it is not suitable as a village for setting up public cultural space. Therefore, multiple clustering results can be generated based on different initial clustering centers, and then the appropriate centers can be filtered according to the needs.

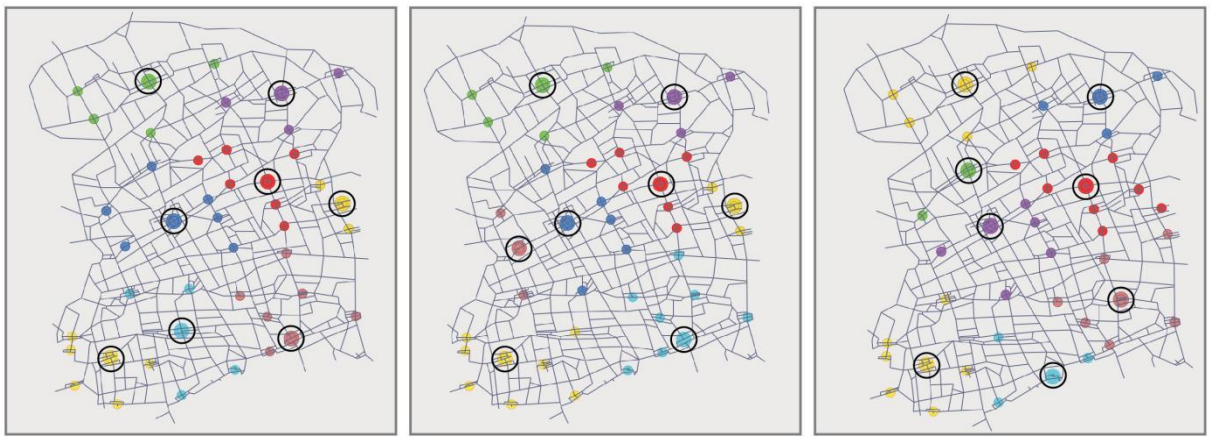


Figure 12. The clustering results and MPDWC values when the value of K is 8. The points circled by black circles are the centroids of each cluster in the clustering result.

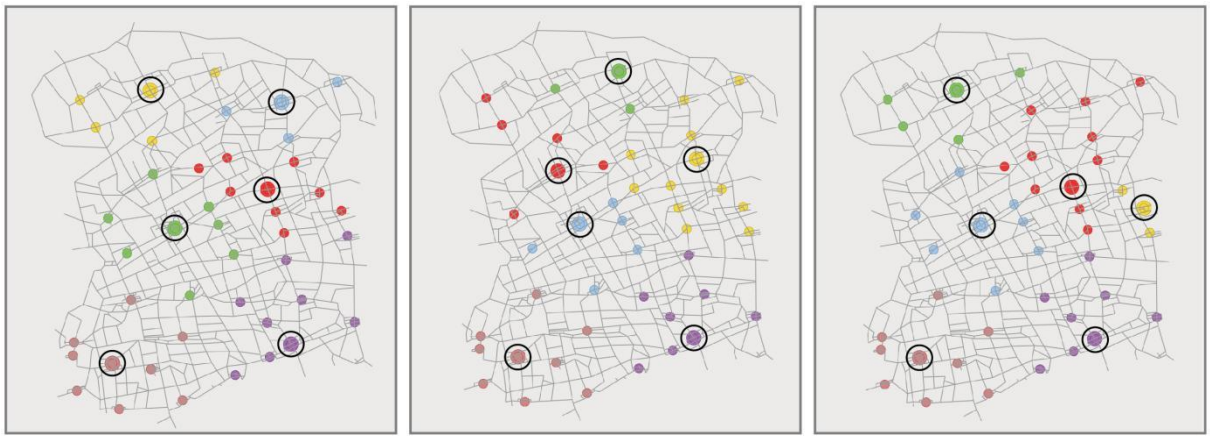


Figure 13. The clustering results and MPDWC values when the value of K is 6. The points circled by black circles are the centroids of each cluster in the clustering result.

5. Discussion

Under the background of rural revitalization, an increasing number of scholars have started to engage in research on rural construction. Rural cultural revitalization is an essential part of rural revitalization, so as a carrier of rural culture, rural public cultural space has received increasing attention. However, the current research on this topic is mostly theoretical and lacks the support of scientific and quantitative research methods. However, in studies of the spatial distribution of some types of public service facilities in

cities, many scholars have adopted quantitative research methods. The purpose is to rationalize and optimize the spatial distribution of public services and to use it to solve the existing problems. In the research of this paper, we also hope to apply scientific and quantitative research methods to study the problems related to rural public cultural spaces. Therefore, based on the characteristics of rural public cultural spaces, a path-clustering algorithm is written, and then the algorithm is applied to the study of the location of rural public cultural spaces. However, many studies apply clustering algorithms to spatial distribution. However, few clustering algorithms have been written using the actual path distance as the similarity metric, mostly based on Euclidean distance. Therefore, the study is not only more relevant to reality, in line with the law of human travel but also has practical application value.

The following two problems still exist in the current study. One is that the algorithm is time-consuming. Taking the path map of Yumin Township studied in the article as an example, it takes 3 h to complete the clustering analysis. Second, the siting study of this public cultural space takes into account the travel distance of people. However, it has not been tested in practice to determine the effect of its application in actual projects. Therefore, future research should focus on two aspects. One is to optimize the algorithm to improve the speed and accuracy of the algorithm. This includes choosing a more efficient algorithm to determine the distance matrix between points. We also need to further investigate the influence of the hyperparameters on the clustering results and how to set the hyperparameters to make the algorithm more efficient. Second, the research will be integrated with practical applications, and the results of the practical applications will be used to evaluate the effectiveness of the research. It is also worth noting that the practical applications of this study go far beyond this. In the future, we will try to apply the algorithm to other spatial distribution studies of public spaces to further broaden the application dimension of the study.

6. Conclusion

A path-clustering algorithm was written according to the logic of the k-means algorithm in this study. Then, the clustering algorithm was applied to study the siting of rural public cultural spaces. In Yumin Township, villages within the township are divided into clusters based on the distance people can travel. In each grouping, a village is selected to set up a rural public cultural space to serve all villages. On the basis of the high accessibility of rural public cultural space, the distribution of its public cultural resources is also more even. It not only meets the villagers' demand for space but also saves public cultural service resources to a certain extent. The study also has the following findings.

(1) Its initial hyperparameters have an impact on the clustering results. Among them, the initial clustering center affects the clustering results, but its WCSPD value does not change much. The k-values need to be selected according to the set travel path distance values. The MPDWC corresponding to different k values is first calculated, and then the k value is determined according to the travel path distance.

(2) In the siting analysis of rural public cultural spaces in Yumin Township. When the travel distance is set to 5 km, its corresponding cluster number is 8, indicating that the villages within the whole Yumin Township will be divided into 8 clusters. Then 8 multi-village concentration public cultural spaces need to be established. When the travel distance is set at 6 km, the villages will be divided into 6 clusters, meaning that 6 multi-village concentration public cultural spaces need to be set up.

(3) The analysis results are diverse, and different clustering results can be obtained by modifying the parameters, which can be filtered according to our needs. The final analysis results are only used as a reference, and more objective factors must be considered in the construction of cultural space. Nevertheless, the application of this quantitative analysis method to the study of the construction of rural public cultural space is very valuable and has certain practical significance.

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References

1. Chen B. Weakened public cultural space: the "weakness" of rural cultural revitalization[J].People's Tribune,2018(21):125-127.
2. He L P. On the public Space of Cultural Life and Construction of Rural Culture[J].Journal of Jiangxi Normal University(Philosophy and Social Sciences Edition),2011,44(2):8-13.
3. Zhang P Q, Hu H L.On the Spatial Turning of Rural Public Cultural Service Construction in the Context of Rural Revitalization Strategy[J].Fujian Tribune(Humanities and Social Sciences Edition),2018(10):99-104.
4. Chen B, Li T T. Our National Rural Public Cultural Space Rebuilding in Urbanization Acceleration Period: Theory and Mode Construction[J].Hundred Schools in Arts,2015,31(6):64-71,112.
5. Ma Y Q.The meaning and realization of rebuilding rural public cultural space[J]. Gansu Social Sciences,2011(3):179-183.DOI:10.15891/j.cnki.cn62-1093/c.2011.03.041.
6. Wang X C,Xiong F,Wang Z W,et al.Planning and Layout of Facilities for the Elders Based on POI and Machine Learning:A Case Study of Wuhan[J].Economic Geography,2021,41(06):49-56.DOI:10.15957/j.cnki.jjdl.2021.06.006.
7. Sevtsuk A, Kalvo R. Patronage of urban commercial clusters: A network-based extension of the Huff model for balancing location and size. Environment and Planning B: Urban Analytics and City Science. 2018 May;45(3):508-28.
8. Tong H. Research on the site selection and path layout of the logistics distribution center of marine ships based on a mathematical model. Transport. 2022 Sep;63(3):23-34.
9. Aliniai K, Yarahmadi A, Zarin JZ, Yarahmadi H, Lak SB. Parking lot site selection: an opening gate towards sustainable GIS-based urban traffic management. Journal of the Indian Society of Remote Sensing. 2015 Dec;43(4):801-13.
10. Wang Z B,Li H Q,Zhu S S.Analysis on the Location of Emergency Medical Facilities: Taking Urban District of Handan City as an Example[J].Journal of Human Settlements in West China,2022,37(04):69-75.DOI:10.13791/j.cnki.hsfwest.20220410.
11. Gen D.Research on the Construction of Rural Public Cultural Service System from the Perspective of Public Cultural Space[J].Thinking,2019,45(5):137-146.
12. Lefebvre H, Nicholson-Smith D. The production of space[M]. Blackwell: Oxford, 1991:304-306.
13. Wu L P,Zhang X P.Multidimensional Perspectives on "Cultural Spaces" in Domestic and International Research[J].Journal of Southwest Minzu University(Humanities and Social Science),2016,37(3):7-12.
14. Sennett R. The fall of public man[M]. WW Norton & Company, 2017:16-18.
15. Li X Y.Design Boost the Reconstruction of Rural Public Cultural Space[J].Art and Design,2022,2(2):54-57.
16. Zheng Z.A Study on the Construction of Public Cultural Space in Rural Areas of Tibet within the Context of the Rural Revitalization Strategy[J].Journal of Ethnology,2021,12(2):68-75,100.
17. Chen J.Study on the planning of public cultural space in modern rural communities[J].Housing and Real Estate,2021(25):67+73.
18. Chen Y,Chen Z Y,Yang Y Y.Research on Rural Public Cultural Space in the Context of Rural Revitalization[J].Rural Economy and Science-Technology,2021(25):67+73.
19. Cao H L.The Evolution of Village Public Space and Its Significance for the Reconstruction of Village Order--A Concurrent Discussion on the Generative Logic of Village Order in Social Change[J].Tianjin Social Sciences,2005(06):61-65.
20. Luo J,Gao M X,Yang Y,et al.Research on the Renewal of Rural Public Cultural Space under the Guidance of Cultural Capital:A Case Study Based on the Construction of Beautiful Houses in Zhulian Village, Liuyang City[J].Journal of Human Settlements in West China,2022,37(02):127-133.DOI:10.13791/j.cnki.hsfwest.20220218.
21. Zhu R X,Gao C F.Promote the construction of public cultural space to create a beautiful countryside[J].NongCun ShiYong JiShu,2019,(03):1-2.
22. MacQueen J. Classification and analysis of multivariate observations[C]//5th Berkeley Symp. Math. Statist. Probability. 1967: 281-297.
23. MacKay D J C, Mac Kay D J C. Information theory, inference and learning algorithms[M]. Cambridge university press, 2003:284-292.
24. Dijkstra E W. A note on two problems in connexion with graphs[J]. Numerische mathematik, 1959, 1(1): 269-271.

25. Floyd R W. Algorithm 97: shortest path[J]. Communications of the ACM, 1962, 5(6): 345.
26. Hamerly G, Elkan C. Alternatives to the k-means algorithm that find better clusterings. InProceedings of the eleventh international conference on Information and knowledge management 2002 Nov 4 (pp. 600-607).