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Exploring Characteristics and Patterns of In Situ Space Morphology: Perspective of the Historical and Cultural Canal Settlement

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Abstract: During the development and evolution of settlements, space morphology created unique local cultural features and played an important role in guiding rural planning in the context of new-type urban development. The in situ characteristics of the space morphology of the ancient historical and cultural towns along the Grand Canal of China reflect the prints of the local culture and history over thousands of years and integrate modern life and the cultural memories of the citizens there. Using Yangliuqing Town, a famous historical and cultural town, as an example, this study quantitatively analyzes the in situ characteristics of the space morphology. It applies the UAV 3D model, POI data, actual site measurements, and other data to establish detailed models of the streets and lanes, quantifies the in situ characteristics of the space morphology of the streets and lanes in terms of space organizational characteristics and VGA manifestation, analyzes the influencing factors of the characteristics of in situ space morphology, and proposes guidelines for renewing ancient towns according to the in situ characteristics of space morphology. The research results indicate that ① multidimensional factors influencing the historical development of the research area have been clarified for the three aspects of its status as a canal transport hub, canal settlement industries, and traditional residential courtyards in ancient towns; ② the in situ space morphology of the streets in Yangliuqing Town is reflected in three aspects such as the core guiding and control of historical and cultural resources, the inherent influence of space element layout, and the attractiveness of street space; ③ it extracts the guidelines for the renewal of the ancient towns in terms of the space morphology strategy, the environmental element strategy, the interface attribute strategy, and the business attribute strategy. The research methods and conclusions boast great significance for clarifying the characteristics of the space morphology of the ancient towns along the Grand Canal and improving the practice of preservation there.

Keywords: settlement space morphology; in situ characteristics; the Grand Canal of China; historical and cultural towns; Yangliuqing Town; space syntax

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1. Introduction

Urban morphology is usually referred to as an exploration of the constituent space's morphological elements, such as buildings, streets, development zones, urban blocks, plots, courtyards, etc. [1]. The approaches to urban space morphology mainly remain situated on a platform of the city's physical attributes that are rooted in spatial arrangements, architectural typologies, street networks, and morphological patterns that have constantly molded settlement environments across history [2]. The different qualities of the spaces build every city and its wealth [3]. Urban space and its morphology endows each city with different characteristics and creates a distinctive urban landscape that is the object of investigation in the field of knowledge widely termed urban morphology [4]. Urban conservation has, in many countries, assumed considerable significance within planning,

which has been encouraged by the worldwide role of UNESCO, notably its program of inscribing sites of special historical significance as World Heritage Sites [5]. As a way to improve the sustainability of urban areas, the International Council on Monuments and Sites (ICOMOS) has also been committed to advocating for the active integration of culture and cultural heritage into urban development and has published *Heritage and the Sustainable Development Goals: Policy Guidance for Heritage and Development Actors* to provide planning strategies and policy basis for the sustainable development of cultural heritage [6]. However, since the reform and opening up, especially in the nearly thirty years of rapid urbanization, the weak connection between urban morphology on the one hand and urban conservation on the other is especially evident in China [4]. Due to long-term ignorance of the input into and attention paid to rural areas, numerous settlements along the Grand Canal of China suffer the problems of low awareness of cultural heritage, countryside culture default, historical relics' destruction, and space morphology disconnection.

Taking Tianjin's Grand Canal settlements as an example, a field survey of 44 typical settlements along the Grand Canal Tianjin Section revealed that some residential buildings suffer from problems such as aging and poor maintenance, low satisfaction of the residents, inadequate public facilities for cultural, educational, and medical services, canal water system pollution, and underutilization. The residents generally lack understanding of the historical and cultural value of the Grand Canal. Ineffective preservation and utilization of the historical and cultural heritage space in the canal settlements have led to a diminishing local character [7].

For this reason, it is urgent to conduct a protective investigation, analysis, and conservation of the space morphology of the canal settlements.

International scholars have produced quantities of in-depth research on the space morphology of ancient towns. In terms of street space, they adopted the quantitative street network analytic method to research the network structure, centrality, and scales of the city streets in different historical periods and provided references for the archaeology of the settlements [8]. In terms of the streets in ancient times along the Grand Canal, quantitative analysis of the topological structure of the streets is more common [9]. Some scholars have applied space syntax to analyze the spatial cognition of the historical and cultural streets of the ancient towns along the Grand Canal from the perspective of heritage tourism in a bid to enhance the experience of sustainable heritage tourism [10]. Scholars have also combined space syntax and GIS to analyze the correlation between the space morphology and the overall arrangement of business in cities and towns [11]. Meanwhile, the method of multi-source data analysis was also applied to explore tourists' changing perceptions of scenic spots in the ancient towns. Providing suggestions [12,13] for the improvement of tourism development has also been a hot topic of research in recent years.

Traditional architecture (similar to local architecture) reflects the environmental, cultural, technological, and historical background of specific places. Regarded to be perfectly adapted to the local climate and environment, it reflects all-round wisdom [14]. For instance, the comfort level and the climatic conditions of traditional dwellings have been researched to provide a reference for designing modern local architecture [15,16]. Idham, N.C., from the perspective of nature and society, explores the synchronicity of the local dwellings and the environment in Java and states that architectural sustainability is the result jointly promoted by physics, nature, society, and culture [17]. Some scholars have pointed out that research on traditional architecture in different areas of the world should enhance fundamental research based on the theories and practices relating to the value of the local cultural heritage and preserved ancient architecture [14]. In recent years, some scholars have researched the adaptation of traditional architecture to the natural ecology and the influence of traditional culture and put forth theories and methods on adaptability design [18,19]. Moscatelli, M. adopted qualitative methods to research the traditional architectural language in Najd, Saudi Arabia, and provided guidance and standards for local architecture design [20]. Kamelnia, H. et al. researched the paradigms of community buildings in modern architecture in Iran and brought forward the idea that the combination

of traditional architectural elements and the environment and the use of natural light were important reasons for the formation of Iranian architecture and generated sound influence on the application of typology in the course of design [21]. Some scholars, on the basis of the neural network method, adopted 3D models and simulation experiments to conduct visual analyses of the decorative art of ancient architecture [22].

The research on the canal settlement space focuses more on the ecological environment [23,24], status survey [7], space evolution [25], space distribution [26], and the protection strategy of these settlements. For instance, the research on the coupling and coordinated relations between urbanization and habitat quality along the Grand Canal of China accelerates regional ecological environmental improvement and sustainable urban development [27]. In researching the ancient towns along the Grand Canal, numerous scholars have conducted extensive investigations and research on the ancient towns along the Grand Canal in the regions south of the Yangtze River [28,29], the ancient towns along the Grand Canal in northern Suzhou [30,31], the ancient towns along the Grand Canal in eastern Zhejiang [32], and the ancient towns along the Grand Canal in Shandong [33] and conducted in-depth research on the cultural heritage distribution law, street investigation, and space morphology characteristics. Scholars have reviewed and researched the vitality of the riverside space in the ancient city of Suzhou and put forth guidelines for riverside space design and implementation in the city [34]. Additionally, some scholars conducted quantitative analyses of the space distribution pattern of the intangible cultural heritage along the Grand Canal of China and provided references for the planning of renewal and utilization of the intangible cultural resources along the Grand Canal [35].

As an important portal to the capital city and the hub of combined transportation of river and sea, the Grand Canal Tianjin Section boasts great value in conservation and research. The Grand Canal of China, boasting a history of more than 1000 years, has formed the characteristic traditional settlement space. At present, in the Grand Canal Tianjin Section, the settlements reserving a more complete holistic space pattern are mostly in Jinghai District and Wuqing District in the exurbs. Nonetheless, only a small amount of original settlements have been protected in the form of characteristic village renovation in Xiqing District and Beichen District, which boast a great number of settlements along the Grand Canal, while other settlements have mostly not been protected in time. The in situ characteristics badly need excavation, conservation, and inheritance [36]. Above all, using the typical blocks in Yangliuqing Town, a nationally famous historical and cultural town along the Grand Canal Tianjin Section, as an example, this study adopts multivariate data and reveals the characteristics and patterns of the in situ space morphology of the street space in the ancient towns along the Grand Canal. The study is aimed at solving the deficiency of local characteristics of the canal settlements and playing a guiding and referential role in settlement planning and renewal under the background of new-type urbanization.

2. Data Source and Methods

2.1. Overview

Yangliuqing Town is a settlement along the Grand Canal Tianjin Section boasting a long history of about 1000 years. It dates back to the Song Dynasty when troops were stationed, wharves were built, and settlements were formed there. “Liukou Town” was set in the Jin Dynasty (AD 1214). At that time, Emperor Qianlong of the Qing Dynasty took a boat to the regions south of the Yangtze River, saw the green embankments and willows, and named the place “Yangliuqing” (meaning “green willows”). After the capital was founded in Beijing in the Ming Dynasty, Yangliuqing Town, increasingly prospering thanks to canal transport, gradually became a pivotal town of commercial and cultural exchanges in northern China [37]. In 2008, Yangliuqing Town was approved by the State Council to be one of the fourth group of famous Chinese historical and cultural towns. Yangliuqing Town is a typical northern settlement along the Grand Canal, housing many extant cultural relic protection units such as Family Shi’s Mansion, Family An’s Mansion, Family Dong’s

Mansion, and Family An's Ancestral Hall. The pattern of the canal watercourse is well-kept and the space relations between the watercourse and the ancient town remain today. As a key part of the Grand Canal in northern China, Yangliuqing settlement and its historical blocks shoulder the historical responsibilities of passing on cultural spirits, integrating the ancient and modern architectural styles, inheriting the culture, and displaying the cultural charm of the ancient towns along the Grand Canal in the new period.

The survey area lies in the south of Yangliuqing Town, bordering on the northern bank of the Grand Canal, which is the cradle of Yangliuqing Town from the earliest time. It houses traditional courtyards like Family Shi's Mansion, traditional residential blocks, traditional commercial blocks, modern commercial blocks, and parking lots, covering almost all the types of land use in the space and boasting strong typicality and representativeness among the canal settlements in northern China (Figure 1).

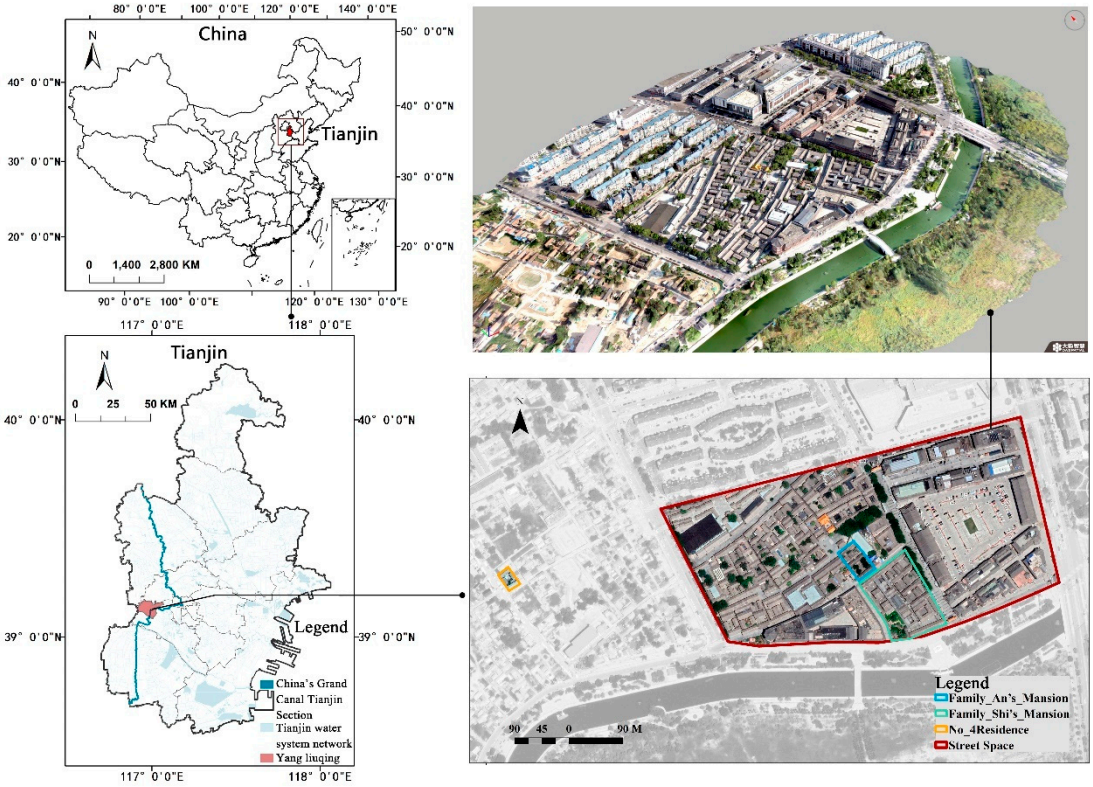

Figure 1. Scope of the research area.

2.1.1. Multidimensional Analysis of the Historical Development of the Research Area

The Space Morphology of the Ancient Town: Direct Influence of the Status as a Canal Transport Hub

The space morphology of the research area is directly related to its status as a canal transport hub. Yangliuqing Town, originally a military stronghold in the Song Dynasty, was developed by the imperial court in the Tangluo area for military farming and stationed troops, settling the soldiers and their accompanying families to open up the wasteland. With the rising demand for canal transport during the Yuan Dynasty, Tianjin became a pivotal transfer station for grain transporting, and Yangliuqing Town also became a transshipment point for inland canal transporting, further developing the settlements there. By the Ming and Qing Dynasties, it had developed into a crucial hub of canal transport and became a hub of commerce, trade, and cultural exchange in northern China. The prosperity of commerce won Yangliuqing Town the reputation as the "Lesser Jiangnan in North China" and "Lesser Yangzhou in North China" (Figure 2). Analysis of the space morphology of the streets in Yangliuqing Town revealed that the main streets, Guyi Street,

Ruyi Street, and Zhushi Street are parallel to the river, while Renyi Lane, Caojia Lane, Hepingshi Lane, and Qiaojiageda Lane are perpendicular to the canal. The traditional street distribution pattern is very typical in the canal settlement space, designed primarily to facilitate canal transport. As an important historical transportation and logistics channel, the canal-side settlement space morphology tends to reflect the need for transportation development along the canal. In this pattern, the streets and lanes in the settlements are mostly arranged parallel to the canal or in a gridlike, belt-like, or radial structure at specific angles. The space pattern facilitates docking, loading, unloading, and transshipment of goods. Additionally, the streets and lanes in Yangliuqing Town are mostly more than 4 m wide, indicating the consideration for drainage, fire prevention, and other practical needs. To sum up, the space morphology of Yangliuqing Town is directly related to its status as a canal transport hub. With its spatial distribution pattern adapted to canal transport needs, it is a typical manifestation of meeting the daily needs of the residents, not merely reflecting the wisdom and craftsmanship of ancient urban planning but also providing important references for the current protection of the cultural heritage of the canal.

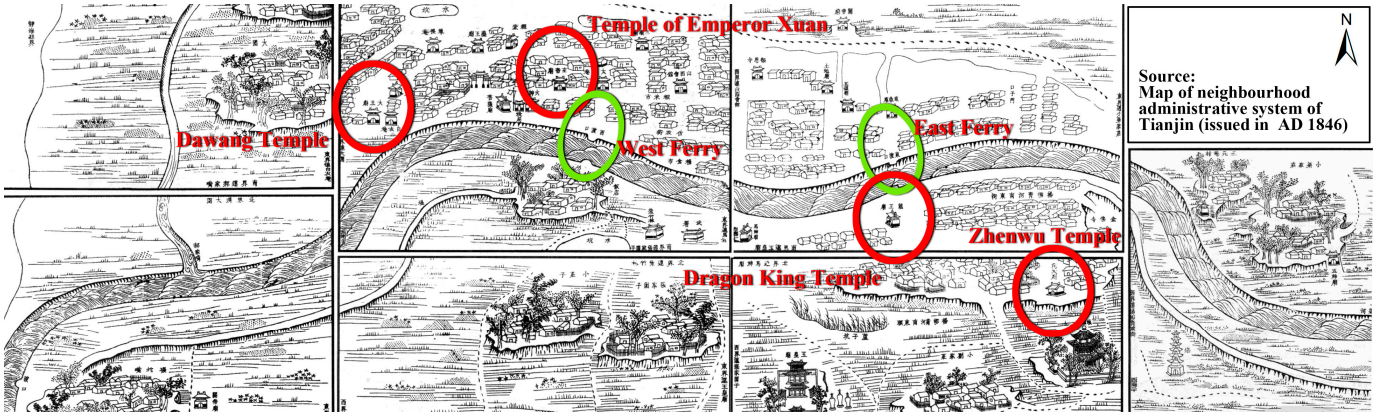

Figure 2. Yangliuqing Town in Illustrated Charts of Administrative Divisions of Tianjin.

Trajectory of Canal Evolution: Interaction between the Rise and Fall of Industries and Space Morphology in Canal Settlements

The evolution of the canal caused the rise and fall of industries and was materialized in the space morphology in the study area. The historical evolution of Yangliuqing experienced its initial stage during the Song and Yuan Dynasties, a prosperous stage during the Ming and Qing Dynasties, a transitional stage from the late Qing Dynasty to the Republic of China, and a transformational development stage in modern times [38] (Figure 3). In the Song and Yuan Dynasties, the overall pattern of Yangliuqing Town was characterized by canal-side development. Based on traditional square-shaped farmland, the settlement expanded along terrace-like embankments, with commercial activities dispersing along the canal. The industries in the initial stage primarily featured sporadic itinerant trade and handicraft, chiefly serving the stationed troops, mostly in the form of "selling reeds" and "selling fish", showing a parallel or perpendicular relationship with the canal and reflecting the characteristics of traditional street markets. In the prosperous stage, Yangliuqing Town saw further development with the completion of the Grand Canal [39]. As recorded in the Illustrated Charts of Administrative Divisions of Tianjin, "Yangliuqing Town is a large village in the southwest [40]". With the rise of canal transport, Yangliuqing's industrial and commercial sectors developed fast, and Yangliuqing Town became a typical urban settlement along the canal. It had ferry terminals, wharves, facilities, temples, and post stations that ensured canal transport and became a gathering place for traders. The market, hence, prospered there. The long-term practice of canal transportation cultivated the pioneering spirit of Yangliuqing's people, fostering advanced business management concepts and producing a group of commercial elites represented by Shi Yuanshi and An Wenzhong. They settled in Yangliuqing, building distinctive traditional dwellings. Meanwhile, intersections

or nodes in street and lane spaces often became marketplaces and wharves, forming commercial centers that further promoted the economic prosperity of the settlements. During the late Qing Dynasty and the Republic of China, wars and the siltation of waterways led to a decline in canal transport, and with the rise of modern railways, traditional canal shipping was replaced. The establishment of the Yangliuqing Railway Station promoted the development of transportation and shipping, forming commercial roads perpendicular to the canal and adding administrative facilities such as guild halls and government offices. Since modern times, the accelerated urbanization process of Yangliuqing has led to the disappearance of many historical buildings and cultural relics. Among the 28 historical and cultural resources studied in the area, 25 are scattered west of Qingyuan Road.

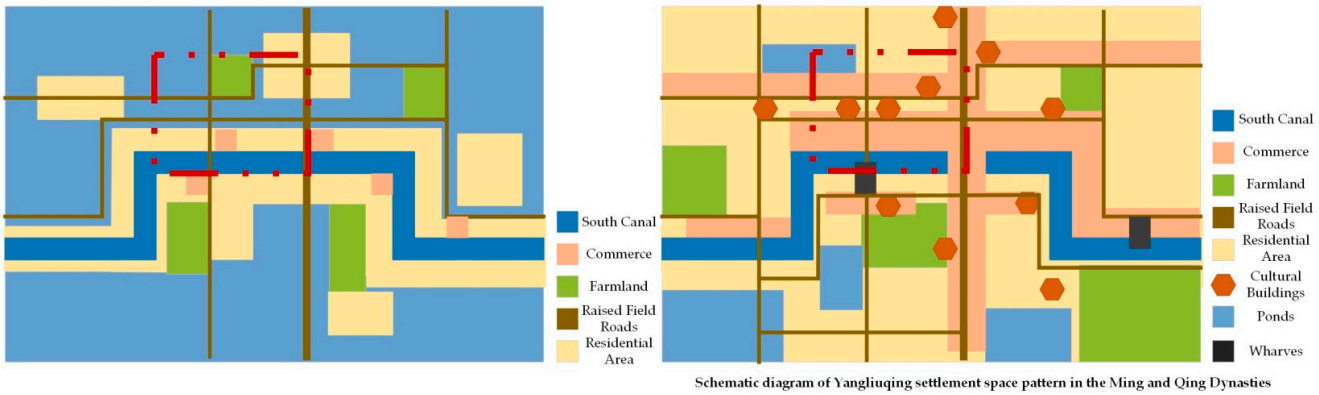

Figure 3. Horizontal schematic diagram of Yangliuqing settlement space in the Song and Yuan Dynasties. Schematic diagram of Yangliuqing settlement space patterns during the Song, Yuan, Ming, and Qing Dynasties [38].

Treasures in Ancient Canal Towns: Representative Remains of Traditional Residential Courtyards in Northern China

The residential courtyards in the research area are important representative remains of traditional dwelling houses in northern China. The Tianjin canal settlements boast a large number of ancient city relics, architectural courtyards, and tomb stone carvings. These important material and cultural relics witness the historical changes of canal transporting and the prosperity of early settlers in the settlements of Tianjin. A large number of exquisite, intact traditional architectural courtyards are mainly concentrated in organized towns such as Hexiwu Town, Shuangkou Town, Duliu Town, and Yangliuqing Town, while cultural relics such as tomb stone carvings are scattered throughout ordinary administrative village settlements [41]. The layout of the courtyards of traditional residences along the Grand Canal Tianjin Section generally displays the characteristics of quadrangle courtyards in North China. The courtyard layout changes with the areas where the canal flows. For instance, the residential courtyards of small families in the exurbs are chiefly triple courtyards, while the typical residences of large families in close suburban settlements boast the general characteristics of the quadrangle courtyard system, generally called the "quadrangle courtyard suite". The layout and shape of the quadrangle courtyard suite have the following in situ characteristics. First, the location of the gate is more flexible and diverse than the "northwest-facing gate to southeast-facing residence" in the quadrangle courtyard. Influenced by the direction of the street, the gate is either northwest-facing or north-facing. Second, the principal building is in the center of the shape and structure in a square, closed courtyard; importance is given to the practical function of the courtyard, and there is no veranda or second gate in small houses. Third, influenced by the residences in South China, the residential courtyards in large quadrangle courtyard suites have tandem and parallel types of transportation. Linking several courtyards, the arrow path can separately set out-facing auxiliary entrances so that the internal and external bypasses are clearer [42].

On the northern bank of the South Grand Canal of Yangliuqing Town, Family Shi's Mansion was the residence of Shi Yuanshi (Figure 4). Built in the Qing Dynasty, it has a history of more than 200 years. In the typical side yard distribution of 3 yards and 5 rows in each compound, the courtyard comprises 18 yards and more than 200 rooms. The whole side yard is designed to have three entrances: the northern entrance to receive distinguished guests, the southern two for the entrance of vehicles and horses from the east, and the entrance of family members from the west. The whole courtyard is low in the south and high in the north, having a discrepancy in elevation of 2 m in the south and the north. Two axes in the courtyard link the north and the south. The northern entrance faces the arrow path and links the eastern and western yards. The corridor in the western side yard stretches up to 100 m and links the yards on both sides. The eastern side is composed of three quadrangle courtyards. Drama stages, the Hall of Longevity, and Buddha Hall are on the western side, linked with a small side yard for the servants to live in (Figure 4).

Figure 4. Aerial photo and characteristic space of typical traditional residences along the Grand Canal.

Family An's Mansion to the north of Family Shi's Mansion used to be the residence of merchant An Wenzhong in the Qing Dynasty, and the courtyard features the largest individual building and highest architectural foundation in Yangliuqing Town. The courtyard comprises two-row quadrangle courtyard suites with 32 rooms in total and an underground gold treasury (Figure 4). As the first person "migrating with the camp" in Yangliuqing Town, An Wenzhong began to migrate with the troops at 16 and supplied daily necessities for the officers and men. He mobilized the businessmen to migrate, established the trade route between the South Grand Canal and the IIi River, and promoted economic prosperity and national unity.

No. 4 Residence of East Yaowangmiao Street is a typical residential quadrangle courtyard of the Qing Dynasty. Originally Dai Encheng's "Daijia Bank", it was used as the Headquarters of the Pingjin Battle in the period of the Liberation War and is the Pingjin Battle Frontline Memorial Hall now. Of small size, the courtyard is composed of northwest-

facing gates, screen walls, and a second gate leading to the main court, with the principal building and wing rooms totaling 16 rooms (Figure 4).

To conclude, these typical traditional residential courtyards collectively showcase the local characteristics of typical northern settlements along the Grand Canal. As an important node along the northern section of the Grand Canal in China, the Yangliuqing Town settlement and its historic districts shoulder the historical responsibility of cultural transmission, with culture as its carrier. It serves as a distinctive public space that integrates the past and present, inherits culture, and demonstrates the significant role of showcasing the cultural charm of the ancient canal towns in the new era.

2.2. Data Sources and Research Design of Street Space

Street space is the most intuitive element in the local space morphology of the ancient towns, serving as the material carrier that reflects and inherits the canal culture and integrates the social culture, norms, and customs. As a theory analyzing the relationship between space and the social logic it carries, space syntax provides a new perspective for in-depth analysis of the forms, structures, functions, and underlying cultural logic of street space [43,44]. The street space data include satellite images, POI data, UAV 3D modeling data, site CAD data, and fieldwork photo data. The street space morphology data mainly comprise street space data, space organization characteristics data, and site VGA analysis data, with the specific research design as follows (Figure 5). ① Apply ArcGIS 10.2 to draw the location map of the street space in ancient Yangliuqing Town and the graph of POI resource distribution. ② Draw the maps of street space and business type distribution, cultural resources distribution, facility for vegetation distribution, main space scale and facility distribution, and main street space morphology and D/H analysis according to the UAV 3D modeling data and CAD data-based Sketchup 3D model. ③ Apply the Dethmap 10 software of space syntax to draw the VGA graph of the street space, conduct a quantitative analysis of the visual integration degree, the visual control degree, and the visual clustering coefficient of the street space, and analyze the in situ characteristics and laws of the street space through the Exosomatic Visual Agent System and vision depth analysis.

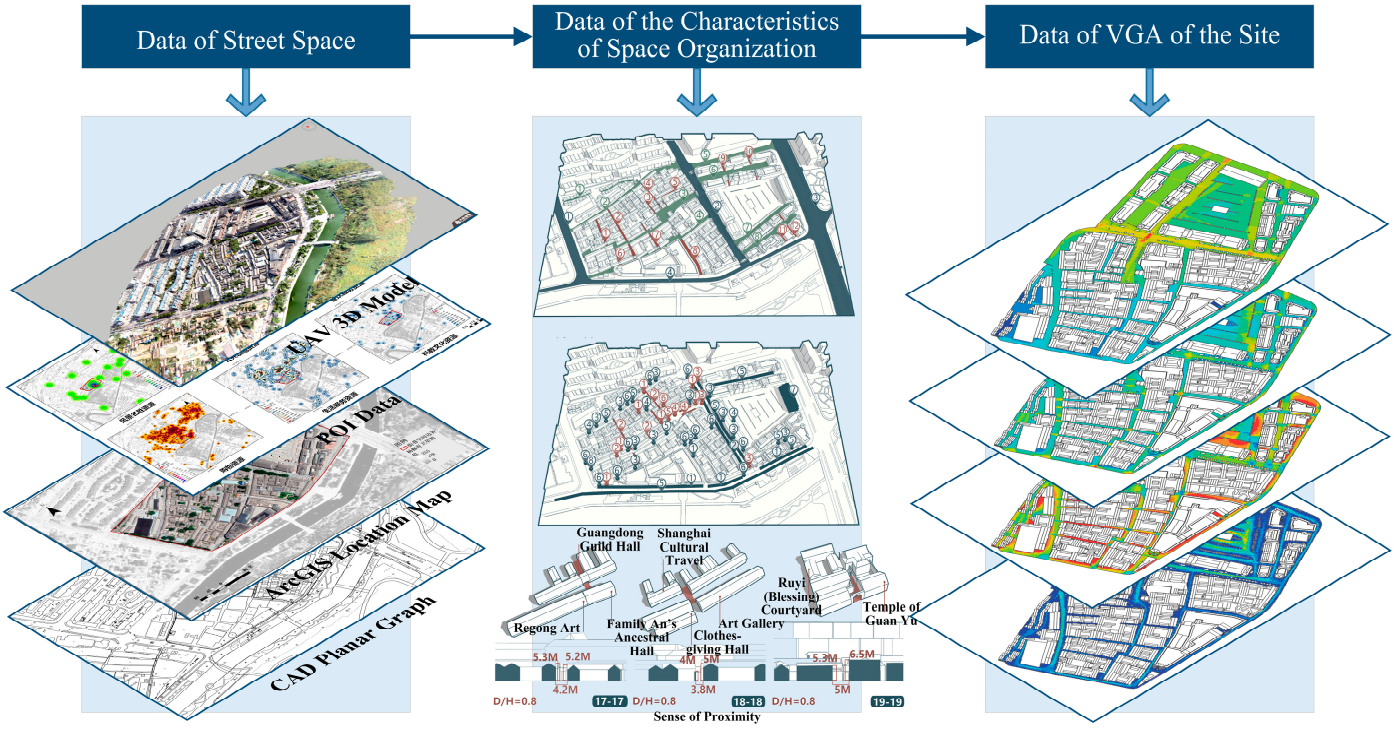

Figure 5. Handling of data of street space morphology.

2.3. Research Methods

The syntax model was established to conduct a meticulous quantitative analysis of the streets and architectural spaces of the canal settlements and analyze the characteristics of the space structure in a bid to scientifically evaluate and analyze the current status and in situ characteristics of the traditional residences and provide a potent basis for extracting the characteristics of the traditional residences and the protection and renewal of the residences.

The syntax model commonly used to analyze the internal space of architecture is the graphic method of relations and convex space analysis. The physical architectural space is expressed with nodes, the space relation is replaced by line segments, and the J-shape model is formed to quantify space relations. Convex space analysis describes the real space environment by establishing a topological space model to conduct a quantitative analysis of space relations. Turner et al. brought forth VGA and agent analysis on the basis of space syntax [45,46]. The visual model analyzes the dot-based visual relations and obtains all-round, comprehensive research conclusions on the basis of the computing background of big data. This study chiefly conducts a quantitative analysis of the in situ characteristics of the traditional residential space along the Grand Canal through the J-shape relation graph, the convex space model, the visual model, and the agent analysis model of space syntax.

By establishing a space syntax model, this study conducts a detailed quantitative analysis of the local space morphology of the canal settlements, deciphers the structural characteristics of the space, and scientifically evaluates and analyzes the space patterns and in situ characteristics, thus providing a strong basis for extracting and protecting the characteristics of the space in the canal settlements. Turner et al. proposed the VGA based on space syntax and the agent analysis method [45,46]. VGA analyzes the point-based vision relationship. The computing background on the basis of big data can effectively analyze the most accessible and most popular area in the space and obtain comprehensive research conclusions. The study employed the VGA analysis method of space syntax to research the street space of Yangliuqing Town and quantitatively analyze the visual integration degree, the visual control degree, and the visual clustering coefficient to reveal the potential core and the richness of the street space. It can simulate the travel patterns of people in the street space through agent analysis and further reveal the complexity and readability of the space from the angle of intelligibility.

(1) The Mean Depth (MD_i): The depth value is the shortest route from a specific node to other spaces; the mean depth represents the mean value of the sums of the topological distance from a specific node to all other spaces. The formula is:

$$MD_i = \sum_{j=1, j\neq i}^{n} d_{ij}/(n-1) \quad (1)$$

In the formula, d_{ij} represents the topological distance (step length) from node i to node j.

(2) The integration degree (I_i): The integration degree standardizes the mean depth value MD_i and removes the influence of the amount n of system nodes on MD_i. The formulas are below:

$$RA_i = 2(MD_i - 1)/(n-2) \quad (2)$$

$$D_n = 2\left\{n\left[log_2\left(\frac{n+2}{3}\right) - 1\right] + 1\right\}/(n-1)(n-2) \quad (3)$$

$$RRA_i = RA_i/D_n \quad (4)$$

$$I_i = 1/RRA_i \quad (5)$$

In the formulas, RA_i is the result of the first standardization of MD_i, D_n is the parameter of standardization and is the result of the second standardization by using D_n.

(3) Visual Integration: Calculate the visual distance from all space nodes to other nodes to show the gathering or discrete state of the viewpoints. The visual integration

represents the potential core in the layout in which most layouts can be easily seen. High visual integration represents strong accessibility to space.

(4) Visual clustering coefficient: This represents the degree of sheltering of the scope of vision in the space. It is the ratio of the number of connections of the visible space in sight and that of all the possible connections of the space. The value range of the visual clustering coefficient is 0–1. The space with a value close to 1 features high visibility rates and low sheltering degrees and tends to be a convex space.

(5) Visual Control: This represents the degree of visual control of a single space in the whole space. On the basis of controlling an individual space node, total up the control degree of all the nodes in the scope of an individual space. The ratio of the total and the individual space is the visual control.

(6) Exosomatic Visual Agent System: This is an AI-based visual space analysis technology that can simulate the law of "natural traveling" under the visual guidance of humans in limited space and form the behavior distribution trajectory to quantify the scope of crowd clustering in the space.

(7) Intelligibility represents the correlation between the whole connectivity of the space and the overall integration. The high value of intelligibility represents a higher degree of understanding the overall space from the local space.

3. Results

From the dimensions of the settlement's streets, the traditional residential courtyards, and the individual residential architectures, this study quantitatively analyzed the in situ space characteristics and morphology of the research area, specifically including the in situ characteristics of the street space morphology in the research area and the in situ characteristics of the residential courtyards.

3.1. The In Situ Characteristics of the Street Space Morphology

The in situ characteristics of the street space morphology of the research area include the in situ characteristics of the street space organization, the street space vision, and the street space.

3.1.1. The In Situ Characteristics of Street Space

Basic Characteristics of Street Space

The structure of street space in the research area comprises roads, streets, and lanes (Figure 6). The roads include Qingzhi Road in the west, Qingyuan Road in the middle, Liukou Road in the east, and Yuhe Road in the south; there are eight streets, namely, Zhushi Street, Ruyi Street, Guyi Street, Zunmei Street, Qiandajie Street, New Year Picture Street, and Mingqing Street. The lanes primarily comprise 12 lanes such as Renyi Lane, Caojia Lane, Hepingshi Lane, Qiaojia Geda Lane, Yongxing Liheng Lane, Shiyiju Lane, Renpingshi Lane, and Chuanxin Tangzi Lane. The business types in the blocks chiefly involve food, life services, lodging, cultural education, entertainment, and shopping.

The research area features abundant cultural resources of street space. The tangible resources include Family Shi's Mansion, Family An' Mansion, Family An's Ancestral Hall, Family Dong's Mansion, the Family Dong School, the Temple of Guan Yu, and theatrical stages. The intangible cultural resources include various resources such as the Yangliuqing Cultural Center, Yucheng New Year Picture Shop, Huoqingshun New Year Picture Shop, and Yangliuqing Tile Carving (Figure 7). The street facilities include service facilities and cultural facilities. The former refers to benches, vending vehicles, dustbins, lighting facilities, and guiding signs. Landscape facilities include elements such as sculptures, tile carvings, and ground surface reliefs. The street vegetation is simple. The arbors include willows, pagoda trees, ginkgo, mulberries, and jujube trees. The shrubs include Euonymus japonicus and hibiscus (Figure 8).

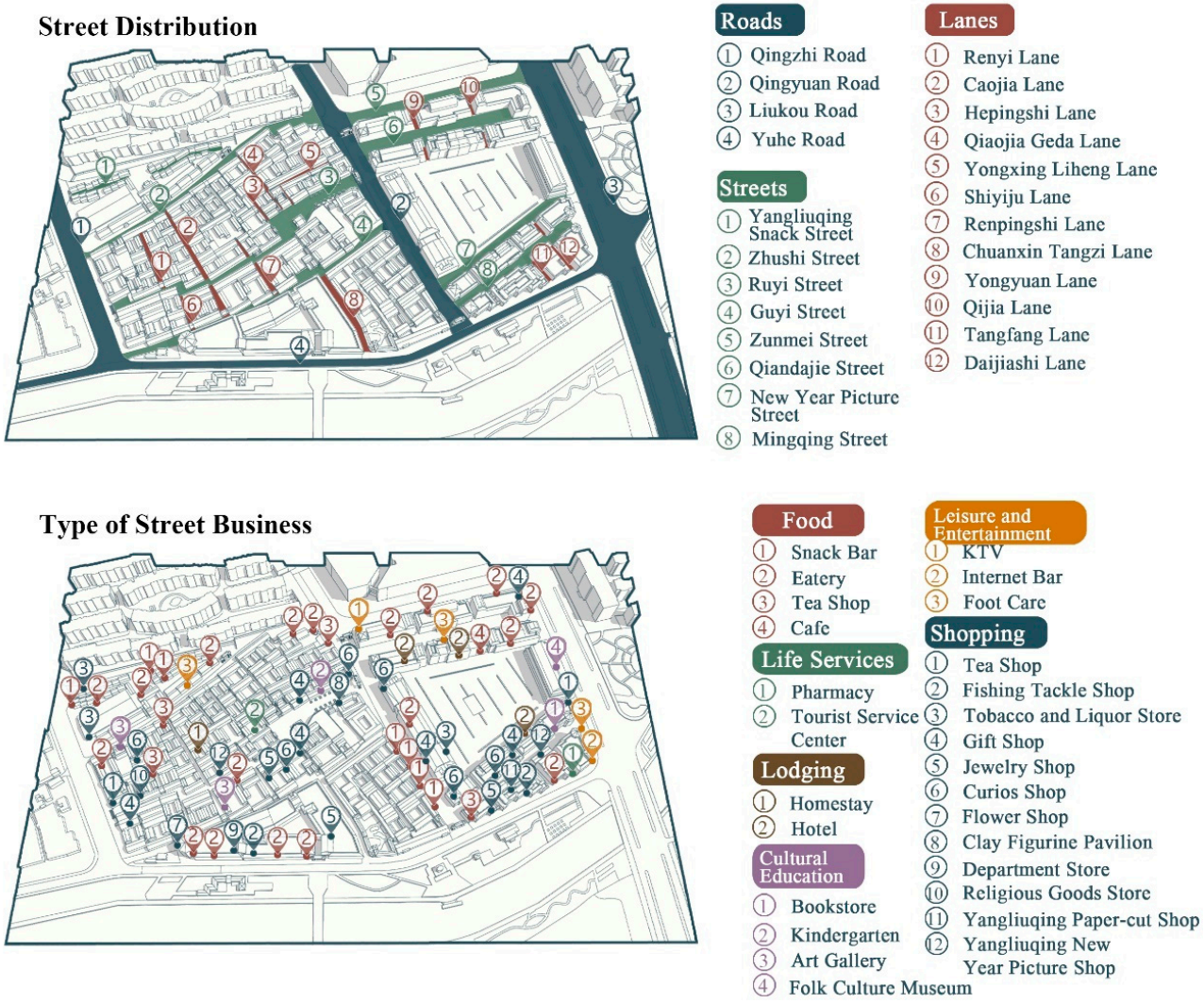

Figure 6. Distribution graph of streets and business types.

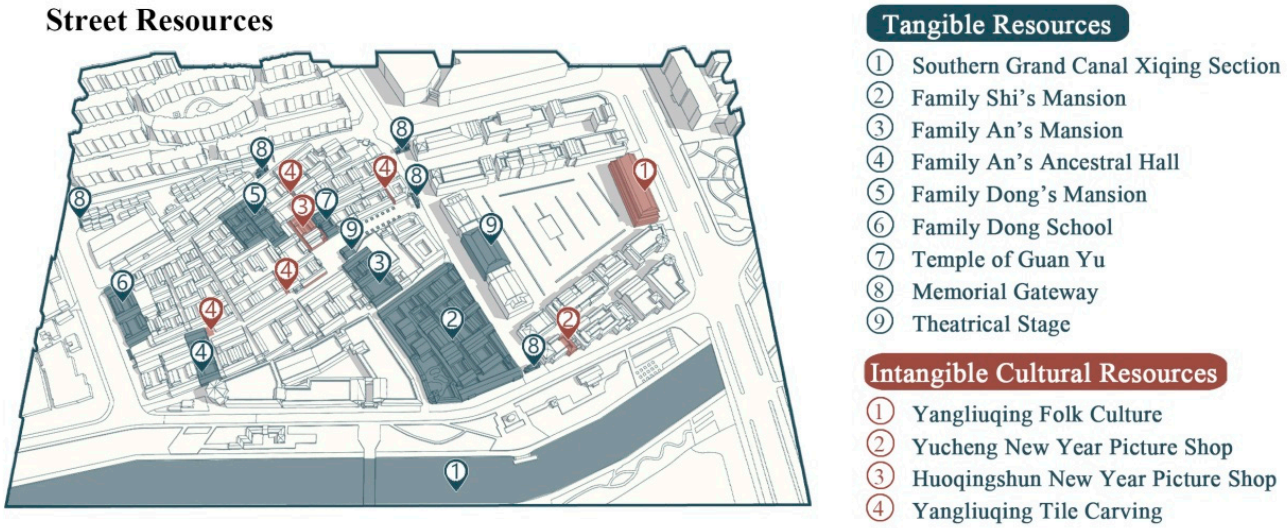

Figure 7. Distribution graph of cultural resources in the streets.

Figure 8. Distribution graph of street facilities–vegetation.

Four kinds of elements, the space morphology, the environmental elements, the interface attributes, and the business attributes, were extracted through the statistics of the basic characteristics of the street space in the research area as the space factors of the in situ characteristics of the street space. The space morphology includes street junctions, space widening, space narrowing, space zigzagging, and irregularity. The environmental elements include vegetation, water bodies, archways, pavilions, corridor and wall structures, benches, and stone benches as well as sculptures. The interface attributes include residential courtyards, temples, archways, theatrical stages, and commercial buildings. The businesses involve food, life services, cultural education, leisure and entertainment, and shopping.

Structural Characteristics of Street Space

Taking Qingyuan Road, Ruyi Street, Guyi Street and the surrounding lanes in the research area as the focus to analyze the streets, Figure 9 shows the scale of street space and facility distribution. In terms of the length of the streets, Ruyi Street stretches 280 m, Guyi Street is 260 m in the east–west direction, Qingyuan Road is 220 m, Caojia Lane and Qiaojia Geda Lane are 125 m, and Renpingshi Lane is 48 m in the north–south direction. As

to facility distribution, the largest number of vending facilities are on Qingyuan Road at the main entrance. The most leisure facilities are in Ruyi Street and the tile carvings are the most abundant in the lanes surrounding Ruyi Street.

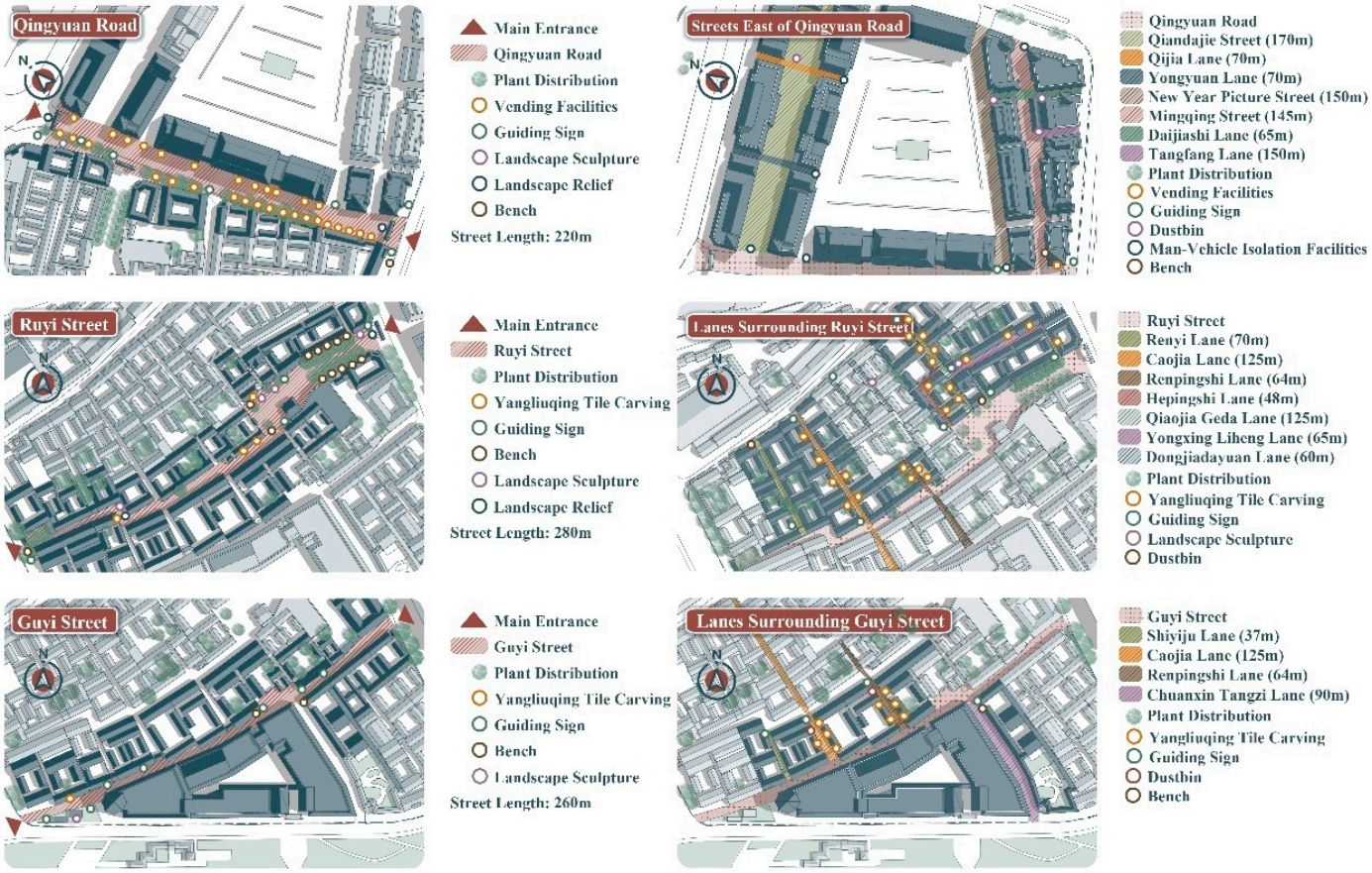

Figure 9. Graph of street space scale and facility distribution.

Seen from the space pattern of Qingyuan Road (Figure 10), the street is perpendicular to the canal, wide at the north and narrow at the south. The road is 22 m at the widest and 18 m at the narrowest. As to the components of the street space, cross-section 1-1 indicates that the main functions of the street from west to east are, respectively, "junction–courtyard–bench–archway–commerce–food–shopping". Similarly, 2-2 indicates the functions of "junction–courtyard–theatre–vegetation–commerce–food", 3-3—"junction–widening–vegetation–bench–commerce–shopping", and 4-4—"junction–widening–vegetation–bench–archway–commerce–shopping". According to the D/H ratio calculated from the four cross-section diagrams from Site 1 to Site 4, the ratio focuses between 0.8 and 1.5, indicating that the space perception of the road is generally comfortable. Ruyi Street is narrow in the west and wide in the east, boasting diverse space variation and a concave shape on the whole, 2.6 m at the narrowest and 29.8 m at the widest. As to the components of street space, cross-section 5-5 indicates that the main functions of the street from north to south are, respectively, "widening–irregularity–temple–door–theatre–bench–commerce–culture–shopping". Similarly, 6-6 indicates the functions of "junction–widening–courtyard–theatre–vegetation–commerce–life–food", 7-7—"junction–widening–door–bench–sculpture–commerce–residence–shopping", and 8-8—"junction–narrowing–plant–commerce–food–shopping". The D/H ratio calculated from the graphs of the four cross-sections from Site 5 to Site 8 indicates that the ratios change drastically. The D/H ratio of the narrowest street in the west is 0.4; a sense of oppression can be felt in the space. The D/H ratio in the central square is 4.4. It is spacious, generating a sense of estrangement. As to the space pattern of Guyi Street, it horizontally stretches

along the canal in the "—" shape, 5 m at the narrowest and 12 m at the widest. As to the components of the street space, cross-section 9-9 indicates that the main functions of the street from north to south are, respectively, "narrowing–vegetation–courtyard"; similarly, 10-10—"junction–widening–courtyard–vegetation–commerce–shopping", 11-11—"narrowing–door–courtyard–culture–food–shopping", and 12-12—"junction–irregularity–vegetation–courtyard–commerce–food–shopping". As to the D/H ratio calculated from the graphs of the four cross-sections from Site 9 to Site 12, the value of D/H at 11-11 is 0.5, the smallest, with an oppressive sense of space, and 0.9–1.2 in other sections, with a comfortable sense of space.

Figure 11 shows the morphology and D/H analysis of main streets and lanes. The streets east of Qingyuan Road include Qiandajie Street, New Year Picture Street, Mingqing Street, Yongyuan Lane, Qijia Lane, Daijiashi Lane, and Tangfang Lane. The whole space displays the layout of the horizontal and perpendicular network of streets in the east–west direction and lanes in the north–south direction. As to the components of the street space, cross-section 13-13 indicates that the main functions of the street from north to south are, respectively, "life–commerce–culture–shopping"; similarly, 14-14—"junction–commerce–culture–entertainment–shopping", 15-15—"junction–widening–commerce–food–shopping", and 16-16—"junction–commerce–food–lodging–entertainment". According to the D/H ratio calculated from the four cross-sections from Site 13 to Site 16, the value of Mingqing Street is 0.5, generating a good sense of space and proximity. The value of Daijiashi Lane is 0.3, and that of Yongyuan Lane is 0.2, where the narrow space generates a sense of oppression; that of Qiandajie Street is 1.5, and the space is open and comfortable. The lanes surrounding Ruyi Street include Yongxing Liheng Lane, Qiaojia Geda Lane, Hepingshi Lane, Renpingshi Lane, Caojia Lane, and Renyi Lane. Yongxing Liheng Lane is horizontal to the canal, while other lanes are perpendicular to the canal. As to the components of the street space, cross-section 17-17 indicates that the main functions of the street from west to east are, respectively, "junction–vegetation–courtyard–commerce–food–culture–shopping"; similarly, 18-18—"junction–courtyard–vegetation–food–lodging–shopping", 19-19—"junction–vegetation–sculpture–courtyard–temple–commerce–shopping", and 20-20—"sculpture–courtyard–food–culture–shopping". According to the D/H ratio calculated from the four cross-sections from Site 17 to Site 20, the value of the lanes is all 0.8, where the space generates a sense of comfort and proximity. The lanes surrounding Guyi Street include Chuanxin Tangzi Lane, Renpingshi Lane, Caojia Lane, and Shiyiju Lane perpendicular to the canal. As to the components of the street space, cross-section 21-21 indicates that the main functions of the street from west to east are, respectively, "junction–door–sculpture–courtyard–commerce–culture–shopping"; similarly, 22-22—"junction–courtyard–commerce–food–shopping", 23-23—"junction–widening–vegetation–courtyard–commerce–shopping", and 24-24—"junction–commerce–culture–shopping". According to the D/H ratio calculated from the four cross-sections from Site 21 to Site 24, the value of both Shiyiju Lane and Renpingshi Lane is 0.8, where the space generates a sense of comfort. The value of Chuanxin Tangzi Lane is 0.7, where the space generates a sense of comfort. The D/H value of Wuming Lane beside Family An's Mansion is 0.3, where the narrow space generates a sense of oppression.

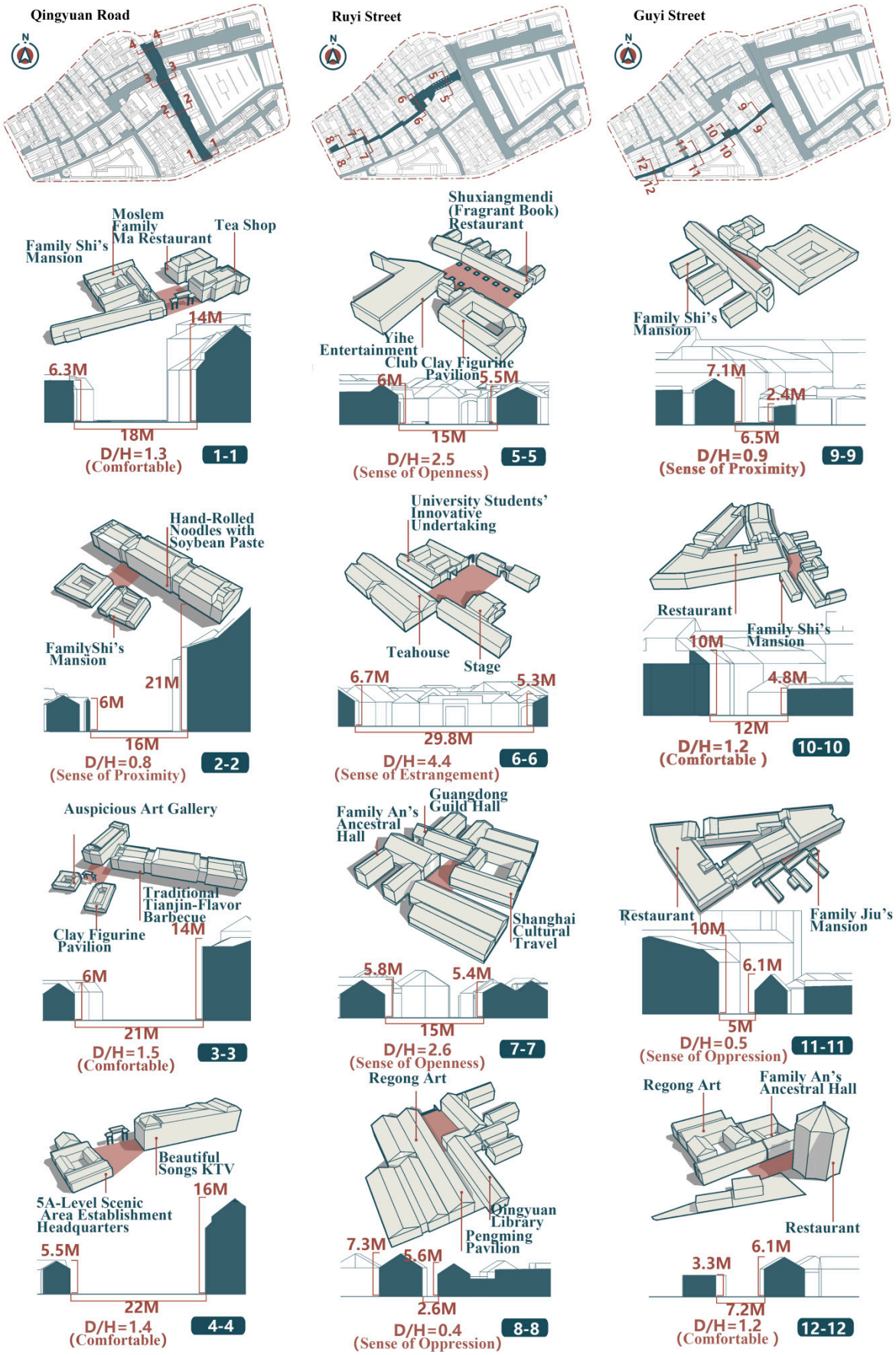

Figure 10. Graph of space pattern of main streets and D/H analysis.

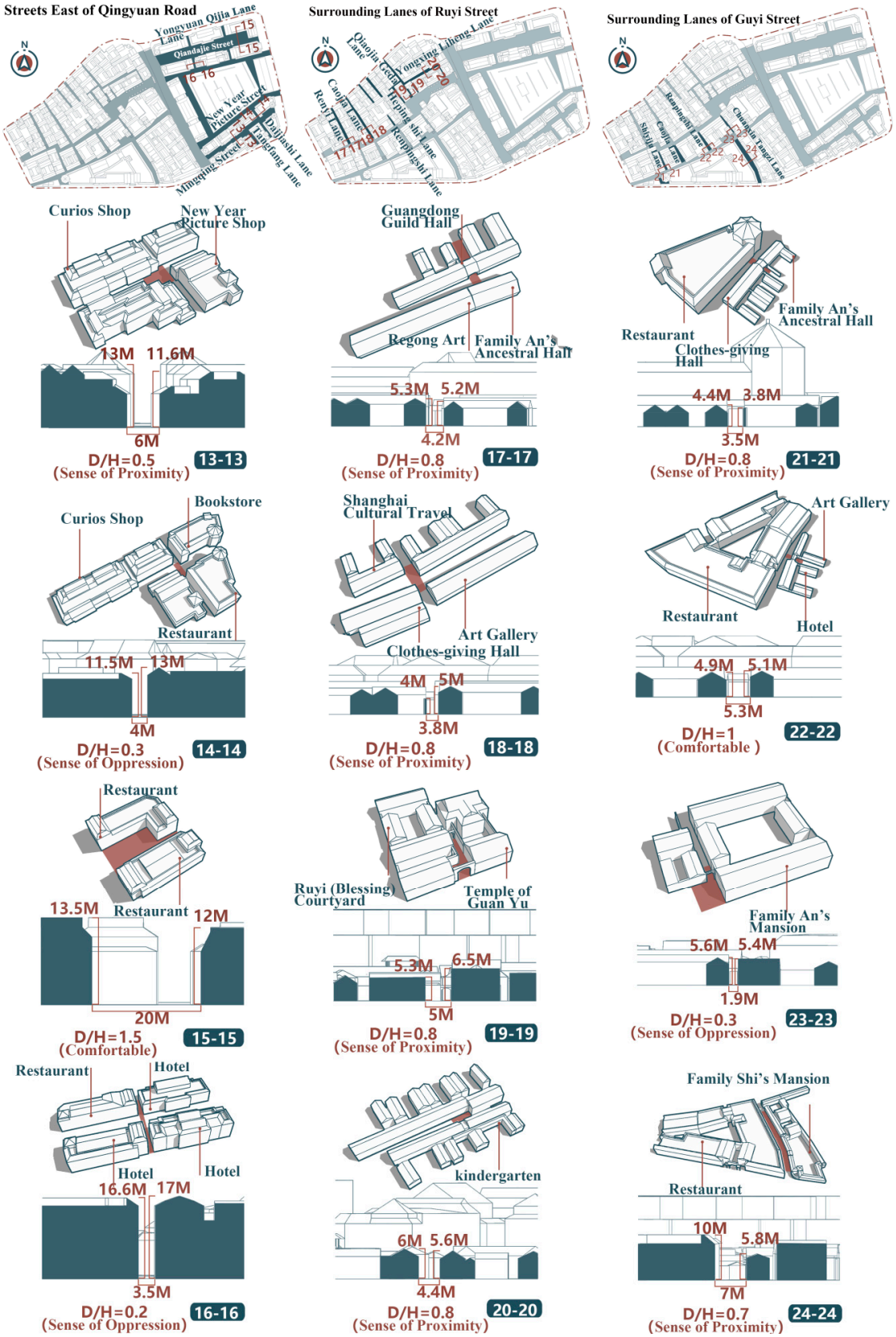

Figure 11. Graph of space morphology of main streets and lanes and D/H analysis.

3.1.2. In Situ Characteristics of Vision in Street Space

The VGA method of Dethmap was chiefly adopted to research the street space in the research area. By researching the visual depth, the integration degree, the visual clustering coefficient, the control degree, and the Exosomatic Visual Agent System of the streets and lanes in the research area, it quantified the in situ perception characteristics and laws of the overall and local parts of the streets along the canal when people are in an active state. According to the result of the visual integration analysis, the threshold range of the integration is between 2.46 and 8.16. The high-value area is around Qingyuan Road, and the high-value places are the junctions of Qingyuan Road and Ruyi Street, Qingyuan Road and Yuhe Road, and Qingyuan Road and New Year Picture Street. The eastern side of Ruyi Street features a high integration degree, followed by the street space east of Qingyuan Road, while the integration degree of Guyi Street west of the site, the space west of Ruyi Street and the lane is rather low, that of the Snack Street in the northwest the lowest (Figure 12).

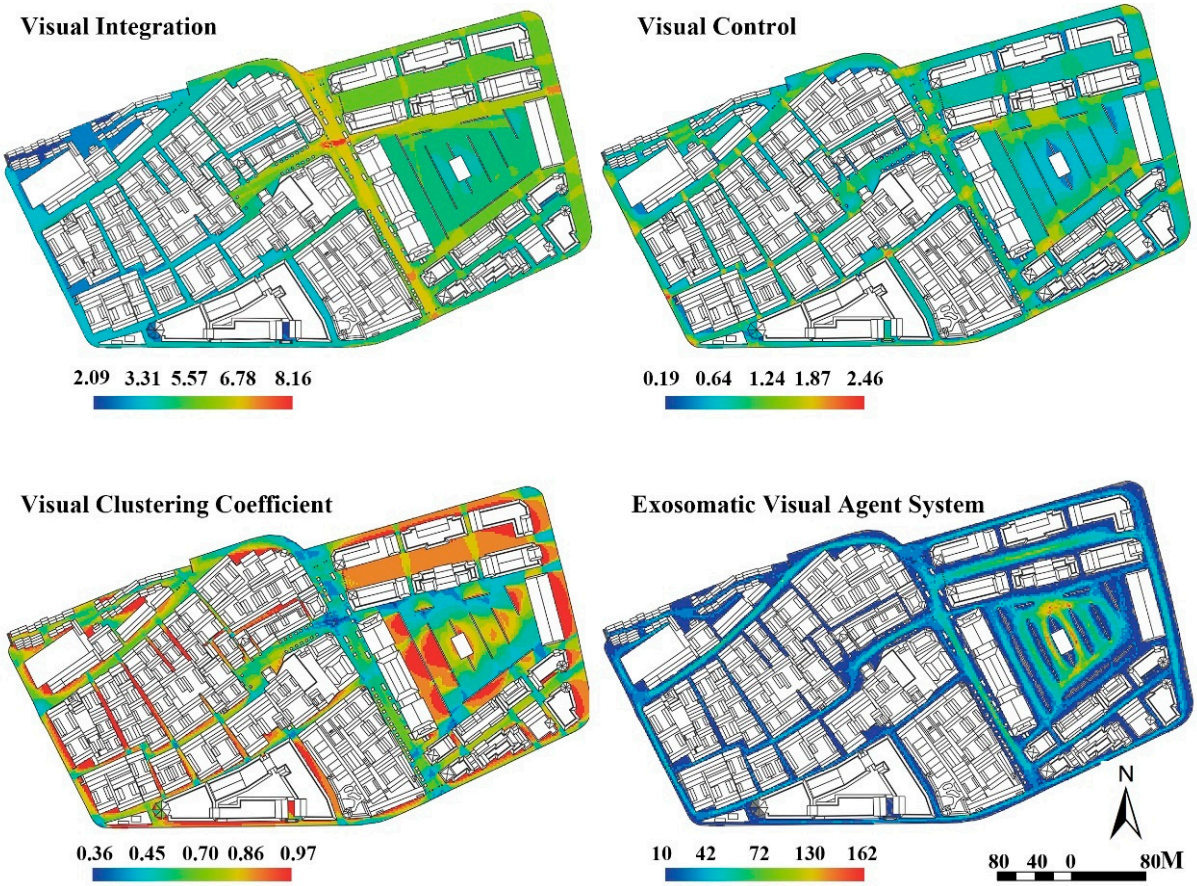

Figure 12. Result of VGA analysis of the street space.

According to the analysis of the cultural resources of the site, the important tangible and intangible resources in the research area are all in the area of high integration degrees. The threshold range of visual control is between 0.19 and 2.46, and high-value areas are at the junctions of the streets (Figure 13). There are 7 high-value areas in Qingyuan Road, 9 in Ruyi Street, 6 in Guyi Street, 6 in Zhushi Street, 5 in Mingqing Street, 4 in New Year Picture Street, and 2 in Qiandajie Street. The areas of low control degrees are at the edge of the buildings of closed vision. The threshold range of the visual clustering coefficient is between 0.36 and 0.97. The high-value areas are mostly at the edge of buildings and in the narrow lanes, while the low-value areas are mostly at the junctions of streets. The Exosomatic Visual Agent System simulates natural travel. It can be seen that the threshold

range of people gathering at the site is between 10 and 162. The simulation result shows that the trajectory of natural travel is the highest in open streets, for instance, Qingyuan Road, Qiandajie Street, Square of Yangliuqing Cultural Center, Zhushi Street, and West Ruyi Street. It can be known from the integration, business type distribution, and field investigation that Qiandajie Street and Zhushi Street are mostly dotted with food, leisure, entertainment, and lodging businesses rather than historical relics. Some stores are out of business, and consequently, the streets are less attractive and vigorous. The main function of the square of Yangliuqing Cultural Center is the parking lot. Despite the great number of people there, the functions of the space are simple, chiefly featuring passing transport and low vitality.

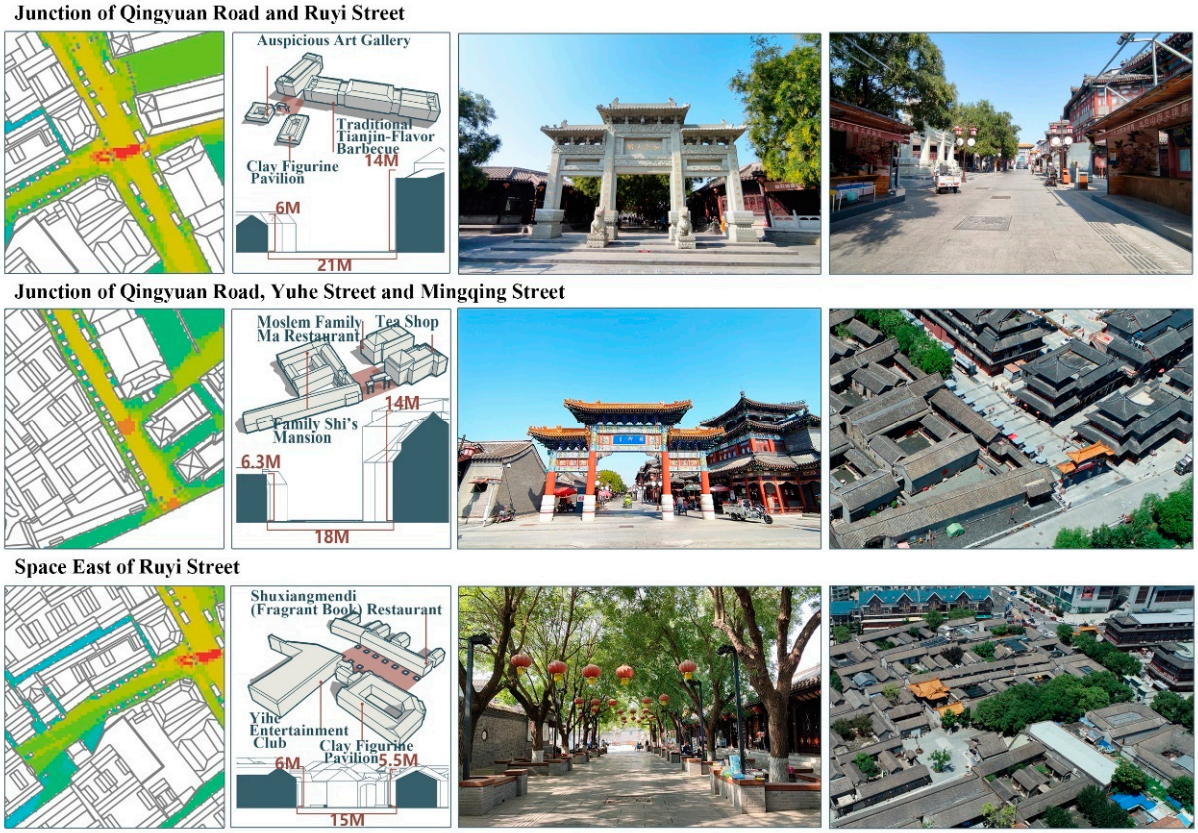

Figure 13. Streets of high integration.

3.2. The In Situ Model of Street Space in the Research Area

3.2.1. The Core Guidance and Control of Historical and Cultural Resources

Historical and cultural resources are the core elements of guidance and control of the in situ characteristics of the street space of the canal settlements, reflecting the traditional society, the cultural deposits, and the epitome of the life of the canal settlements. Established in the period of Jingde of the Northern Song Dynasty, Yangliuqing Town was called "Inlet" then and "Liukou" by the stationed troops of the Northern Song troops and gradually evolved to be a settlement. "Liukou Town" was established in AD 1214, ushering in the organizational system of the town. With grain transport as the main mode of tax of the country in the Ming Dynasty, the canal settlements developed fast. In 1731, Yangliuqing was under the jurisdiction of Tianjin County, initially called "Yangqing Post", which was renamed "Yangliuqing" during the reign of Emperor Qianlong of the Qing Dynasty. Afterward, Yangliuqing developed rapidly with its prosperous businesses, water and land transportation, and abundant goods thanks to its location along the Grand Canal and gradually became a pivotal town of commercial and cultural exchange in North China. Yangliuqing Town gradually housed the residential courtyards of the eight big families,

namely, Family Shi's Mansion, Family Zhou's Mansion, Family An' Mansion, Family Dong's Mansion, Family Cao's Mansion, Family Han's Mansion, Family Zhang's Mansion, and Family Jiu's Mansion. Meanwhile, various freight houses, trading companies, banks, and temples also mushroomed.

The most characteristic Yangliuqing New Year woodblock print was created during the reign of Emperor Chongzhen of the Ming Dynasty. With the northern transport of writing brushes, ink, paper, and pigment of Zhejiang, the technology of process printing and artificial colored drawing of Yangliuqing New Year pictures developed, became a giant of the painting industry of North China and spread its fame at home and abroad thanks to prosperous grain transporting. Yangliuqing paper-cuts boast a history of more than 300 years. Influenced by New Year pictures, the paper-cuts feature wide themes, exquisite forms, and delicate carving and are, hence, still popular. Yangliuqing kites have a long history, abundant themes, vivid colored patterns, and unique characteristics. The streets in the settlements have become important places, inheriting historical and cultural resources. It can be seen from the cultural resources and business distribution of the street space that the street architecture of abundant historical and cultural resources and businesses have become "must-see destinations". The overlapping visual integration shows that high-value areas of historical and cultural resources are distributed in Qingyuan Road, the eastern space of Qingyuan Road, and the eastern space of Ruyi Street, while the integration of historical and cultural resources is low in the west (Figure 14).

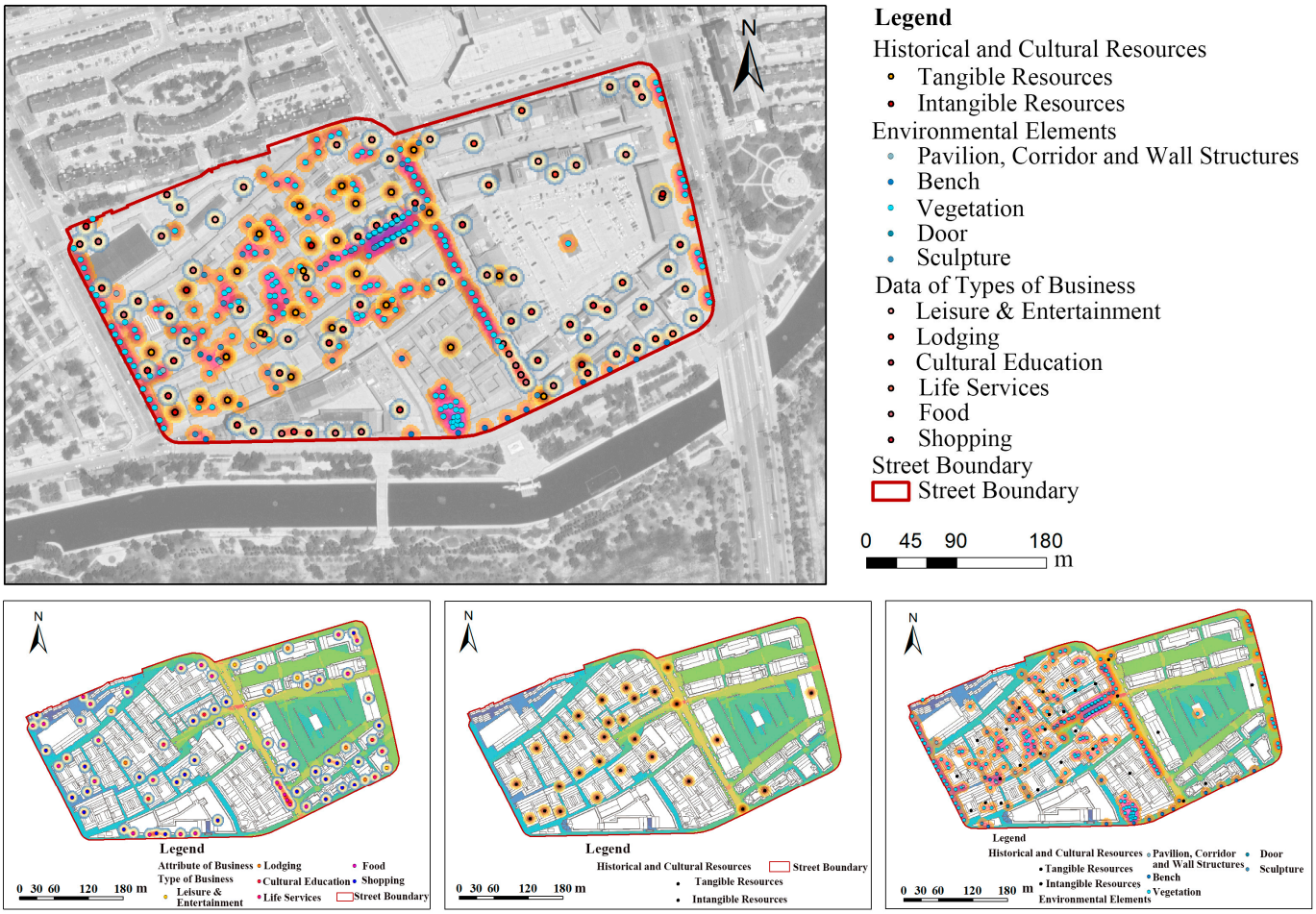

Figure 14. Analysis of overlapping element distribution and visual integration of street space.

3.2.2. Inherent Influence of Space Element Distribution

Space element distribution has significant, inherent effects on the street space along the canal. Figure 15 shows the analysis of the nuclear density of the business-type distribution in the street space of the research area. The distribution laws, influence, and functions are listed as follows. Historical and cultural resources are chiefly in the middle west and west of the site. The tangible resources are chiefly distributed in Qingyuan Road, Ruyi Street, and Guyi Street, while intangible resources are in the center of Ruyi Street, in the west of Guyi Street, and in the east of Qingyuan Road. According to the quantity statistics, there are 28 historical and cultural resources, including 22 tangible resources and 6 intangible resources. According to the result of the mean nearest neighbor analysis, the nearest neighbor ratio is 1.38, and z is 3.90, indicating that the historical and cultural resources in Yangliuqing Street are in the distribution of "multi-point dispersion". Environmental elements are mainly in the middle west of the site, while a small number of elements are in the south and west of the site. According to the types of environmental elements, the vegetation elements are most densely distributed in the west of Qingyuan Road and Ruyi Street, north of Yuhe Road, and west of Qingzhi Road and Liukou Road; benches are primarily in Ruyi Street, Qingyuan Road, and Yuhe Road; sculptures are in Ruyi Street, surrounding streets and lanes and southern and northern sections of Qingyuan Road. According to the quantitative statistics, there are a total of 237 environmental elements, including 175 plants, 27 benches, 24 sculptures, 6 pavilions, corridor and wall architectures, and 5 doors. According to the result of the mean nearest neighbor analysis, the ratio is 0.67, and z is −9.60, indicating the distribution of "area clustering" of the environmental elements of the streets. The business elements are in a disperse distribution, chiefly in Qingyuan Road and surrounding streets and lanes, Ruyi Street, Guyi Street, Zhushi Street, and northern Yuhe Road. As to the number of business types, there are a total of 81 business elements, including 32 for shopping, 30 for food, 7 for lodging, 5 for cultural education, 4 four leisure and entertainment, and 3 for life services. According to the result of the mean nearest neighbor analysis, the nearest-neighbor ratio of the business type is 1.17, and z is 2.89, indicating the "mesh dispersion" distribution pattern of the environmental elements of the streets.

3.2.3. Staying and Attraction at the Street Junctions

Citizens and tourists often stay in the streets as they are attracted by the elements or regional culture of the streets. This also reflects the vitality of the streets. It can be found from the visual control degree that the control degree at the nodes of street junctions is the highest, and it is the easiest to attract citizens and tourists to stop there.

Figure 16 shows the junction space of the three main streets: Qingyuan Road, Ruyi Street, and Guyi Street. The areas of high visual integration are at the junctions of the streets. The four nodes of junctions at Qingyuan Road show that the widening of the space is more frequent. Commercial buildings and residential courtyards of interface attributes appear the most frequently, followed by memorial archways; vegetation and benches in environmental elements appear most frequently. The four nodes of junctions of Ruyi Street show that the widening, narrowing, and irregular space is the element to improve visual attractiveness. On the basis of the vegetation and benches in the environmental elements, characteristic archways and sculptures are also elements improving the attractiveness. The residential courtyards, temples, theatrical stages, and commercial buildings of interface attributes feature various types; commercial buildings for shopping and food appear the most frequently, and those for cultural education and life services are important supplementary elements. The four nodes of Guyi Street show that the narrowing in the space appears the most frequently, followed by irregularity and space widening. Above all, the analysis of overlapping space elements and visual integration degree shows that ① the street junctions of the highest visual integration degree feature the most abundant space elements; ② various space morphology, diverse environmental elements, abundant interface attributes, and diverse business types are the reasons for enhancing the attractiveness

of the street junctions; ③ the D/H of streets of wide sizes ranges from 0.8–1.5, featuring stronger visual integration and attractiveness.

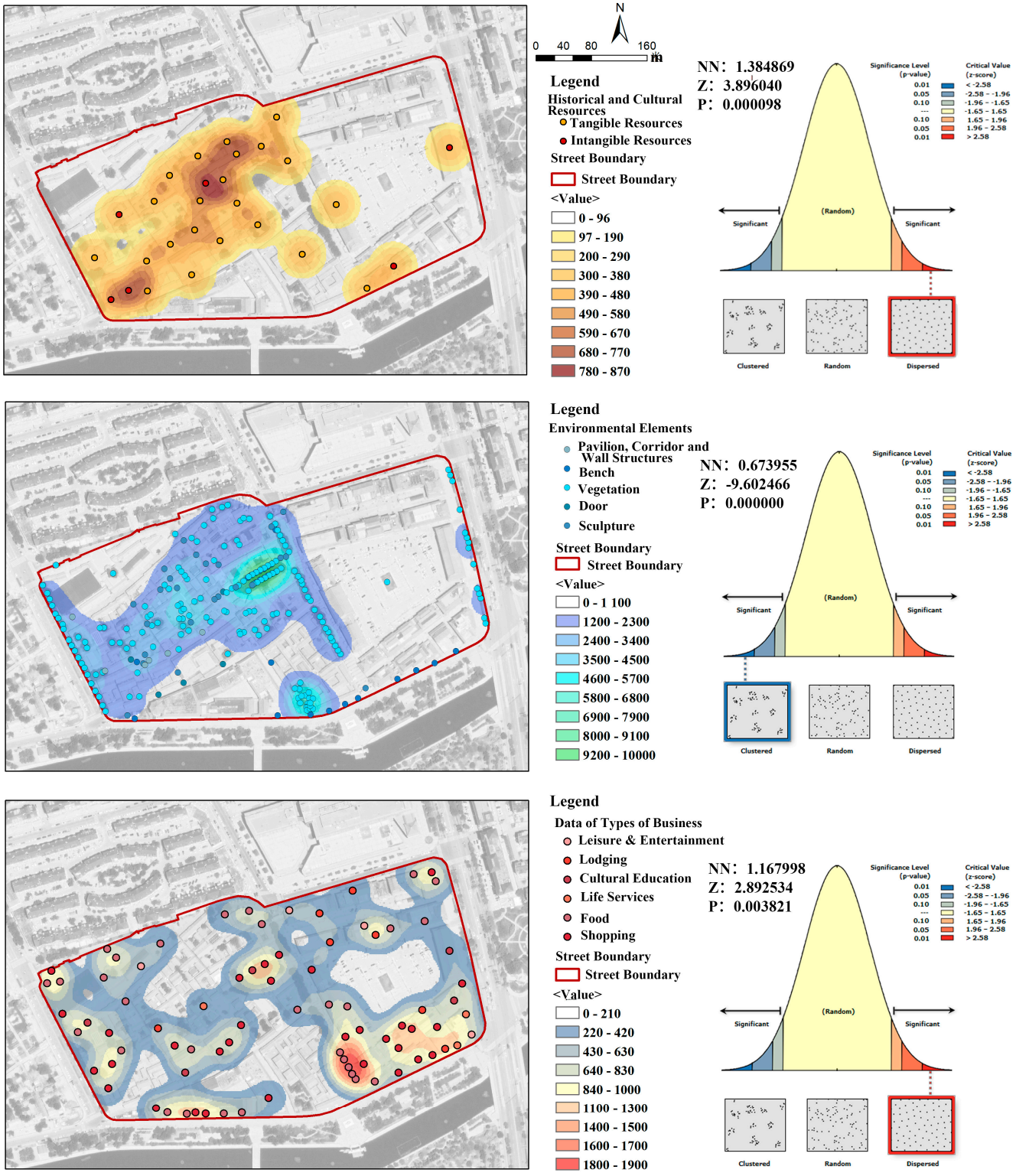

Figure 15. Analysis of the nuclear density of the business type distribution in the street space of the research area.

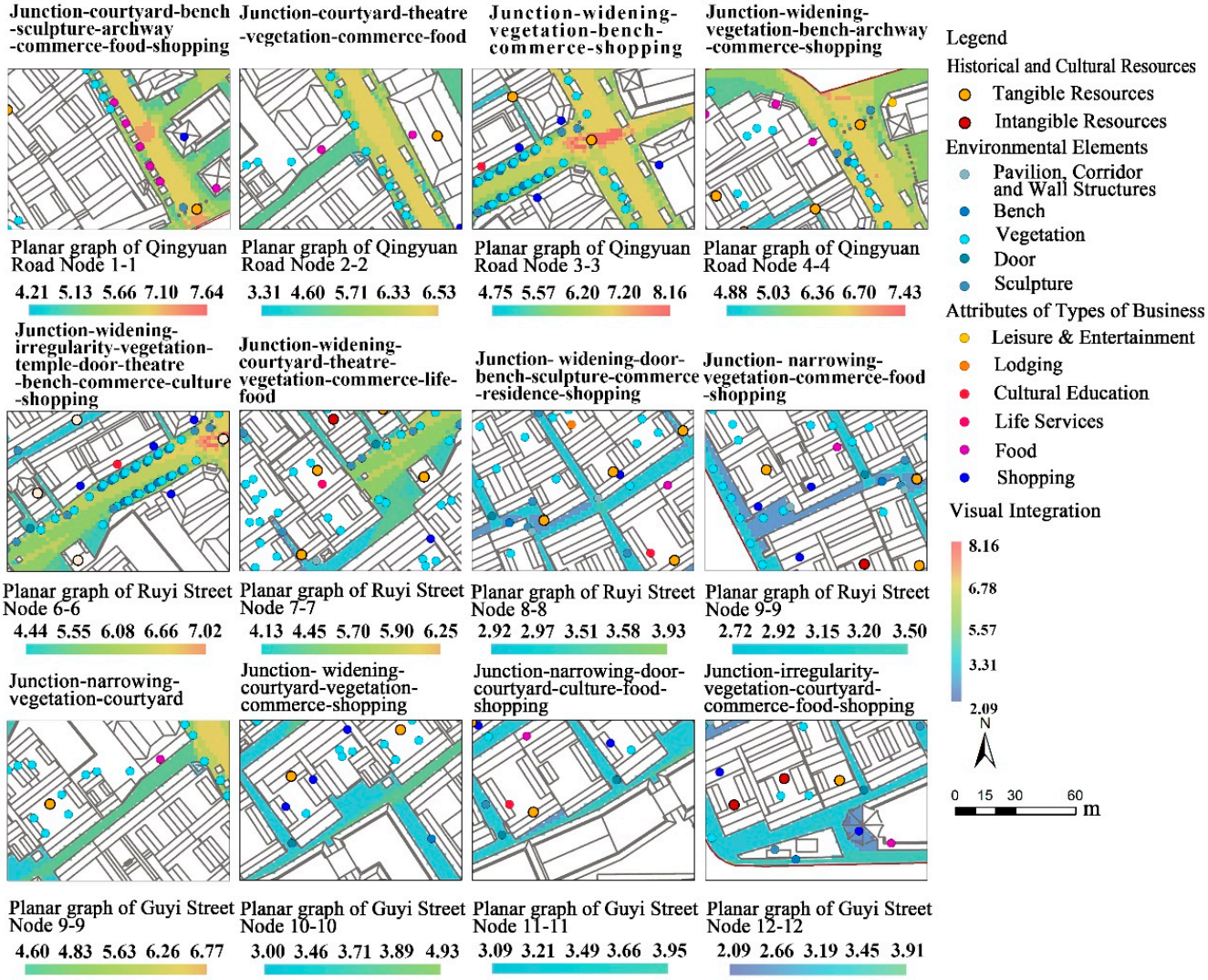

Figure 16. Analysis of the overlapping elements and visual integration of the junctions of the main streets.

4. Discussion

The renewal of the streets and lanes in canal-side ancient towns should maintain the traditional urban fabric of canal settlements, preserve the scale of street and lane spaces, and propose protection requirements and renewal measures for elements such as street and lane forms, orientations, widths, D/H ratios, buildings on both sides, and street facilities in canal settlements. Yangliuqing Town provides guidance for the renewal of ancient towns based on local space characteristics, covering the following four aspects: morphological elements, environmental elements, interface elements, and business type elements.

4.1. Guidelines for the Renewal of the Spatial Elements of Canal Ancient Towns

The guidelines for updating the spatial elements of canal-side ancient towns should preserve, restore, and enhance the distinctive landscape features of the original spatial fabric of towns, emphasizing the local characteristics of canal settlement spaces. Based on the spatial characteristics of streets and lanes in Yangliuqing Town, it is noted that the D/H ratio of main roads like Qingyuan Road ranges between 0.8 and 1.5, with street widths of 18–22 m, providing a generally comfortable spatial perception. The functions of main road spaces generally include "junction–widening–vegetation–bench–signage–commerce–shopping–narrowing–food", featuring a rich variety of spatial elements. As the main

entrance to the ancient town's scenic area, it must meet iconic requirements while ensuring people's needs for gathering and evacuation. Major streets and lanes such as Ruyi Street and Guyi Street exhibit D/H ratios ranging from 0.4 to 4.4 and 0.5 to 1.2, respectively, with widths varying from 2.6 to 15 m and 5 to 12 m. It indicates that this variability is influenced by traditional space morphology and surrounding business elements. The functions of major street spaces generally include "widening–irregularity–temple–door–theatre–bench–commerce–culture–shopping–narrowing–life–food". Traditional lanes, exemplified by those surrounding Ruyi Street and Guyi Street, have D/H ratios ranging from 0.2 to 0.8 and widths varying between 3.8 and 5 m and 1.9 and 7 m. The functions of the lanes include "junction–vegetation–courtyard–commerce–food–culture–shopping–sculptures".

In summary, the renewal of streets and lanes in canal-side ancient towns should be based on current spatial characteristics such as D/H ratios, street widths, and functional elements of space. It should enrich functional elements as much as possible while meeting the needs of different types of roads and lanes, aiming to preserve the original features of canal settlement spaces. Updates to street and lane sections should integrate with the hierarchy of the street and lane system, enhancing service functions and traffic characteristics. They should also reasonably design street widths to meet the needs of local residents and visitors while fulfilling basic functions such as transportation and fire safety.

4.2. Guidelines for the Renewal of the Environmental Elements of Canal-Side Ancient Towns

The spatial environmental elements of canal towns mainly include vegetation, water bodies, arches, pavilions and corridors, wall structures, seating stones and benches, sculptures, and other elements. Based on the above analysis of the spatial element layout, it is known that the environmental elements in Yangliuqing Ancient Town are mainly in the western areas of the research zones, such as the town entrance area, Qingyuan Road, Ruyi Street, Zhushi Street, and Guyi Street. According to the analysis of the integration of spatial elements and visual integration, it is evident that street intersections with the highest visual integration have the richest spatial elements. The diversity of environmental elements enhances the attractiveness of these street intersections. Therefore, environmental elements can be combined with the cultural prototype of traditional courtyards in Yangliuqing, refining classic cultural symbols, architectural colors, and materials as design vocabulary for site walls, facilities, seating, sculptures, and other elements. In the meantime, sponge facilities should be integrated to enhance the drainage and landscape environment of the street space. Measures such as rainwater collection facilities, rain gardens, grass planting ditches, permeable pavements, and sunken green spaces should be implemented for rainwater management, creating diverse ecological landscapes for local residents and tourists to appreciate.

4.3. Guidelines for Renewal of Interface Elements of Canal Towns

The interface elements of the canal towns include residential courtyards, temples, archways, opera houses, and commercial elements. Preservation measures in Yangliuqing Town should continue the historical context of streets and lanes based on protecting interface attributes. The traditional architectural style of Yangliuqing is of the courtyard system, with its own regional and cultural characteristics, such as the "quadrangle courtyards" represented by Family Shi's Mansion and Family An's Mansion. Yangliuqing Ancient Town exhibits the general characteristics of the courtyard system: large courtyards centered around the main house, forming square and enclosed courtyards and exhibiting axial symmetry. Construction follows traditional practices using small-scale methods with materials such as black bricks, grey tiles, stones, and wood. Many parts are adorned with colored paintings, plaques, wood carvings, brick carvings, stone carvings, etc. Generally speaking, the architectural style is not only dignified and quaint but also boasts advantages like dust prevention and providing warmth in winter and coolness in summer. The architectural style of canal settlements should adhere to the local vocabulary of Tianjin's canal settlement architecture, creating canal dwellings with regional characteristics and cultural heritage.

Through typical demonstrations and systematic approaches, it forms a distinctive architectural complex with the characteristics of the Grand Canal Tianjin Section, showcasing a strong "residential style along Tianjin Canal".

4.4. Guidelines for Renewal of Business Type Elements of Canal Towns

The business elements of Yangliuqing Town include cuisine, life services, cultural education, leisure and entertainment, and shopping categories. Existing business elements play a crucial role in preserving folk culture and supporting the development of ancient town tourism. Through the VGA of the research area, it is evident that street intersections with the highest visual integration have the richest spatial elements. The diversity of business types also enhances the attractiveness of these intersections. However, it has been found that the western side of the research area still lacks vitality in many traditional alleyways and *hutongs*, resulting in low attractiveness and passenger flow. Therefore, in terms of business elements, Yangliuqing Town should focus on updating business resources under the concept of integrating culture and tourism. This involves comprehensively applying smart technological methods to innovate district experiential scenes, integrating Yangliuqing's rich local resources into distinctive town business scenes, and blending smart landscapes to create immersive cultural experiences. On the one hand, this includes reinterpreting the elements of Yangliuqing's New Year painting culture, courtyard culture, canal transport culture, and market culture to construct memory scenes, revitalizing street functions, and showcasing the profound cultural heritage of northern Chinese folk traditions. On the other hand, adding public-interest business functions such as cultural exhibitions, public services, intangible cultural heritage experiences, and historical promotions can enhance the readability of scenes, transform historical memories into visible elements, and allow the public to immerse themselves in the historical and cultural experiences of Yangliuqing during activities. This approach becomes a powerful factor in enhancing the in situ characteristics of the ancient town.

Furthermore, folk culture is the continuation and inheritance of the history of the ancient town settlements along the Grand Canal Tianjin Section. Leveraging its unique geographical advantages of the interconnected Haihe River, Tianjin has developed a distinctive and thriving folk culture within its canal settlements, which has been passed down and preserved to this day. Despite the cessation of canal transport functions, the folk culture that has witnessed the industrial development and historical changes of these settlements continues to thrive through generations. Yangliuqing Town, as a typical representative of Tianjin's folk culture, boasts a rich intangible cultural heritage. The national-level intangible cultural heritage includes Yangliuqing woodblock New Year prints and Tianjin drumming, while municipal-level heritage features Yangliuqing paper-cutting, canal culture, and fan-making techniques. At the district level, Yangliuqing kites are recognized as intangible cultural heritage. These diverse types of intangible cultural resources are scattered throughout the streets and lanes of Yangliuqing Ancient Town, serving as important attractions for tourists. Furthermore, folk tales from Yangliuqing are widely circulated, primarily among the working people in Xiqing District, Tianjin, and beyond. These include stories such as "Fan Painting", "Yangliuqing New Year Prints", "Lotus Promising A Year of Abundance", architectural tales like "PuliangPagoda", "Restoration of Wenchang Pavilion", and legends such as "The Legend of Baitan Temple", and stories involving historical figures like "Qianlong's Appreciation of Art", "Contributions of Emperor Yang of Sui Dynasty to Tianjin", and "The Encounter of Zhang Decheng with Shi Yuanshi". In conclusion, folk culture represents the continuation and inheritance of the history of the ancient town settlements along Tianjin's canal, playing a crucial role in the preservation and development of their local space morphology.

5. Conclusions

With the globalization and industrialization of modern architectural technology, historical streets and lanes, and traditional architecture are increasingly threatened and destroyed.

Nonetheless, historical streets and lanes and traditional architecture are heritage resources worthy of promotion and conservation and boast important reference value for the risks of future environmental changes [47]. Yangliuqing Town, a historical and cultural town of the country and a space of representative, typical streets, was selected. With multiple data, the in situ characteristics of streets were quantitatively analyzed in terms of the characteristics of space organization and VGA representation. The research results indicated that ① multidimensional factors influencing the historical development of the research area have been clarified. Specific influencing factors include: the space morphology of the ancient town settlement is directly related to its status as a canal transport hub; changes in canal transporting have promoted the rise and fall of the canal settlement industry and materialized within the space morphology; the remaining traditional residential courtyards in the ancient town represent the traditional courtyard-style residences in northern China; and folk culture continues the historical heritage of the ancient town settlements along Tianjin canal. ② The in situ model of the street space morphology of Yangliuqing Town is reflected in "core control of the historical and cultural resources", "the internal influence of the layout of space elements", and "the appeal of the space at the crossings of streets". ③ Based on these research findings, this study proposed guidance for the renewal of ancient towns based on the in situ characteristics of space morphology, focusing on morphological elements, environmental elements, interface elements, and business type elements. The research provided viable research thoughts and techniques for the follow-up evaluation and updating of the in situ characteristics of the canal settlements.

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