Article

Study on Courtyard Residence and Cultural Sustainability: Reading Chinese Traditional Siheyuan through Space Syntax

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Abstract: The United Nations and local governments have supported a four-point sustainable development framework, including environmental responsibility, economic viability, social equity, and cultural vitality. This study is based on the theoretical framework of sustainability to study the traditional Chinese siheyuan residence. Space syntax attempts to explain how spatial structures express social or cultural significance, such as the hierarchical relationship and privacy in it. The main purposes of this study are: (1) To analyze the spatial topological layout of traditional siheyuans by using the space syntax theory, and thus deduce the cultural connotation embedded in traditional siheyuans; (2) to compare and analyze the spatial morphology and behavior patterns of traditional and modern houses; (3) to explore how to integrate courtyard features into contemporary design and promote cultural sustainability. This study expounds the concept and application of syntactic analysis, and the relationship between the syntactic attributes of specific buildings in a particular area, and the culture and life of the local people within that area. As time goes by, the spatial form of houses has changed. However, in terms of spatial allocation index, the significant difference between traditional residences and modern residences lies in the integration and equivalence of all spaces in residences. We can learn from the cultural values of traditional siheyuans, meaning "people-oriented", to rationally design modern residences with cultural connotations.

Keywords: traditional siheyuan; cultural sustainability; space syntax

1. Introduction

The courtyard house is a kind of family residence with a long history. The main space of the building, which is arranged around the central courtyard, is one of the oldest residence types in the world. It can be traced back to 5000 years ago, when it was built in the Middle East and China [1]. The courtyard house occupies an important position in architectural history, and only in the past few centuries did architects ignore its use. Recently, more attention has been paid to the courtyard housing type to solve some of the inherent problems of dense inner-city housing. As cities face the challenges of rapid modernization and urbanization in the new era, the traditional courtyard residence is disappearing. In response to the international metropolitan environment, city planners and scholars are working hard to protect this important element of the Chinese cultural heritage [2].

Some researchers have studied the influence of social and cultural factors on traditional Chinese courtyards, according to professional knowledge [3–6]. D. Zhang introduced the interaction of nature, culture, and architecture, and proposed the concept of culturally-sustainable architecture [5].

She proposed four major themes from Chinese philosophy, including harmony with heaven, harmony with earth, harmony with people, and harmony with oneself, as well as the physics of Aristotle (384–322 B.C.), the Greek philosopher: Form, space, matter, and time. She used this innovative architectural and social science method as the standard to evaluate the newly built and renovated siheyuan residential projects in China since the 1990s, and examined the political, economic, cultural, social, and spatial factors affecting cultural sustainability [6].

The focus of this study is not on individuals or the individual forms shown in scattered courtyards, but on genotypes with universal significance. It is to study how traditional courtyards endow profound social and cultural connotations with forms through their special spatial and organizational patterns; to study the spatial form of courtyards and the interaction between social and cultural factors within; to understand how courtyard culture enters the material entity and form of courtyards through space configuration; and finally, to discuss the sustainable development of the cultural heritage of siheyuan.

This paper takes space syntax as the main research method and proves it by field investigation. Space syntax, in its simple form, is based on the theme that human society has complete space information, space environment or residence space, and embedded social information. This theme transforms the analysis method of architectural environment study from the popular trend of aesthetic visual analysis, to a complex quantitative method, which employs numerical analysis to quantify space properties, and extracts cultural information from siheyuan through mathematical models. Social and cultural information describing the formation process is embedded in the spatial layout of each building. The study of space syntax has developed useful tools to collect such information, outlined the social logic behind the spatial layout of buildings, and analyzed their values.

2. Literature Review

The Chinese have been living in siheyuan-style houses for thousands of years. To date, the earliest siheyuans discovered by archaeologists were built in the middle of the Neolithic Age, as represented by Yangshao Culture (5000–3000 B.C.) [7]. The ancient Chinese preferred this type of residence because the fences helped to protect the privacy of the family to the maximum extent, as well as to prevent wind, noise, dust, and other threats. The courtyard provides light, air and landscape, and also serves as a space for family activities when weather permits. A traditional Chinese siheyuan usually accommodates three or four generations of large families [6,8,9].

Scholars admit that sustainable development consists of four pillars: Environmental responsibility, economic viability, social equity, and cultural vitality. The root of the word "sustainability" is from the Latin *sustinere* (*tenere*, to hold; *sus*, up). Dictionaries provide more than 10 meanings for "sustain," the main ones being to "maintain", "support", or "endure" [10,11].

How space works for people is not simply about the space itself, but about the relationship between all the spaces that make up a layout. The layout refers to a spatial pattern or configuration, implying the existing relationship [12]. Traditional Chinese architectural culture does not emphasize the independence of architecture, the core and essence of which is the architectural portfolio. The traditional siheyuan is a good reflection of such a portfolio, which produces a spatial relationship that conforms to the traditional order of life.

Various writers, such as Darlow and Wheelwright have observed that sustainable development is to a large extent a cultural task because it seeks to change attitudes and lifestyles [13,14]. Judy Spokes, the executive officer of Cultural Development Networks, asserts that "culture is both overarching and underpinning" [15]. As such, Brand and Nurse believed that culture should be placed front and center of the sustainable development framework, and fully integrated into the other three pillars, as it is the basis for testing the meaning and practice of sustainable development [16,17]. Creative City Network of Canada likewise contends that "culture is a core dimension of vibrant and sustainable communities", because the character of a place is inseparable from its traditions and culture, as they are lived and expressed in the activities and social life of the community [18].

It is necessary to increase the cultural dimension on the basis of environmental, social and economic dimensions, when we understand "sustainability", because the unique role of cultural dimension in sustainable development has been paid more and more attention. The cultural dimension of sustainable development is not only the important power of social integration, but also environmental sustainability. In 2001, Australian scholar Jon Hawker took the lead in proposing four levels of sustainability: Cultural activities (well-being, creativity, diversity and innovation), social equality (justice, participation, cohesion and welfare), environmental responsibility (ecological balance) and economic ability (material prosperity). He believes that a sustainable society depends on a sustainable culture. Culture, as the fourth pole in the triple framework of sustainability, must be a separate and "unique" reference point [15]. Western scholars have different understandings of the role of cultural sustainability in the sustainable development system. Some scholars regard cultural sustainability as a separate dimension in the framework of sustainable development; some scholars regard it as an intermediary model that balances the relationship among the three pillars of the economy, the environment and society; and other scholars regard it as the overall social basis for achieving sustainable development [19].

Therefore, the reason as to why cultural sustainability is one of the important characteristics of the city is that it is not only the driving force for urban civilization, but also the lifeblood of the city's vitality, and the source of sustainable urban development [20], based on its basic connotation. For the development of contemporary Chinese cities, traditional buildings and neighborhoods, urban environment and biodiversity have been damaged to varying degrees, with rapid urbanization and large-scale development and construction, which will not only affect the healthy development of urban culture, but also restrict the ecological and social sustainability of the city. Siheyuan, a traditional Chinese courtyard building with a long history, is an extremely important historical and cultural heritage. The urban structure of traditional courtyard buildings varies according to local development processes and policies. This unique spatial order and organization in these regions reflects the local historical environment and cultural characteristics. The public courtyard in the siheyuan promotes social interaction, and the private courtyard promotes self-cultivation. The relationship of the neighborhood is influenced by two factors: One is the form and space of the courtyard house, and the other is the background of a changing society, socio-economic differences, residence periods, modern lifestyles, community participation, common language, cultural awareness and residents' culture [21]. The public courtyard helps to maintain some traditional Chinese cultural activities. The main function of the public courtyard is to maintain communication and interaction between people and people, as well as people and nature. However, many cultural activities are rarely or no longer involved in public courtyards due to factors such as time, climate, ownership, size and the facilities of the courtyard. We should protect and inherit the traditional courtyard and its culture.

3. Research Method

Space syntax is a term that appeared in the 1970s, and it is used to describe the theory and technology related to space and social relations [22,23]. Space syntax analysis uses the concept of "graph theory" to express geographic space, and the research hypothesis believes that the interaction between human and environment is influenced by the space organization structure. "Graph theory" is also known as "topology", which expresses the concepts of "space" and "logic" with a structure that consists of "points" and "lines". The focus of this study is on the structure (connection) relationship between points and lines, not on distance nor direction. In the space syntax, the understanding and generalization of space includes the following analysis systems:

(1) Convex space analysis. Through this rule, the actual building space can be translated into a system consisting of convex spaces.

(2) Axial line analysis. In this system, elements are linear when the subject of study is movement [24].

(3) Visibility graph analysis: Including single isovists and isovist fields: Visibility graph analysis is utilized in cases where the subject of study shows complicated behavior patterns [24]. Underlying

this analysis are fields of view that are visible from a particular point. Therefore, this analysis model is based on the reflection of light, and determines the patterns of the motional behavior of people in the environment [25–31].

This study mainly uses Convex Map for modeling analysis. When dealing with social interactions, spaces are convex [24]. Convex spaces are analyzed from two aspects: (a) Spaces exhibiting non-linear behavior and the (b) buildings and common spaces among them, as well as the interior arrangement of houses [27,32]. The systematic analysis process of convex space is illustrated with a simple diagram (Figure 1).

| (a) | (b) | (c) |
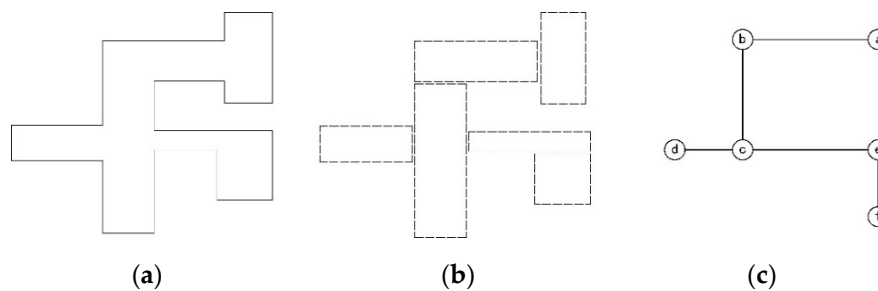
Figure 1. Convex map transformation process diagram: (**a**) Original building space; (**b**) Convex Map; (**c**) Topological relations.

4. Study Process

4.1. Traditional Chinese Siheyuan

Figure 2 shows a bird's eye view of the traditional Chinese three-entrance siheyuan. In this type, the southern external courtyard is located next to the entrance court. Rooms on the south side of the external courtyard are adjacent to the street, and used as housing for male servants, a reception area for guests, or for classrooms where private tutors taught young members of the owner's family. After passing through the well-decorated gate, the middle or inner courtyard is the focal point of the complex. The middle room in the northern wing of the inner courtyard is a prestigious unit occupied by the leader of the family. This middle room has the most beautiful decorations and ornaments made with costly materials. The person of secondary importance in the family uses the rooms in the east wing. By the same token, the rooms in the west wing are for the third-ranking family member. The northern courtyard of the complex is the back court, which is the least important, private in nature, occupied by daughters, female servants, and/or used as a storage area. Rooms in this court are called Hou Zhao Fang (back-coop rooms) [2].
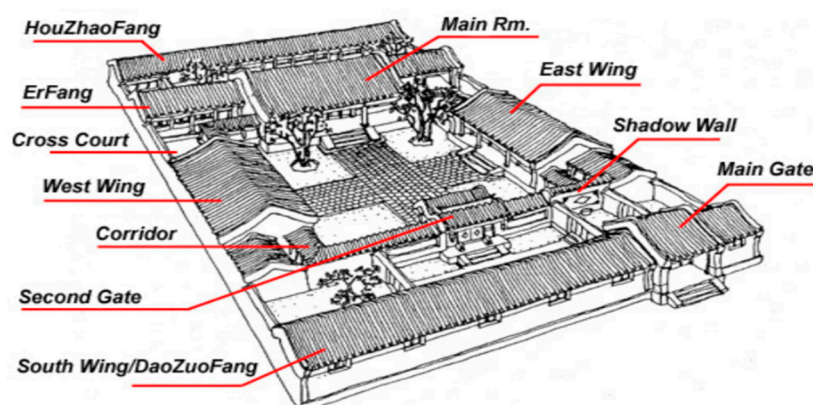
**Figure 2.** A Bird's Eye View of Traditional Siheyuan [2].

Literature shows that rich cultural information is embedded in the formation of this traditional house, which also reflects the influence of Chinese traditional cultural philosophy that "men work outside, and women take care of the home". The formation of the overall architectural layout shows that its spatial order has a certain cultural significance.

It can be said that it is a Chinese tradition that, where there is a house there is a courtyard. People regard houses and courtyards as an inseparable whole. This tradition has been going on for thousands of years, thus, forming a typical residential type—siheyuan. The biggest characteristic of this residential mode is that it centers on the space courtyard and allocates residential buildings around it, thus, forming an inward and enclosed courtyard. The basic principle followed by garden architecture is that, while it originates from nature, it is higher than nature, and tries to combine artificial beauty with natural beauty. The expressed interest can be summarized by "poetic and picturesque" [33].

4.2. Analysis of Building Layout Relationship with Space Syntax

Traditional architecture is chosen to describe syntactic analysis, as the traditional architectural layout contains strong cultural information.

The layout of traditional Chinese architectural space is deeply influenced by traditional Chinese cultural thoughts. Traditional cultural thoughts can be divided according to the philosophical system, meaning Confucianism, Taoism, Mahayana Buddhism, and Neo-Confucianism from the Northern Song Dynasty to the Qing Dynasty. Moreover, the three thoughts of "Yi", "Li", and "Dao" influence the traditional Chinese spatial conceptual layout. Figure 3 embodies the concept of "binary coexistence" in *The Book of Changes* [34].

(**a**)　　　　　　　　　　　　　　　　(**b**)
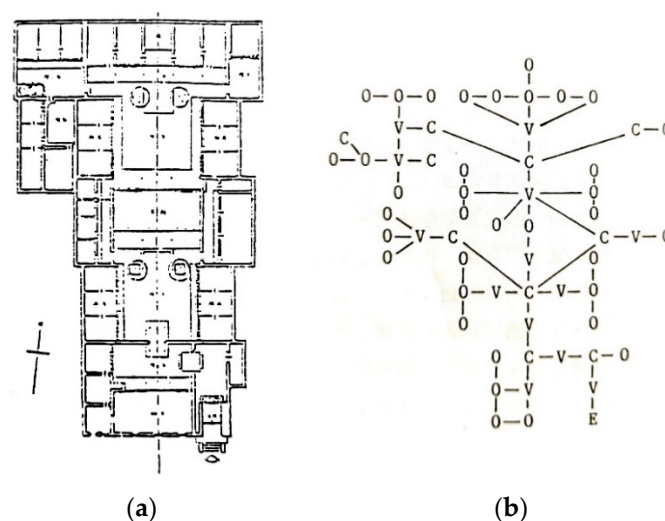
Figure 3. Space organization map of traditional siheyuan: (**a**) Original architecture plan; (**b**) space organization map.

The principle of binary coexistence in traditional architecture is embodied in the existence of "intermediate space", as the third space element, and as "indoor" and "outdoor" space elements. This paper uses Donald Preziosi's method of mark analysis to illustrate the coexistence relationship of the three space elements. This method uses "O" to represent the indoor space, "C" to represent the outdoor space, "V" to represent the intermediate space, and "—" to represent the circulation relationship between spaces [34].

The change of traditional Chinese architectural space is to merge indoor, outdoor, and intermediate spaces, and make use of the different "characteristics" of these three spaces. This change gives users rich, diverse, and profound space experience, rather than just to seek changes in indoor spaces.

According to the principle of binary coexistence of traditional architectural space organization, and with a simple traditional architectural space as the space syntax illustration, we can easily

understand the concepts and terms of space syntax, as well as the relationship between traditional architectural spaces. We uniformly use Donald Preziosi's method of mark analysis, which assumes that O is an indoor space, C is an outdoor courtyard space, and V is an intermediate connecting space (Figure 4).
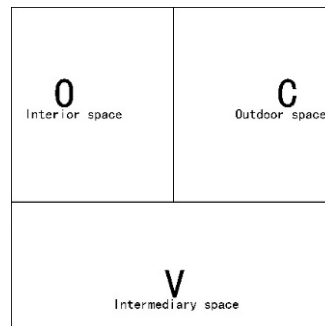
Figure 4. Analysis map of indoor, outdoor and intermediate space.

There are several possibilities for indoor, outdoor, and intermediate space organization. The space in the above figure obviously does not have any openings. The following figure shows three different possibilities of openings between spaces O, C, and V. Spaces are represented as blank points "O", accesses between them are represented as "—", and each setting can be represented as a graph, called alignment graphs in terms of syntax analysis. In fact, this figure has some advantages, meaning it can provide information regardless of the size or relative location of the space (Figure 5) [35,36].

(**a**)   (**b**)   (**c**)
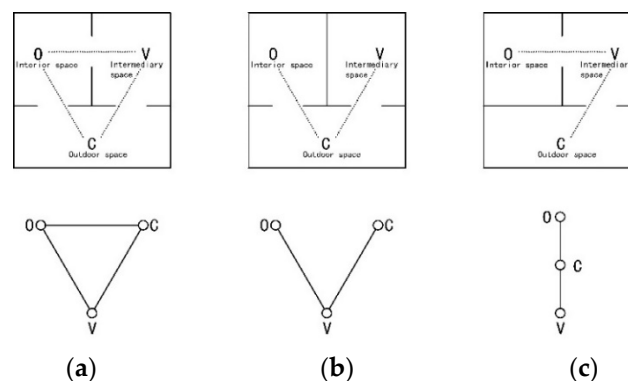
Figure 5. Relation analysis map of indoor, outdoor and intermediate space: (**a**) Indoor or outdoor space can be accessed through the "V" intermediate space, and the indoor space and outdoor space are mutually accessible. The depths of the three spaces are the same. (**b**) In this case, both the "O" indoor space and the "C" outdoor space can only be accessed through the "V" intermediate space. This shows the importance of intermediate space; in other words, the privacy of indoor space and outdoor space is higher than that of (**a**). The depths of the indoor space and outdoor space are higher than that of the intermediate space. (**c**) The situation is more complicated; the indoor space must be accessed through the intermediate space and outdoor space in order. Outdoor space is more important, as it controls indoor space and intermediate space, respectively. Compared with outdoor and intermediary space, indoor space is cleaner, quieter, and more mysterious.

However, the above-mentioned space fully illustrates the application results of the principle of binary coexistence: (1) The spaces with binary characteristics, indoor "O" and outdoor "C", coexist, and even the traditional building is a space model unit composed of the binary space combination. (2) The intermediary space between binary characteristics inevitably exists, and the intermediary space "V" even dominates the connection between indoor space and outdoor space in garden residences.

(3) There are hierarchical relations in spaces; the locations and relations of spaces will affect the hierarchies of spaces. Next, this study quantifies the value of the depth relationship between spaces by using spatial syntactic operations.

4.3. Quantification Method of Space Syntax

Social Logic of Space [36] proposed several concepts to analyze these settings in numerical terms, and this discussion focuses on these terms. The first term is "depth", which calculates the number of spaces required to pass before reaching another space from a certain point. *MD* calculation can be expressed as [37]:

$$MD= \frac{\textit{Total value of depth for all spaces from the root space}}{\textit{Total number of space in the graph}-1}$$

When *MD* is determined, the depth or shallowness of a space from a specific root point can be identified. When all spaces are directly connected to the root space, the depth has the lowest value, i.e., the system is shallowest, as shown in Settings (a) and (b). When spaces are connected in a linear sequence, the depth becomes the highest, with only one space directly connected to the root space, as shown in Setting (c). This study obtains the concept of relative asymmetry (RA) by comparing the space depth of a specific point with its theoretical depth or shallowness. Generally speaking, this process shows the concept of the integration of space and its system from a specific root point [33]. The calculation of *RA* adopts the following equation: The inverse concept of *RA* is integral. The high *RA* value of space indicates its low integration with the system, while a low value indicates its strong integration [35].

$$RA= \frac{\textbf{2}(\textit{MD}-\textbf{1})}{\textit{Total number of space in the graph}-\textbf{2}}$$

The last term is related to the connectivity between a specific space and other spaces, which is called the control value (CV). Each space has a certain number (n) of direct neighbors; therefore, each space gives its direct neighbors $\frac{1}{n}$. These numbers are added to measure the control value of each space, where high control values indicate high connectivity, and low control values indicate low connectivity of the space under consideration. Table 1 describes the term and its meanings. According to the formula, the above examples (a), (b), and (c) are calculated, and the corresponding results (Figure 6) are obtained.

Table 1. Explanation of the terminologies used in syntactical analysis.

Terminologies	Higher Value	Lower Value
Depth	Further away from the root space	Nearer to the root space
Mean Depth (MD)	Deep space	Shallow space
Relative asymmetry (RA)	Less integrated with the spaces	More integrated with the spaces
Integration	More integrated with the spaces	Less integrated with the spaces
Control Value (CV)	Greater connectivity	Lesser connectivity
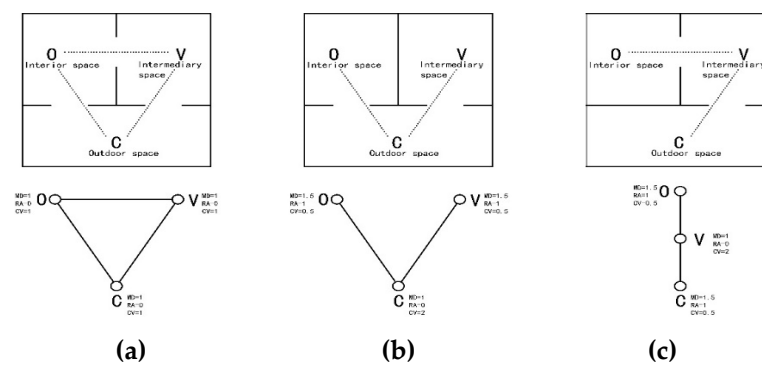
Figure 6. Syntax values of indoor, outdoor and intermediate spaces. According to the spatial syntactic operation mode, the (**a**–**c**) spatial syntactic values in FIG. 5 are calculated.

Syntax values should be interpreted according to the practices of those people in the house. As shown in Layout (a), *MD* and *RA* have the lowest values for all three spaces C, V, and O. Outdoor space, corridor space, and indoor space are equally convenient in implementation, and the entire space is shallow and highly integrated. All spaces have similar connectivity to each other; therefore, access to and utilization of different spaces in Layout (a) are easy for residents. In this case, while the layout is considered more reasonable, the privacy of each space is lower.

In Layout (b), the *RA* value of outdoor space C is lower than that of V and O, which indicates that C is more highly integrated in the space than the other two. In addition, the "CV" control value of C is higher, indicating its high connectivity and importance in the space. Indoor and intermediate spaces are relatively independent and have better privacy.

Layout (c) shows a different situation; in this case, the most integrated space is intermediate space V, which has a high CV and a low *RA* value. The indoor space must be accessed through the intermediate space from the outdoor space, thus, the indoor space becomes deeper. This situation has an indoor space that has a higher degree of privacy and security.

The above example explains the terminology used in syntactic analysis [36]. The example also shows the space types that can be provided according to the culture and life of the people in a particular society. For example, for the indoor layout, different cultural and living needs have different functional layout requirements. The above three spaces may be laid out in traditional buildings. Syntax values (depth and connectivity) resonate with different space layouts, and this situation can be illustrated by complex space layouts. In the next section, the traditional Chinese siheyuan is illustrated with examples to discuss the cultural information related to the syntactic attributes of the house.

5. Reading the Space Syntax of Traditional Siheyuan

### 5.1. Analysis Diagram of Convex Space of Siheyuan

According to the Convex Map modeling method in space syntax, the plan of a traditional siheyuan building is transformed into a space system composed of a convex map, and the space relationships are set (see Figure 7).
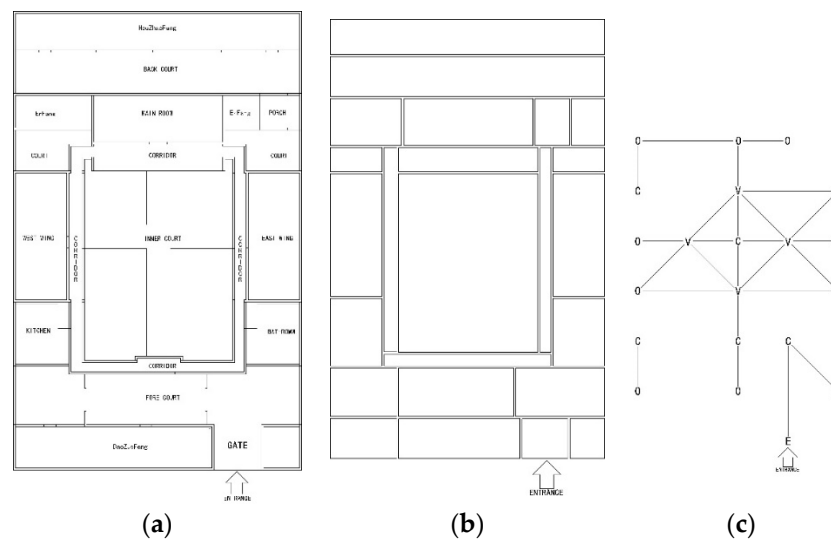
Figure 7. Siheyuan Convex Map System Analysis Diagram; (**a**) is the space plan of the original building, (**b**) is the transformed space syntax—convex map system diagram, (**c**) is the space relationship diagram transformed by Donald Preziosi's mark analysis method according to the topological relationship.

In order to illustrate the relationship among the spaces in the siheyuan, the researcher used the SketchUp software to draw the quadrature axonometric map (see Figure 8), and then use the quantitative approach of space syntax to calculate the syntactic value of each point in the siheyuan space. As the number of space points is huge, the researcher divided the spatial relationship diagram into three pictures for explanation, which present the outdoor space syntax value distribution points, the intermediate space syntax value distribution points, and the indoor space syntax value distribution points (see Figures 9–11).
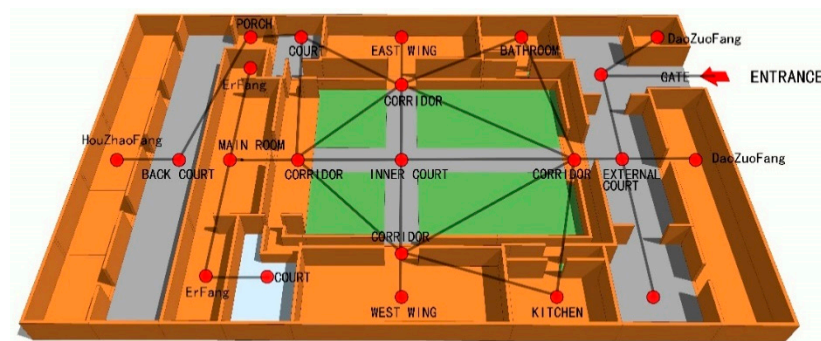
Figure 8. Siheyuan axonometric drawing.
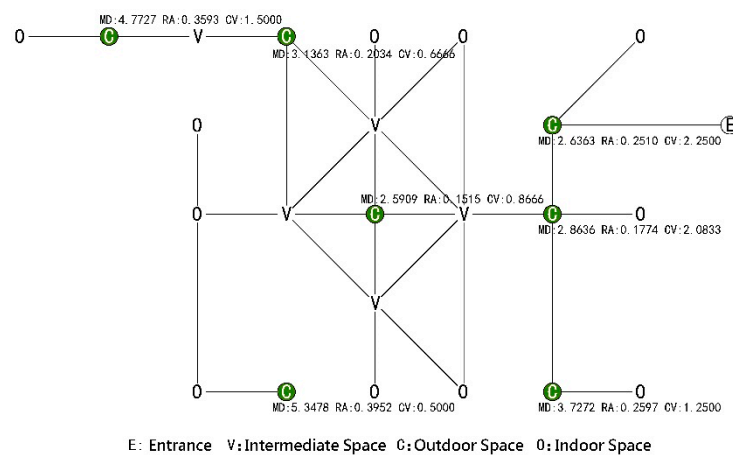
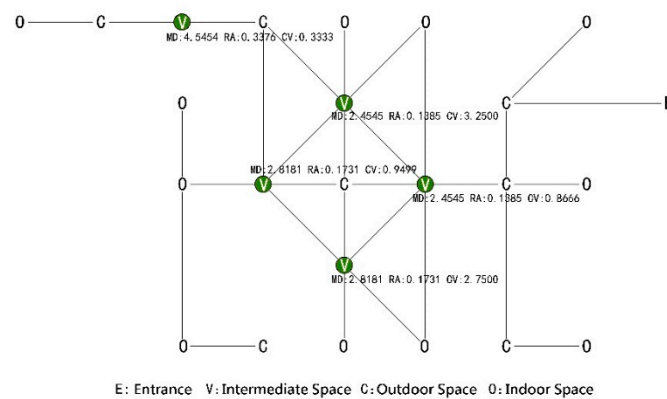**Figure 9.** Outdoor space syntax value distribution points.

Figure 10. Intermediate space syntax value distribution points.
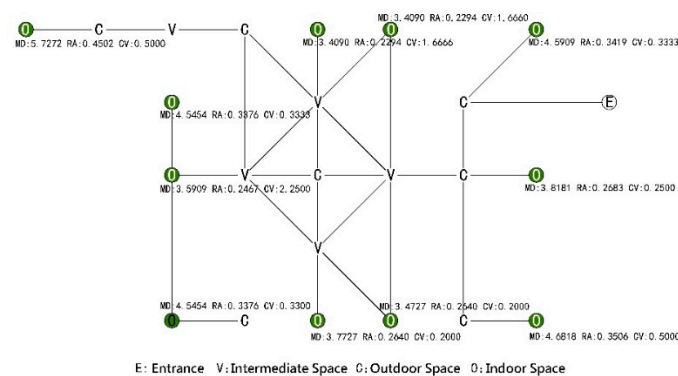

Figure 11. Indoor space syntax value distribution points.

5.2. Results Analysis

The residence is a traditional standard three-entrance siheyuan. In the big courtyard house, the first entrance is the house door. According to the distribution point characteristics of Figures 9–11, its room has a relatively high *RA* value and a low CV value, meaning poor connectivity and being lowly integrated. According to the traditional culture of siheyuan and people's living habits, it is not because the space needs privacy, but because the room is located in the south and faces the north, which belongs to a relatively poor position in the whole siheyuan. The main functions of the first entrance are welcoming guests, storing goods, etc. However, as its courtyard space is the necessary place to connect the outside and the inner courtyard, the courtyard has low *RA* value and high CV value, meaning it has good connectivity and is highly integrated.

The second entrance is the place where the host lives, which is located in the center of the siheyuan. The interesting thing is that all rooms in the binary space can only be accessed through the intermediate space. We can see the syntactic value distribution characteristics of the intermediate space corridor (Figure 10). As the number of controlled rooms is different, the connecting spaces on all sides have different values; however, their common characteristics have relatively low *RA* values and high CV values. As the main connecting space, it has strong connectivity and is highly integrated. The rooms also have certain patterns; spaces with poor connectivity are the side room spaces on the left and right sides of the host room, while the toilet and kitchen are next to the wing room with high *RA* value and low CV value, proving that these spaces all need high concealment. From the *MD* value and CV value, we can see that the position of the host room is higher than the wing rooms on both sides with high *MD* value and CV value, indicating that its privacy is higher than the wing rooms. At the same time, its connectivity is also higher than the wing rooms on both sides; therefore, it is a verified fact that the cultural characteristic of "the north room is the most superior and the two wing rooms are the second superior ones".

In the third entrance, this characteristic can be seen from the *MD* value of the room, which has the highest *MD* value and CV value of the whole siheyuan, indicating its deep location, poor connectivity, and high privacy. This space is usually a private room or boudoir, which is the activity space of women or their families, and ordinary people are not allowed to enter at will (Figures 9–11).
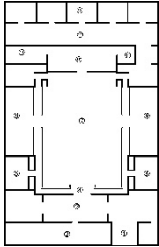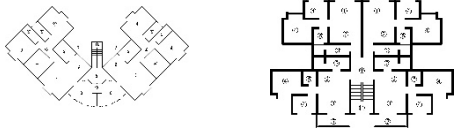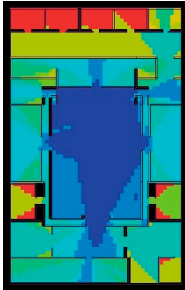
5.3. Discussion

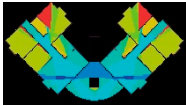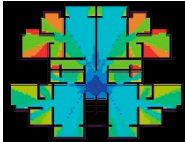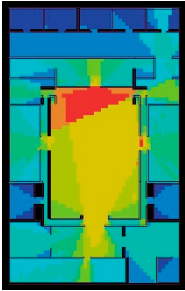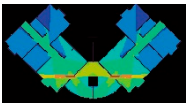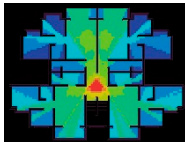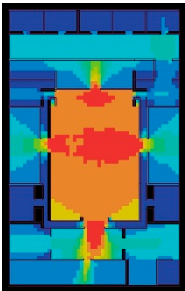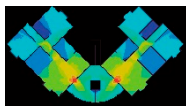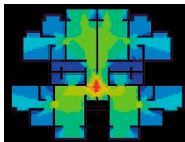The above comments have discussed the traditional Chinese siheyuan in detail according to space syntax. As the basic residential type in China for thousands of years, the courtyard-style residence, the siheyuan, has some valuable spatial characteristics that are difficult for other residential types to realize. However, with the increase of urban population brought about by modern urbanization, the horizontal development based on siheyuan typology can no longer adapt to the growth of modern urban population density. While modern high-rise buildings provide more residents with well-equipped housing, they have lost those traditional space, as well as social and cultural, values.

The following is a survey of the traditional siheyuan and modern apartment houses with two different layouts according to connectivity, integration, and depth indices, as based on visibility graph analysis in the space syntax (Table 2).

Through analysis and comparison with traditional siheyuans, modern residences have the following characteristics:

(1) The entrance and corridor of modern residences have high connectivity and integration, which means that family privacy is gradually declining.
(2) In modern apartment buildings, the highest connectivity in the hall occurs at the door-to-door position of apartment units on the same floor. In other words, when the door is opened, other apartments can see the interior of the house, thus, affecting the privacy of the family.
(3) In the bedrooms of traditional and modern residences, the connectivity and integration index are extremely small, while the depth values are large. However, in modern residences, private space is usually protected only by doors, and if the door is opened, the interior of the space will be displayed. In traditional houses, the entire space is private, because the intermediate space (corridor) separates the courtyard and the interior space to prevent the private space from being directly exposed to other spaces.

Table 2. Traditional siheyuan and Modern houses Visibility graph analysis.

Architecture	Traditional Siheyuan	Modern Houses
Plan Map		
	1. GATE 2. DaoZuoFang 3. FORE COURT 4. CORRIDOR 5. KITCHEN 6. BATHROMM 7. INNER COURT 8. WEST WING 9. EAST WING 10. MAIN ROOM 11. ErFang 12. BACK COURT 13. HouZhaoFang	1. Sitting room 2. Dining room 3. kitchen 4. Bedroom 5. Toilet&Bathroom 6. Hallway 7. balcony 8. House gardens 9. Public corridor 10. The lifts 11. stair
Depth		
integration		
Connectivity		

Contemporary apartment layouts do not produce more social interaction than the traditional siheyuans in terms of family scale, meaning most of the layout is economical in area and reasonable

in function. Although the space functions are perfect, they do not have the function of traditional courtyards. Without a central space, such as a courtyard, people not only lose the outdoor space to contact with nature, they also lose the space for family communication.

6. Conclusions

This study elaborates the concepts and applications of syntactic analysis, as well as the relationship between the syntactic attributes of specific buildings in a specific area and the culture and life of the people in that area. Metaphorically, the concept of space in the space syntax theory can be compared with linguistic concepts. Although language is full of vitality, it will affect the culture of the speaker, and culture will influence the formation of language over time. Without understanding the culture behind language, one cannot fully understand the language. Similarly, the study of space is incomplete, meaning it has not been linked with people's culture and life. Space organization is a function of the form of social solidarity, and different forms of social solidarity are based on society as a space and cross-space system. Through this study, the following conclusions are summarized:

1. The paper calculates the syntax value of each space in the siheyuan through the quantitative method of space syntax. Then it analyses the relationship between the distribution characteristics of the syntax value and the influence of traditional culture on the spatial layout. The analysis indicates that the spatial layout is related to culture, and that the spatial order of any particular area is part of the culture of this area. The spatial relationship between outdoor and indoor space and the intermediary space of the traditional siheyuan is influenced by traditional Chinese culture. Previous studies scarcely seem to connect the spatial form of the siheyuan with social functions of courtyards, cultural concepts and human activities. We should try to inherit the cultural significance of a traditional siheyuan and realize its sustainable development.

2. The results of the analytical comparison between the traditional residence and modern residence shows that privacy in a modern residence is not respected. Although this change may be due to modern lifestyle and new technology, it is necessary to consider briefly the physical and spiritual needs of human beings. Recent centuries show that many such needs have existed in human history. It is necessary to improve the privacy of the modern residence. A comprehensive inspection of this type of building to extract and redefine the concepts lacking in contemporary life will undoubtedly help meet the basic needs of society.

3. The change in the Chinese family structure demands a subsequent change in the housing form, which has implications for new housing designs [38,39]. For example, in siheyuans in Beijing, adult children need additional rooms in the courtyard, which makes the courtyard full of impromptu expansion, and this situation has led to the decline and mass demolition of traditional siheyuans. In order to develop traditional Chinese architectural culture, we must design new houses that consider whether they are culturally sustainable, and whether they are conducive to the traditional cultural expression of residents, according to the aspects of environment, space, society, culture, and behavior, in order to better apply traditional cultural values to modern design and promote the sustainability of cultural heritage.

4. In addition to studying the sustainability of the traditional siheyuan culture from the perspective of space syntax value, the influence of social and cultural aspects, such as historical context, language, folk beliefs, religion, values, norms, customs, ideology, symbols and even the way of daily life on the spatial organization of the traditional siheyuan, can also be explored in future studies. The traditional Chinese siheyuan can be regarded as a successful and sustainable design strategy, thanks to its double functions of privacy and security. In the process of design, space layout and social and cultural backgrounds are carefully considered. They have responded to the most serious environmental challenges and social and cultural needs for a long time. Due to population growth and the changes of cultural values and society, these traditional principles may not apply to contemporary residential design, but some of them still work in residential

design in urban areas with similar environmental and cultural characteristics, thus promoting the sustainable development of traditional culture.

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