

Research on Spatial Morphology of Traditional Settlements Based on Spatial Syntax

—A Case Study of Xiuxi Village, Li County, Sichuan Province

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Abstract

The protection of traditional settlements mainly focuses on the spatial morphology. For the previous research methodology, it tends to make analysis through qualitative methods rather than quantitative methods. Taking Xiuxi Village, Li County, Sichuan Province as an example, this paper studies the spatial morphology and actual space of the traditional settlement of the Qiang people, refines and analyzes its spatial elements, obtains the overall spatial structure characteristics of the traditional Qiang settlement, so as to verify the feasibility of spatial syntax in the protection and renewal of the spatial morphology in the traditional Qiang settlement, and propose a specific case for the spatial morphological research of traditional Qiang settlement by the using of a quantitative analysis method.

Keywords

Spatial Morphology, Space Syntax, Xiuxi Village, Traditional Settlement

1. Introduction

At different stages of social and historical development, traditional settlement plays an important role in carrying forward the history and conserving the culture. Today, although its function no longer meets the requirements of modern people on the life standard, it does embody the planning concept of “harmony between human and nature” of the ancients by its house construction adapting to local conditions and applying local materials, which is worthy of our study and inheritance [1]. In today’s society, traditional settlements are facing the destruction caused by improper planning and over-exploitation of commerce and tourism. Therefore, it is urgent for us to carry out more in-depth research on

traditional settlements.

Xiuxi Village, Puxi Township, Li County, Aba Tibetan and Qiang Autonomous Prefecture in Sichuan Province have been listed as the fourth round Chinese traditional villages. This paper chooses Xiuxi Village, Puxi Township, Li County, a village in the representative of traditional Qiang settlement as study object, to establish a spatial axis model. Five syntactic variables are introduced, namely, depth value, connection value, integration degree, comprehensibility and selectivity. Furthermore, it analyzed the spatial morphology of Xiuxi Village's traditional settlement, so that the traditional settlement can be better recognized and protected.

2. General Situation of Xiuxi Village

Xiuxi Village of Puxi Township is located in the eastern part of Zagunao Town (**Figure 1**), Li County Government, Aba Prefecture, northwest Sichuan Province. It belongs to the alpine and gorge region, with the majority of Qiang residents in the village. There are a total of 57 households and 289 residents in Xiuxi Village. The villagers usually live in high mountains above the elevation of 2000 meters, with steep terrain, barren land, and more than half of the cultivated land at a slope of 30 degrees or higher. The type of crops is single there, and the economic level of the villagers is very underdeveloped, lived by fungi hunting or working outside. According to statistics, the net income per capita of Xiuxi Village in 2007 is 1749 yuan, which is at a lower level by the comparison with other nearby villages [2]. In recent years, with the adjustment of the industrial structure in the village, the income of villagers has increased obviously. At the same time, the tourism industry of the village has been started for the well preservation of the Qiang culture, taken as a card of Qiang culture tourism. In 2017, the per capita net income of Xiuxi Village increased by 10 times or so, reaching 9800 yuan, and the quality of life in Xiuxi Village is improved significantly [3].

3. The Application of Spatial Syntax in the Study of Xiuxi Village Space

Spatial syntax mainly studies the spatial structure theory of the relationship between spatial organization structure and human cognitive intention involving a quantitative analysis of the structure and elements of human settlements by describing the space of architecture, city, settlements and landscape. In the 1960s and 1970s, Professor Bill Hillier and Julienne Hanson of the University of London jointly conceived the theory of spatial syntax.

The basic principle of spatial syntax is the segmentation of space, *i.e.* the whole spatial system will be expressed by a set of small spaces. Three methods are applied to spatial segmentation, including axis, convex and visibility. In this paper, depth value, connection value, integration degree, selectivity and intelligibility, all above mentioned five parameters, which are selected and applied to the three methods to analyze the spatial morphology of Xiuxi Village.

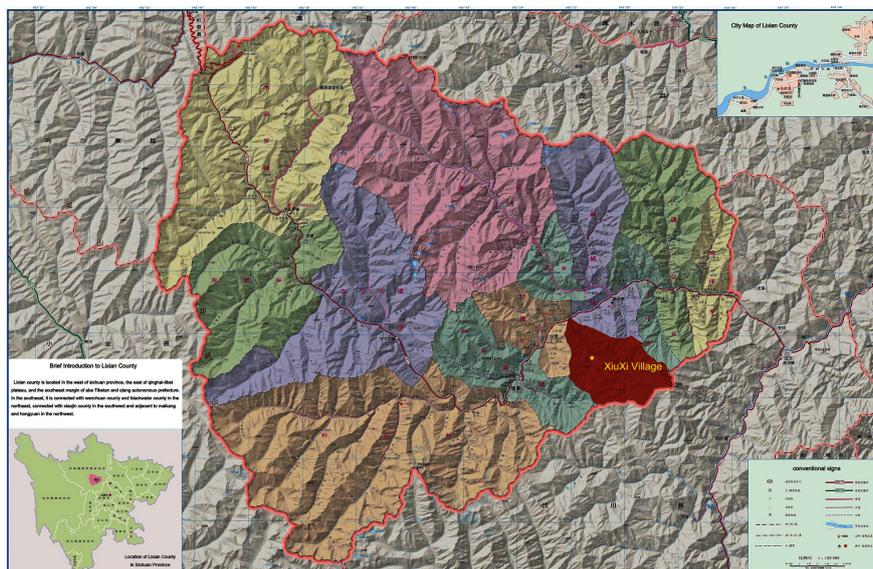


Figure 1. Location map of Xiuxi Village, Puxi Township.

3.1. Convex Analysis

Depth value refers to the shortest distance between a namespace node and other nodes in this system, which represents the accessibility of each space in the whole space system [4]. By analyzing the changes of street space in villages, it is possible to compare the changes of space depth in villages. As the **Figure 2** shows, we can see that the cool colors represent the large value of spatial depth, while the warm colors represent the small value of spatial depth, which illustrates the accessibility level of each space in Xiuxi Village.

As the graph of depth value (**Figure 2**) shown, the depth value 17.893 of the intersection connecting Laozhai and Xinzhai in Xiuxi Village is the smallest, followed by the entrance group of Xinzhai Village, which is the necessary entrance to the group space, closely related to the surrounding space with the depth value 18.368. Regarding to the two entrance axes of the inhabited area, their depth values are 18.839 and 18.926 respectively. Among them, the entrance is located in the geometric center of the whole village, while the others are mainly the circular roads in the settlement and scattered areas of Xiuxi Village. Therefore, we can see that besides the entrance space in the geometric center, the space on the circular road may also have better accessibility.

In addition, based on the above calculation results, we can also find that a considerable number of spatial depth values are similar in the villages. According to the analysis, we find that Xiuxi Village is divided into 268 convex spaces, of which 172 convex spaces, 52% of the depth values are mainly distributed between 20 and 25. This shows that most of the convex spaces in Xiuxi Village have similar depth values, that is the similar accessibility, in spite of their different geographical locations. It can be seen that the average depth of the whole settlement is larger, indicating that the traffic flow in the settlement is not smooth.

Through the above analysis, the following conclusions can be drawn:

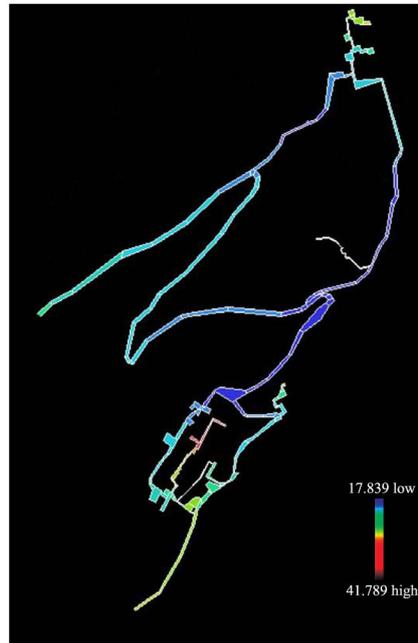


Figure 2. Analysis on convex average depth in Xiuxi Village.

1) The space with smaller depth value is not necessarily a convex space near the geometric center of the village, or maybe is a convex space on the outer ring roads. The space with smaller depth value should be closely related to the surrounding spaces.

2) The depth values of a considerable part of the village are relatively similar, which indicates that there is similar accessibility among the spaces with different geographical location in the village.

3.2. Horizon Analysis

The clustering coefficient is the strength of optical effects limited by spatial boundaries. As shown in **Figure 3**, the highest clustering coefficient is the village entrance square, and the visibility between any two viewpoints in the entrance square is the largest. The aggregation coefficient of the End-Space in the village is close to 1, which indicates that the End-Space has a strong effect on optical limitation. The clustering coefficient value of the village roads is low, and the road intersection presents multi-directional choices. The location with smaller clustering coefficient is an important roadway node in the village. In practical application, the square of Xiuxi Village is enclosed in a regular shape, with obvious centripetal effect. It is a gathering place for villagers to gather together, where sacrifices and other important festival activities are carried out here.

Connection values are quantitative descriptions of viewpoints, *i.e.* the number of nodes that can be connected directly. In the same space, the higher connection value of the horizon, the wider observable range of the viewpoint we can obtain; on the contrary, the smaller the observable range [4]. As shown in **Figure 4**, we can find that the higher the connection value, the more likely the gathering

and other activities will be carried out, such as the entrance square, the sacrificial center and so on. The entrance of the square has the broadest horizon, because at the entrance of the square we can not only look at the roads on both sides, but also we can observe the activities inside the square. The connection value in the village roadway is low, the reason is that the sense of direction on the road is stronger than that in other places caused by the single visual range of people on the road.

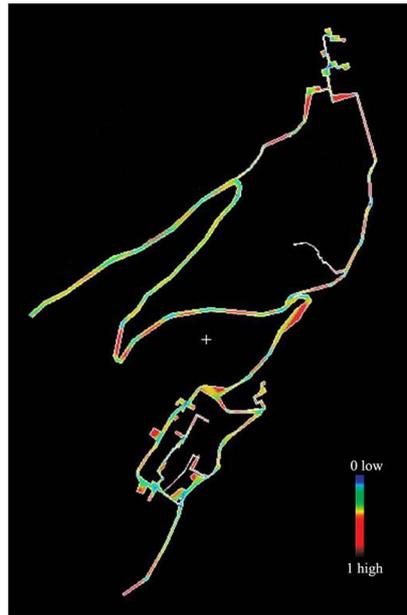


Figure 3. Analysis on horizon clustering coefficient of Xiuxi Village.

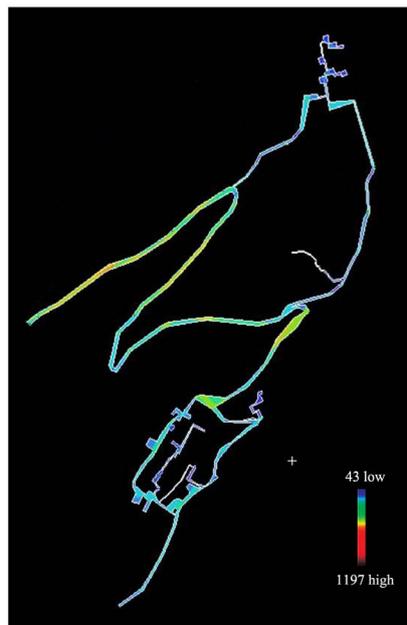


Figure 4. Analysis on horizon connection value of Xiuxi Village.

Through the above analysis, the following conclusions can be drawn:

1) The places with high clustering coefficient in villages mostly belong to enclosed regular space, and the visual changes are relatively stable; the places with low clustering coefficient are mostly road intersections with unstable visual changes.

2) The space with the smallest connection value in villages mainly belongs to End-space, which is often relatively far away from the space with higher connection value.

3.3. Principal Axis Analysis

3.3.1. Integration Degree Analysis

Integration degree indicates the degree of settlement or scattering of unit space and other spaces in the system. The greater the integration degree is, the closer relationship it will obtain between the space and other spaces in the system [5]. In addition, the degree of integration also includes the degree of global integration and the degree of local integration. Global integration reflects the centrality of one space relative to other spaces. The degree of local integration indicates the closeness of any space related to its adjacent space. The core of local integration also reflects the characteristics of local areas, especially for traditional settlements, it is more important to analyze the characteristics of local integration degree of each settlement. Among them, because of the small scale of Xiuxi village settlement, only the local integration degree with the topological sorting of 3, 5 and 7 is selected as the analysis object.

From the analysis diagram of the integration degree of Xiuxi Village, we can see that the axis color transits from red to blue in turn, indicating that the spatial accessibility decreases successively. The overall integration center of Xiuxi Village is located at the intersection of Xinzhai and Laozhai, which is on the road to the entrance of the village. As shown in **Figure 5**, the integration degree of the Village intersection is 0.519, and the value of the road at the entrance of the village is 0.487, which contains the highest integration degree of 0.519. It shows that both of the two roads in the whole village have the best accessibility, with the easiest reach access and the easiest convergence of human flow.

It is found that, through the investigation of the present situation, both of the two roads are the most important spaces for external exchange in the village. When the topological sorting is 3, 5 and 7, we find that the obvious difference is that the village intersection won't have significant integration advantage. In addition, when the topological sorting is 3, 5 and 7, there are more highly integrated axes appeared in the model, as shown in **Figures 6-8**. These axes are mainly distributed on the peripheral roads, sacrificial plazas and other settlement areas of the village, became relatively independent integration centers in the settlements. The integration degree values of topological sorting 9 and 11 are close to that of global integration degree, which indicates that the scale of rural area is smaller. Compared with the urban area, only the local integration degree of topological sorting 3, 5 and 7 is selected for the study.

Finally, we find that the center of global integration and local integration overlap with the space with strong traffic function in actual use. These spaces either serve as entrance space to the settlement or as the main traffic artery running through the whole settlement, taken as the most important space within the village or between the settlements.

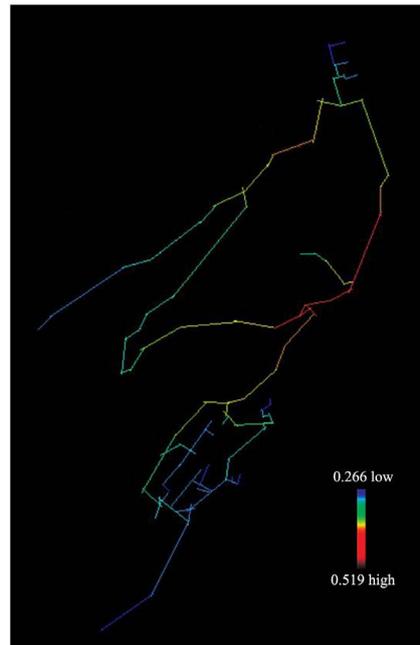


Figure 5. Analysis on the global integration degree of the axis of Xiuxi Village.

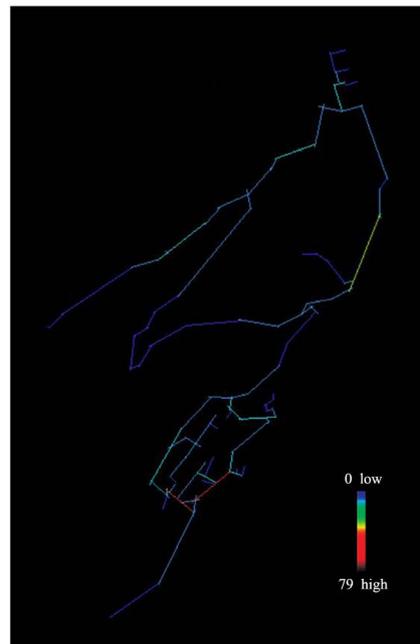


Figure 6. Analysis on integration degree in r3 of axis of Xiuxi Village.

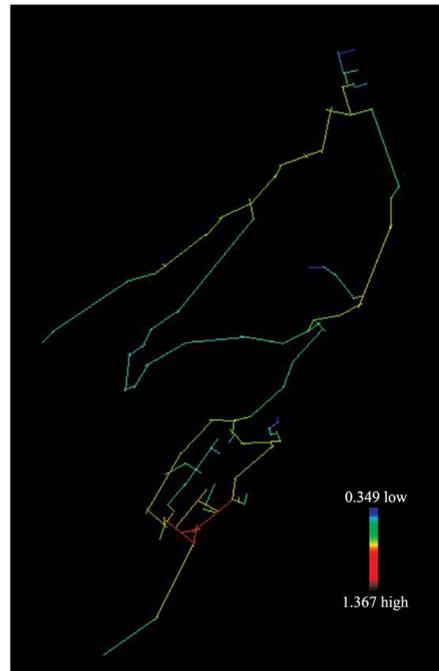


Figure 7. Analysis on integration degree in R5 of axis of Xiuxi Village.

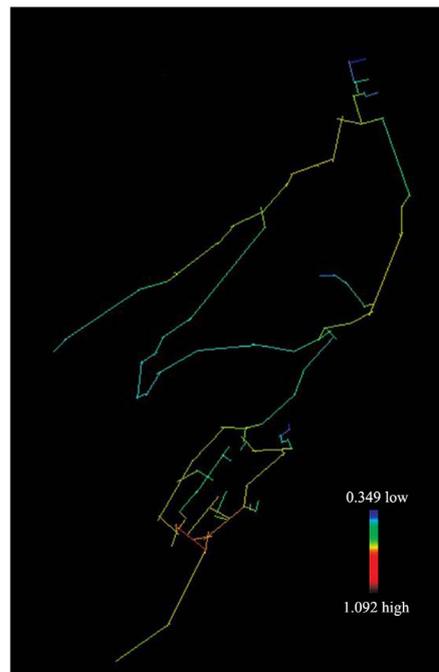


Figure 8. Analysis on integration degree in R7 of axis of Xiuxi Village.

Through the above analysis, the following conclusions can be drawn:

- 1) Both of the global integration center and local integration centers are often applied into the important spaces with powerful functionality in practical use, such as entrance space, public activity space, traffic arteries, etc.

2) The axis with high connection value has higher integration capability in the local integration degree, but in the absence of obvious advantage in the global integration degree. It shows that in the process of village self-organization, the development of local area generally depends on a certain space, which is the integration center of this area.

3.3.2. Selectivity Analysis

The degree of selectivity is “the number of occurrences a space appears on the shortest topological path”. The importance of the degree of selection lies in convex space. The higher the degree of selection is, the greater potentiality of the space have for the attraction of traffics [5].

From the selectivity analysis chart of Xiuxi Village (**Figure 9**), we can see that the axis color transits from red to blue in turn, indicating that the potentiality of the space that attracts crossing traffic getting smaller. The overall selectivity center of Xiuxi Village is located at the intersection of Xinzhai and Laozhai and on the road to the entrance of the village. As shown in **Figure 10**, the selectivity of Village intersection is 5504, and the data of the road at village entrance is 5412, which includes the highest selectivity of 5504. It shows that both of the two roads in the whole village have the best potentiality to attract traffic, indicating that the highest frequency the space is traversed and utilized. Similarly, by choosing the degree of selectivity with the topological sorting at 3, 5 and 7 (**Figures 10-12**), we will find that these axes are distributed in the nodes and squares of the village, of which the spaces are with good potentiality to attract traffics.

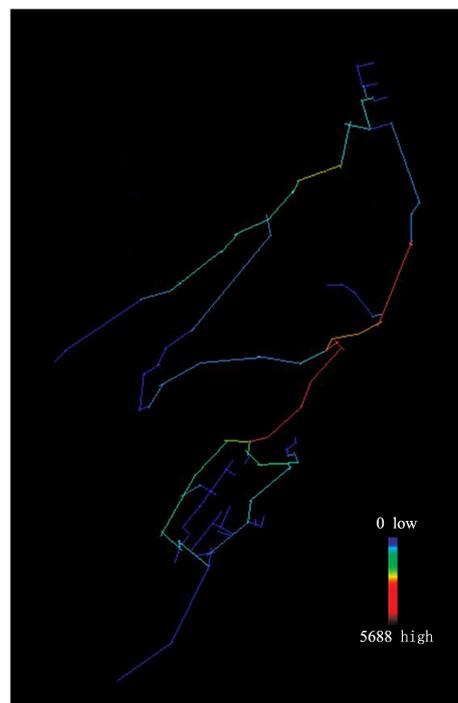


Figure 9. Analysis on global selectivity of Xiuxi Village.

Basing on the above analysis, it can be concluded that the axes with high global and local selectivity are mostly located at the intersection nodes and public activity space of the village.

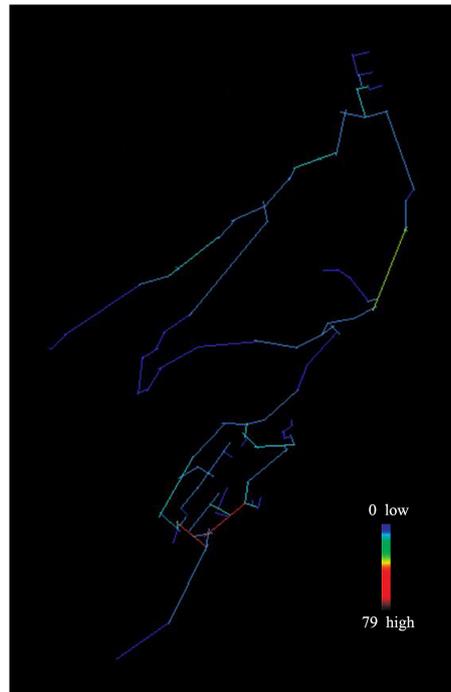


Figure 10. Analysis on selectivity degree in R3 of Xiuxi Village.

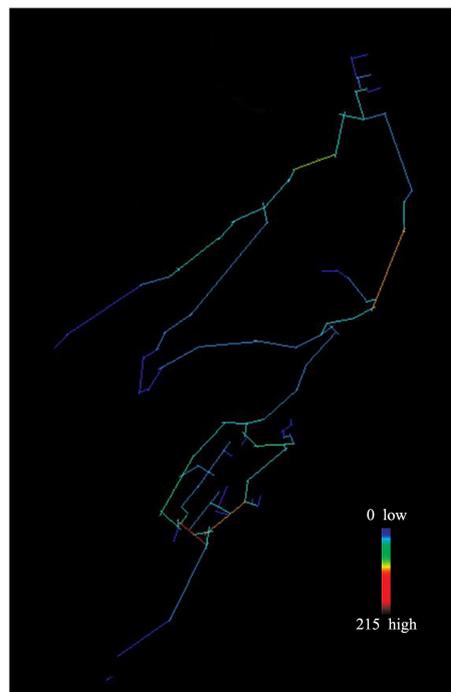


Figure 11. Analysis on selectivity degree in R5 of Xiuxi Village.

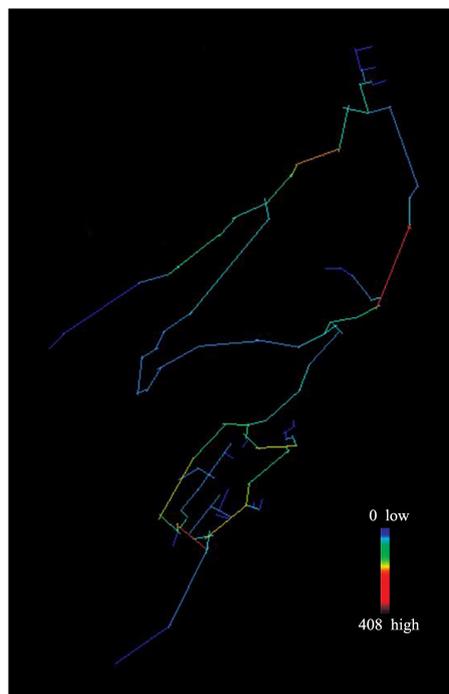


Figure 12. Analysis on selectivity degree in R7 of Xiuxi Village.

3.3.3. Intelligibility Analysis

Intelligibility is used to indicate how difficult it is for people to recognize the global space by understanding the local space. The higher the intelligibility is, the better synergy it can be won between local integration and global integration. It shows that people can feel the whole space environment through the cognition of local space. There is a strong correlation between local space and the global space. People can quickly integrate into the global space through understanding of the local spaces with reference to their positive interaction. On the contrary, low intelligibility means that it is difficult to recognize the global space through the understanding of the local spaces. Since there is no interaction between the local spaces and the global space, and there is less correlation between them. They are independent of each other for the lack of connection [4].

In spatial syntax, we use goodness of fit R^2 to express the spatial intelligibility, directly displayed with the scatter diagram. Usually, the higher R^2 is, the more accurate it is to use this line to predict scatter plots. On the contrary, the more unreliable it is. Hill believes that the goodness of fit below 0.2 belongs to low intelligibility, between 0.2 and 0.4 belongs to medium intelligibility, and higher than 0.4 is high intelligibility.

According to the intelligibility analysis shown on the scatter diagram (**Figure 13**), the intelligibility of Xiuxi Village is 0.0625031, which indicates the lower spatial intelligibility and the poor interaction between local space and global space, so it is not easy to recognize the global space. Of course, its smaller scale will also be taken as an important factor affecting intelligibility.

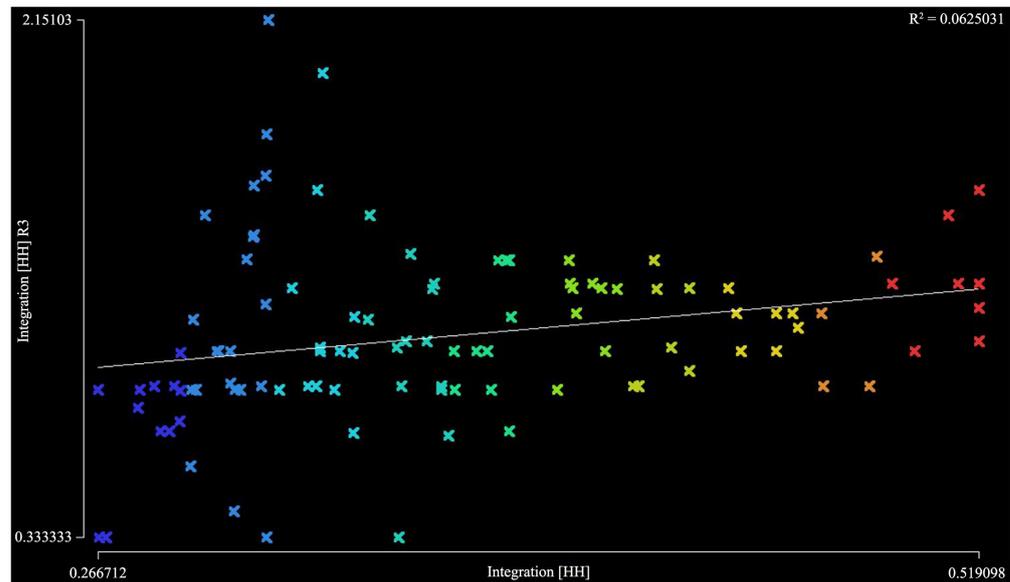


Figure 13. Analysis on intelligibility of Xiuxi Village.

4. Conclusions

The protection and renewal of traditional settlements tend to describe, explain and analyze the spatial morphology of villages qualitatively. Based on the spatial syntax theory, this paper quantitatively analyzes the spatial morphology of Xiuxi Village, analyzes and summarizes the spatial morphology characteristics of Xiuxi Village. Through three common spatial syntax methods, including convex space method, horizon method and axis method, it analyzes the spatial morphology of Xiuxi Village based on a series of basic variables such as the depth value, connection value, integration degree, selectivity and intelligibility of its spatial system. It is attempted to quantify and explain the ancient village space from a new non-traditional perspective, focusing on the relationship between human social activities and spatial morphology, so as to provide a theoretical basis for the protection planning of traditional Qiang settlements.

In the meantime, we also find that the analysis results solely obtained by spatial syntax calculation are not fit for taking as a complete basis for planning and design. It lacks comprehensive consideration of the natural, historical, social and cultural factors closely related to spatial morphology. It should be taken into account by relevant professionals in combination with the actual complex situation and various planning factors to comprehensively upgrade the scientific nature and effectiveness of conservation planning in ancient villages.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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