Influence of Visual Proportion of Urban Street Cultural Landscape on Crowd Aggregation —— An Empirical Study on Street Space in Downtown Chengdu

Zhang Ling Qing[1, 2, 3], Deng Wei[1, 2, 4, *], Zhang Cheng Yan[3], Ding Yu Hui[3], Wan Jiang Jun[3]

[1]Research Center for Mountain Development/Institute of Mountain Hazards and Environment, Chinese Academy of Sciences, Chengdu, China

[2]School of Resources and Environment, University of Chinese Academy of Sciences, Beijing, China

[3]School of Architecture and Urban-Rural Planning, Sichuan Agricultural University, Chengdu, China

[4]School of Geography and Resource Sciences, Sichuan Normal University, Chengdu, China

Email address:
41360@sicau.edu.cn (Zhang Ling Qing), dengwei@sicnu.edu.cn (Deng Wei), 41358@sicau.edu.cn (Zhang Cheng Yan),
41390@sicau.edu.cn (Ding Yu Hui), 41472@sicau.edu.cn (Wan Jiang Jun)
[*]Corresponding author

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Abstract: This paper explored the correlation between the visual proportion of urban street cultural landscape and crowd aggregation. In the study, the relevant theoretical assumptions and measurement scales were established first; Then the street panoramic images of 535 sampling points were obtained through systematic sampling and field shooting; Easygo and POI (Points of Interest) data of the research area collected every two hours within one week were picked up through big data capture; Finally, the driving force of geographical differentiation was detected by using the geographic detector. The results showed that: (1) in the artificial landscape, the visual proportion of architectural landscape had a significant impact on crowd aggregation and the explanatory power q was 0.15. Neither the visual proportion of roadway landscape nor that of sidewalk landscape had significant impact on crowd aggregation; (2) In the natural landscape, both the visual proportion of greenery landscape and that of sky landscape had significant impact on crowd aggregation and the explanatory power q was 0.09 and 0.05 respectively; (3) The interaction between the visual proportion of architectural landscape and that of greenery landscape or between the former and that of sky landscape showed a two-factor enhancement and the interaction between the visual proportion of greenery landscape and that of sky landscape showed non-linear enhancement; (4) There were significant two-factor enhancement effects in the interactions among the the visual proportion of architectural landscape, that of greenery landscape, of sky landscape and aggregation of POI facilities, of which the biggest q value was 0.76.

Keywords: Urban Street, Cultural Landscape, Crowd Aggregation, POI, Geographic Detector, Downtown Chengdu

1. Introduction

At present, the urbanization rate of our country has reached more than 50%, and the urbanization rate in some areas has even reached more than 75%. According to the S curve principle of urbanization development, the growth of urbanization in many cities will gradually slow down. [1, 2] On the other hand, with the further implementation of China's

land and space planning, the boundary of urban development will be strictly defined through "three lines" [3] (The "three lines" refer to the three control lines of ecological protection red line, permanent basic farmland and urban development boundary delineated according to ecological space, agricultural space and urban space.) The city needs to move towards the connotative development path, from incremental development to stock development [4]. At present, some cities are actively involved in the renewal of urban stock space and

transformation of slow traffic [12-14] such as promoting the reconstruction of urban villages, central business district (CBD) renewal [7-8] and historic block building [9-11] etc. in order to improve the quality of urban space, enhance the attraction of cities and gather popularity [5-6]. This will greatly change the cultural landscape pattern of the city's original streets, and then influence people's spatial perception and behavior through sensual, intellectual and rational perception [15]. In this process, how to quantitatively analyze the correlation between urban street cultural landscape and spatial behavior activities has become an urban issue worthy of in-depth exploration.

In terms of quantitative research on urban cultural landscape, Professor Long Ying of Tsinghua University proposed the concept of Pictorial Urbanism [16] emphasizing the study of human-oriented urban morphology based on pictures. He used the latest big data technology, artificial intelligence technology to carry out a series of quantitative collection and analysis of urban images. For example, the change of street space quality in downtown Qiqihar from 2013 to 2015 is judged by using Tencent Street View Picture as a carrier. [17] With the popularity of mobile terminals and information technology, scholars can obtain multi-temporal, large-scale and accurate crowd activity data through mobile phone signaling, Baidu Heat Map, Tencent Easygo and other platforms. In recent years, by using these data, some scholars have studied the spatiotemporal characteristics of large-scale crowd aggregation. Take, for example, Duan Yaming et al. finely identified Chongqing's "multi-center, cluster-like" urban structure using kernel density analysis and other methods based on Easygo heat data for a continuous week. [18] Wu Zhiqiang et al. studied the crowd aggregation, location and population center of gravity and other indicators in downtown Shanghai by using the Baidu Heat Map. [19] Some scholars have studied the correlation characterization of crowd aggregation, Zhang Yan and others, for example analyzed three kinds of indicators such as job-housing balance, job-housing separation and commuting behavior, and identified the types and characteristics of job-housing space in Beijing based on multi-source data fusion such as mobile phone signaling. [20] However, in general, there are more literature on the application methods of big data in urban crowd activities, and fewer on the driving force behind it, so it is of theoretical value to explore the correlation between urban cultural landscape and crowd gathering activities.

This research further explores the influence of visual proportion of urban street cultural landscape on crowd aggregation based on the quantitative research results of Environmental Psychology, Sciences of Human Settlement, cultural landscape and crowd aggregation. By systematic field sampling and network big data capture of each street in the central areas of Chengdu, 535 high-definition panoramic images of the street, about 1.04 million heat data of population from Tencent Easygo and nearly 180 thousand Gaode points of interest (POI) data were obtained. On the basis of theoretical analysis, the theoretical hypothesis, operational definition and measurement scales of the correlation of variables were further clarified. Variable data were obtained by image semantic recognition and spatial statistical analysis. Finally, geographic detectors were used for differentiation and factor detection, interaction detection, ecological detection and risk zone detection. The relevant results are of positive significance to urban street cultural landscape reconstruction and urban population spatial density planning.

2. Data and Methods

2.1. Overview of the Study Area

This study selected the central city of Chengdu, Sichuan Province as a typical study area (Figure 1) with Tianfu Square as its center. The northern and eastern regions are bounded by Fuhe River, southern region by Southern river, and the west is bounded by Yinma River and the West Suburbs River. Now it is the seat of Sichuan Provincial Government and Chengdu Municipal Government, the commercial and financial center of Chengdu, with many important historical and cultural relics and municipal parks, integrating four major functions of living, working, recreation and transportation. The city's overall street pattern has lasted for more than 2300 years without major changes. The total area is about 18.60 square kilometers, with a perimeter of 17.84 kilometers, presenting a 30- degree declination, which is not exactly in the north - south direction. According to the intersection division, there are 718 streets in the study area. The total length of the street is about 150.30 km, and the average length of each street is 209.34 metes. Of all the streets, the shortest is 15.66 m, the longest 1173.85 m and the standard deviation is 128.93 m. The old and new streets coexist here, and the modern and traditional streets have distinct representative and blending characteristics.
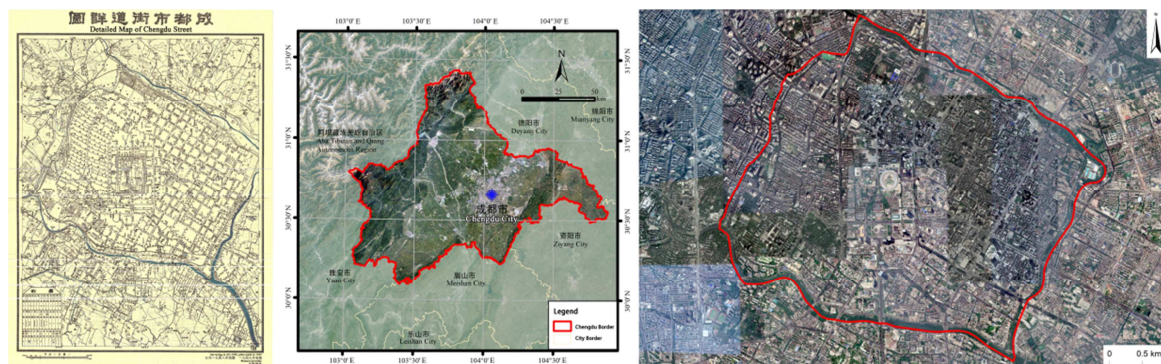

Figure 1. *Historical Map of 1948 (a), Location Map of Chengdu City (b) and Map of Study Area (c).*

2.2. Correlation Theory Analysis and Research Hypothesis

2.2.1. Concept of Cultural Landscape

In his book Landscape Morphology, American geographer Carl Sol argues that cultural landscape is a form of human activity attached to the natural landscape. From the perspective of culture, the landscape is a region with unique forms of communication. He advocates to study the geographical features by observing the landscape on the ground [21] Li Xudan, a human geographer in China, believes that "cultural landscape is a complex of cultural phenomena on the earth's surface, reflecting the geographical characteristics of a region." [21] Gu Chaolin believes that cultural landscape is a comprehensive product of human cultural activities based on natural landscape patterns. The difference of natural landscape is an important factor that causes the regional differentiation of cultural landscape. Humanistic landscape is formed through the transformation and utilization of natural landscape under the premise of adapting to natural conditions. Different social, political and economic structures of human groups have different ways of transforming and utilizing the natural landscape, so that the cultural landscape of different regions has more cultural characteristics and differences [21]. The relevant definitions emphasize that cultural landscape is the product of human activities on the basis of nature, and it is characterized by difference. However, there is no further description of the characteristics of cultural landscapes that react to human activities.

2.2.2. Influence of Cultural Landscape on Human Activities

The related research in environmental psychology makes up for this deficiency. From the point of view of natural landscape, environmental psychology has found that natural landscape has the effect of restoring human body and mind, and puts forward the theory of stress reduction and attention recovery theory [22]. They explain from different angles why people tend to be close to natural factors, and why a restoration effect is generated even by viewing pictures of natural scenery. From the perspective of humanistic landscape, Environmental Psychology emphasizes the concept of cognitive map, [22] namely, the structured psychological representation of the environment in which people live. Kevin Lynch, in his book *Image of the City*, elaborated the related issues [23]. Through the cognitive map drawn by people, he identified five elements of people's cognition of the city: regions, nodes, landmarks, boundaries and paths. These cultural landscape elements affect people's spatial cognition, thus influence people's behavior through activities such as "finding the way". On this basis, some scholars further empirically analyzed the interaction between cities and human perception using pictorial data with large amount of information containing geographic tags in 26 cities [24]. These studies explored the reaction mechanism of cultural landscape to people's perception and behavior, and made up for the deficiency of the original definition of cultural landscape. However, relevant research focused more on factors such as easy identification, aesthetics, and restoration of cultural landscapes, most of which are qualitative research, and

there is still no further quantitative research on the visual structure influence mechanism of cultural landscape.

2.2.3. Correlation Analysis of Different Types of Cultural Landscape and Crowd Aggregation

In recent years, due to the vigorous development of self-driving industry and the progress of artificial intelligence technology, street view recognition technology has been popularized, people can quickly classify and quantify street view map by calling intelligent algorithm through programming [25]. This technique, which can calculate the proportion of each type of landscape pixel area, provides a new possibility for the study of the influence mechanism of cultural landscape visual proportion.

All kinds of classification algorithms generally divide the city street view into buildings, roadways, sidewalks, greenery, sky, cars, people and other elements. In order to explore the influence mechanism of visual proportion of all kinds of cultural landscape, this study divides the urban street cultural landscape into humanistic landscape types, including architectural landscape, roadway landscape and sidewalk landscape; natural landscape types, including greenery landscape and sky landscape. Furthermore, referring to the settlement theory of Human Settlement Sciences, this paper theoretically discusses the correlation between the visual proportion of various cultural landscape and the crowd aggregation.

The most important thing for a settlement is the human need for space, which is the most important "force" for the formation of a settlement, according to the founder of Human Settlement Sciences, Doxiadis [26] proposed five principles to meet people's needs: (1) The principle of maximum opportunity for communication, that is, people can get closer to what they need by living together, such as convenient commodity trading, in-depth face-to-face communication, rich collective interaction, more access to external information and centralized government management, etc. (2) The principle of the minimum cost of connection (energy, time and expense), that is, people can communicate with each other at a lower cost by living together;(3) The principle of the optimal security, that is, to concentrate people's strength, knowledge and skills to ensure the overall security of the settlement; (4) The principle of optimal relationship between human and other elements, that is, fully coordinated relationship between human, nature, supporting network and other elements;(5) The principle of optimal system composed of the first four principles, as the dynamic optimization and combination of the first four principles can shape a high quality settlement.

Corresponding to the five types of cultural landscape, architecture should be the most attractive element, because many people's activities are completed in the buildings, and the architectural space provides the most opportunities for communication and the safest shelter space. The roadway should be the least attractive element of the five types of cultural landscape, because it is only a channel of connection, unable for people to stay for communication, and has security problems. The sidewalk is highly praised in all kinds of

research and practical renovation projects, but the sidewalk itself is only a safe and flexible channel of connection, which needs to be combined with the buildings, points of interest (POI) and other elements in order to create more opportunities for communication at a low cost and to coordinate various elements. Therefore, the sidewalk itself is not attractive, but it may produce greater attraction when combined with other elements. The greenery landscape and sky landscape are attractive in theory because they can provide the opportunities for people to interact with nature, low in cost, relatively safe and has the function of restoring human health, among which the communication function and resilience of greenery landscape are stronger, so it is more attractive. But in general, the cultural landscape is only a representation of things and functions, and may not have a decisive influence, but rather the aggregation of urban points of interest (POI) may greatly affect the aggregation of people to a large extent, because it can directly meet the first three principles of the settlement, which Guo Han et al. have carried out relevant research [27]. Therefore, in this study, we can further explore the interaction between various cultural landscape and points of interest (POI).

2.2.4. Theoretical Assumptions

Based on the above analyses, this study proposed 5 research hypotheses.

Hypothesis 1: There is a positive correlation between the visual proportion of buildings and crowd aggregation, between the visual proportion of greenery and crowd aggregation and between that of sky and crowd aggregation, of which the visual proportion of buildings has the strongest correlation with the crowd aggregation, and the correlation between the crowd aggregation and the latter two decrease in turn.

Hypothesis 2: There is no correlation between the visual proportion of roadway and crowd aggregation and between that of sidewalk and crowd aggregation.

Hypothesis 3: The visual proportion of sidewalk and architectural landscape has positive correlation with crowd aggregation after interaction.

Hypothesis 4: All five types of landscape interact with the points of interest (POI) and produce a closer correlation with crowd aggregation.

Hypothesis 5: The interaction between the five types of landscape also enhances its correlation with crowd aggregation.

2.3. Data Acquisition and Analysis

2.3.1. Operational Definition and Measurement Scales

To obtain more accurate empirical analysis results, this study further clarified the operational definitions of visual proportion of urban street cultural landscape, crowd aggregation and points of interest (POI) aggregation and the corresponding measurement scales were formulated as shown in Table 1.

Table 1. *Operational definition and measurement scales.*

| Dimensions	Operational definition	Method of measurement	Grading methods
Visual Proportion of Urban Street Cultural Landscape	The visual proportion of all surrounding buildings, roadways, sidewalks, greenery and sky seen by people at the street sampling points	Taking 720-degree high-definition panoramic views of sampling points, using image semantic recognition program to carry out pixel-level semantic classification, and get the proportion of each pixel	Dividing the proportion and quantity into 1-7 levels according to the equal interval classification
Concentration of points of interest (POI)	Density of points of interest (POI) around the sampling points	Using network to capture/grab all kinds of points of interest (POI) information in the study area on a certain day to establish a 500m buffer zone of sampling points, and calculate the number of points of interest (POI) in the buffer zone	
Crowd aggregation	Number of people gathered around sampling points	Using the network to capture/grab the data at 2- hour intervals within a week on the Heatmap of Tencent Easygo to build a 500m buffer at the sampling points, and calculate the sum of all the heat data in 84 time periods in the buffer zone	
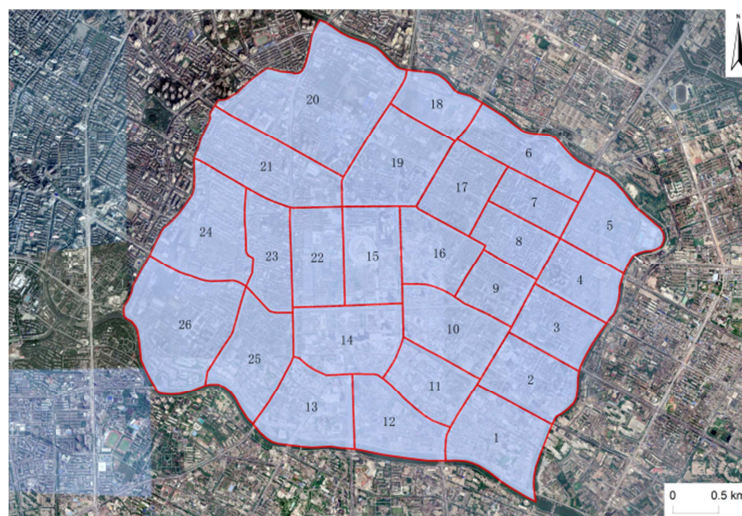
Figure 2. *Distribution map of 26 blocks in the study area.*

2.3.2. Data Acquisition and Analysis of Panoramic View of Street Sampling Points

This study first divided the entire study area into 26 blocks (figure 2).

Through the systematic sampling method, a certain number of streets were selected for sampling in each block. One sampling point was set for each road, and a total of 535 sampling points were set. From January 19 to January 25, 2020, high-definition panoramic images were taken at 535 sampling points in the study area using the high-definition panoramic camera insta360 pro2. Different from the panorama captured by Baidu Street View, the pixel of the panorama shot on the spots were as high as 7680×3840, 7 times higher than that of 1024×512 pixels of Baidu Street View Map. The light and dark contrast was appropriate, and there were no photos taken with cars at the bottom that occupied the road landscape, so no photos needed to be cut off which could more clearly and completely express the latest street cultural landscape. Acquisition process and sample pictures (Figure 3).

(a)　　　　　(b)

Figure 3. Photos of collection process (a) and panorama (b) of Chengdu street culture landscape.

Each high-definition panorama contained all the visual landscape information of the street. Import the high-definition panorama into the Python image semantic recognition program, by calling the Tensorflow package and and cityscapes model (deeplabv3_mnv2_cityscapes_train_2018_02_05) which has been trained for urban street view semantic recognition, batch semantic recognition and statistics on 535 street view images were performed and the proportion of different cultural landscape elements in each map was calculated.

There are 19 kinds of urban landscape semantic recognition models as shown in Table 2. The statistical results of semantic analysis of a street view panorama are shown in Table 3. According to the theory, the data of the visual proportion of architectural landscape, that of roadways, of sidewalks, of greenery and of sky were selected and divided into seven levels according to the equidistant interval classification, as shown in Table 4. The spatial distribution map of the visual proportion of different types of landscape is shown in Figure 4.

Table 2. Semantic classification codes of training set models.

Classification code	Name	Classification code	Name	Classification code	Name
0	Roadways*	7	Traffic Sign	14	Trucks
1	Sidewalks*	8	Vegetation*	15	Buses
2	Buildings	9	Terrain	16	Trains
3	Walls	10	Sky*	17	Motorcycles
4	Fences	11	People	18	Bicycles
5	Poles	12	Cyclists		
6	Traffic Lights	13	Cars		

Note: The selected cultural landscape elements are marked with*.

Table 3. Analysis data of street cultural landscape panorama in Central City.

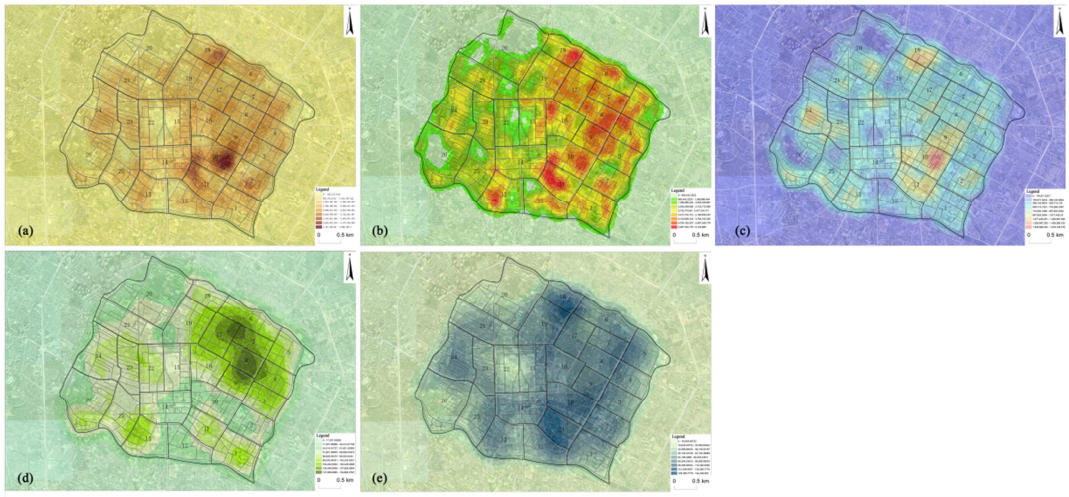| Number	Original pictures and pictures after semantic recognition	Classification legend	Name	Percentage
......				
01-01-03		0	Roadways	5.8%
		1	Sidewalks	1.7%
		2	buildings	14.7%
		3	Walls	0.006%
		4	Fences	0.05%
		5	Poles	0.4%
		7	Signs	0.2%
		8	Vegetation	22.3%
		9	Terrain	0.3%
		10	Sky	51.6%
		11	People	0.007%
		12	Cyclists	0.2%
		13	Cars	2.6%

Figure 4. Kernel density map of visual proportion of cultural landscape in sampling points

Kernel density map of visual proportion of architectural landscape (a), that of roadway landscape (b), that of sidewalk landscape (c), that of greenery landscape (d), that of sky landscape (e).

Table 4. Percentage classification of semantic segmentation of street panorama.

Number of Sampling Points	AL_1 Grading of Visual Proportion of Architectural Landscape	AL_2 Grading of Visual Proportion of roadway landscape	AL_3 Grading of Visual Proportion of sidewalk landscape	NL_1 Grading of Visual Proportion of greenery landscape	NL_2 Grading of Visual Proportion of sky
......					
01-02-01	2	6	2	4	3
01-03-02	2	6	2	4	2
01-01-03	2	7	1	3	4
01-01-04	3	7	1	3	2
01-03-05	4	7	1	1	4
01-03-06	4	6	1	1	4
01-03-07	5	7	1	1	4
....					

2.3.3. Data Acquisition and Analysis of POI Facilities

Write Python code to capture various points of interest (POI) data on the Gaode map of the study area and surrounding areas on March 3 (The longitude of the upper left corner of Gaode coordinates: 104.03995, latitude: 30.686994; the longitude of the lower right corner: 104.101791, latitude: 30.632385). The names, types, longitude and latitude coordinates of 15 types of facilities were obtained, including catering services, road ancillary facilities, scenic spots, public facilities, companies and enterprises, shopping services, transportation facilities services, financial and insurance services, science, education and cultural services, business housing, life services, sports and leisure services, medical and health services, government agencies and social organizations and accommodation services, totally 179734 pieces of data. A buffer zone covering 535 sampling points with a radius of 500 meters was established by GIS software. With the function of spatial connection, the points of interest (POI) were connected to the buffer zone. The function of statistical summary was used to calculate the number of points of interest (POI) within the buffer zone of each sampling point. An equal interval classification was used to divide the number of points of interest (POI) in the buffer zone of each sampling point into 1-7 levels, as shown in Table 5. After kernel density analysis, the spatial density distribution map of the points of interest (POI) was obtained as shown in Figure 5.
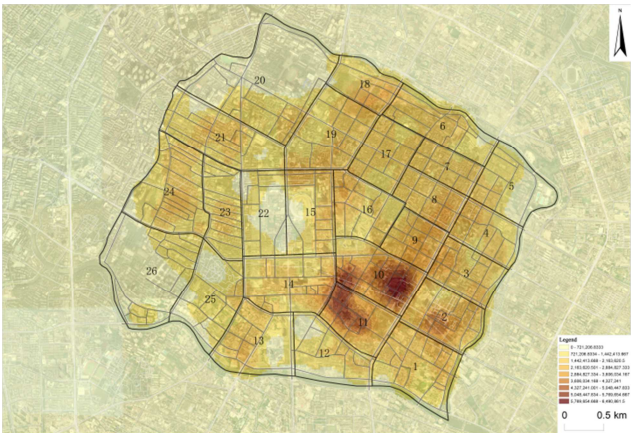

Figure 5. Spatial density map of POI facilities in 500-meter buffer zone of sampling points.

Table 5. Measurement table of the connection of POI facilities in 500m living circle.

Number of Sampling Points	Quantity	Grading
......		
01-02-01	3704	3
01-03-02	4142	3
01-01-03	4890	4
01-01-04	5492	4
01-03-05	5710	5
01-03-06	6518	5
01-03-07	5632	5
01-02-08	5342	4
....		

2.3.4. Acquisition and Analysis of Population Heat Data of Tencent Easygo

The written Python program was used to call Tencent Easygo API. From 2:00 a.m. on January 6, 2020 to midnight on January 13, in a week, the real-time data (count value, which represents the crowd aggregation) of the Easygo heat map were captured at 2- hour intervals, and approximately 1.04 million data (geographical coordinates and heat values) were obtained. After conducting kernel density analysis of the heat map values of different time periods on Tuesday, January 7, the daily variation diagram is obtained as shown in Figure 6 (a)
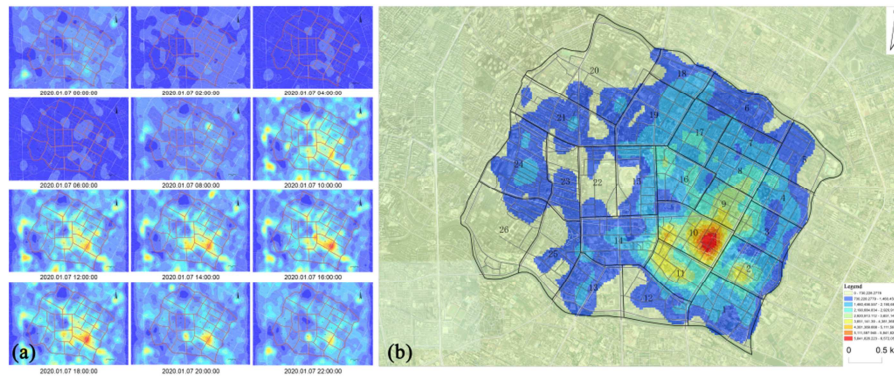
Figure 6. Kernel density map of crowd aggregation at 2- hour intervals on Jan. 7, 2020 (a); Kernel density map of population aggregation in one week from January 6 to 13, 2020 (b).

The crowd aggregation analysis conducted at a certain time or on a certain day can reflect the changing characteristics of crowd aggregation, but in order to reflect the stable crowd aggregation index of different sampling points in the study area, a circular buffer zone with a radius of 500 m was set at each sampling point to calculate the sum of all heat map values of the buffer zone for 84 hours in a week, and the equal interval classification method was used to divide them into 1-7 levels, as shown in table 6. After the kernel density analysis, the overall population aggregation distribution pattern was obtained, as shown in figure 6 (b).

Table 6. Quantitative table of crowd aggregation in 500m Living Circle.

Number of Sampling Points	Quantity (NL_NUM)	Grading (NL)
......		
01-02-01	29332	3
01-03-02	34143	3
01-01-03	39263	3
01-01-04	44205	4
01-03-05	47086	4
01-03-06	58584	5
01-03-07	59385	5
01-02-08	56630	5
....		

2.4. Detection by Geographic Detector

Geodetector is an emerging method of spatial correlation analysis after 2010, which is based on the assumption that if an environmental independent variable has an important influence on a certain dependent variable, then the spatial distribution of the dependent variable and the spatial distribution of the independent variable should be similar [28-29] The analysis technique is based on ANOVA to detect independent variables with significant influence. The independent variables detected must be discrete variables, and if the detected are continuous variables, they are required to be discretized appropriately [30]. Continuous dependent variables of population aggregation in 500m buffer zone at sampling points, visual proportion of street culture landscape and discrete independent variables of points of interest (POI) aggregation in 500m buffer zone have been obtained. Finally, the reliability of independent variables measurement (risk detection), the explanatory power of independent variables to population aggregation (differentiation and factor detection), the reliability of independent variables interaction (ecological detection), the explanatory power after independent variables interaction and the characteristics of variation (interaction detection) have been analyzed using geodetector.

3. Result Analysis

3.1. Risk Detection Results

The risk detection (reliability analysis) of each independent variable was carried out by geographical detector and the results showed that the significance T test of six independent variables was 0.05. The six independent variables were the grading of the points of interest (POI) aggregation, grading of visual proportion of architectural landscape (AL_1), grading of visual proportion of roadway landscape (AL_2), grading of visual proportion of sidewalk

landscape (AL_2), grading of visual proportion of greenery landscape (NL_1) and grading of visual proportion of sky landscape (NL_2). Through the test, it has a certain degree of reliability.

3.2. Differentiation and Factor Detection Results

Spatial differentiation and factor detection (correlation analysis) of independent variables and dependent variables were carried out by geographical detector. The results showed that the P values of the points of interest (POI) aggregation, grading of visual proportion of architectural landscape (AL_1), grading of visual proportion of greenery landscape (NL_1) and grading of visual proportion of sky landscape (NL_2) were all 0.000. Through the significance test, the P values of the grading of visual proportion of roadway landscape (AL_2) and that of sidewalk landscape (AL_2) were both greater than 0.05, which failed the significance test.

The points of interest (POI) aggregation has the greatest explanatory power for crowd aggregation, whose q value is 0.73; the explanatory power of visual proportion of architectural landscape comes the second, whose q value is 0.15; the explanatory power of visual proportion of greenery landscape and that of sky landscape is 0.09 and 0.05, respectively.

Table 7. Detection Results of Differentiation and Factors.

	POI	AL_1	AL_2	AL_3	NL_1	NL_2
q statistic	0.727438	0.153047	0.044	0.027794	0.087375	0.0512
p value	0.000	0.000	0.84797	0.831046	0.000	0.000

3.3. Ecological Detection Results

Ecological detection of independent variables is conducted by geographical detector (reliability test of interaction) and the results showed that the values of significance F test were 0.05, which passed the test. See Table 8 for details.

Table 8. Ecological detection results.

	POI	AL_1	AL_2	AL_3	NL_1	NL_2
POI						
AL_1	Y					
AL_2	Y	Y				
AL_3	Y	Y	N			
NL_1	Y	N	N	N		
NL_2	Y	Y	N	N	N	

Note: Sig. F test: 0.05.

3.4. Interaction Detection Results

The geographical detector was used to detect the interaction of independent variables (the effect of interaction) and the results showed that the values of significance F test were 0.05, which passed the test. A double-factor-enhanced interaction was shown between the points of interest (POI) aggregation and the five visual proportion of landscape, between the visual proportion of architectural landscape and that of greenery landscape and between the visual proportion of architectural landscape and that of sky landscape (the explanatory power after interaction is greater than the maximum of the two, but less than the sum of the two explanatory power); a nonlinear enhanced interaction is shown between the visual proportion of architectural landscape and that of roadway landscape, between the visual proportion of architectural landscape and that of sidewalk landscape; between the visual proportion of roadway landscape, that of roadway landscape, that of greenery landscape and that of sky landscape (the explanatory power is greater than the sum of the explanatory power after the interaction). See Table 9 and Table 10 for details. Among them, the interaction between the points of interest (POI) aggregation and the visual proportion of architectural landscape has the strongest explanatory power for the crowd aggregation, reaching 0.76.

Table 9. Explanatory power of interaction detection.

	POI	AL_1	AL_2	AL_3	NL_1	NL_2
POI	0.727438	--	--	--	--	--
AL_1	0.762947	0.153047	--	--	--	--
AL_2	0.756852	0.262613	0.044	--	--	--
AL_3	0.75206	0.210326	0.088727	0.027794	--	--
NL_1	0.752814	0.188893	0.163716	0.145404	0.087375	--
NL_2	0.757777	0.203582	0.143485	0.137828	0.193487	0.0512

Table 10. Characteristics of interaction.

Interact	Weaken Direction	Interact Result		Enhance, nonlinear - Dirction
POI∩AL_1	Weaken			Enhance, nonlinear-
		Interact Result: Enhance, bi-		
POI∩AL_2	Weaken			Enhance, nonlinear-
		Interact Result: Enhance, bi-		
POI∩AL_3	Weaken			Enhance, nonlinear-
		Interact Result: Enhance, bi-		
POI∩NL_1	Weaken			Enhance, nonlinear-
		Interact Result: Enhance, bi-		

Interact	Weaken Direction	Interact Result		Enhance, nonlinear - Dircetion
POI∩NL_2	Weaken			Enhance, nonlinear-
		Interact Result: Enhance, bi-		
AL_1∩AL_2	Weaken			Enhance, nonlinear-
		Interact Result: Enhance, nonlinear-		
AL_1∩AL_3	Weaken			Enhance, nonlinear-
		Interact Result: Enhance, nonlinear-		
AL_1∩NL_1	Weaken			Enhance, nonlinear-
		Interact Result: Enhance, bi-		
AL_1∩NL_2	Weaken			Enhance, nonlinear-
		Interact Result: Enhance, bi-		
AL_2∩AL_3	Weaken			Enhance, nonlinear-
		Interact Result: Enhance, nonlinear-		
AL_2∩NL_1	Weaken			Enhance, nonlinear-
		Interact Result: Enhance, nonlinear-		
AL_2∩NL_2	Weaken			Enhance, nonlinear-
		Interact Result: Enhance, nonlinear-		
AL_3∩NL_1	Weaken			Enhance, nonlinear-
		Interact Result: Enhance, nonlinear-		
AL_3∩NL_2	Weaken			Enhance, nonlinear-
		Interact Result: Enhance, nonlinear-		
NL_1∩NL_2	Weaken			Enhance, nonlinear-
		Interact Result: Enhance, nonlinear-		

3.5. Research Results

Through the empirical analysis of 535 sampling points in downtown Chengdu, the following conclusions are drawn: (1) In the artificial landscape, the visual proportion of architectural landscape has the greatest influence on the crowd aggregation but neither the visual proportion of roadway landscape nor that of sidewalk landscape has significant impact on crowd aggregation. Among them, the explanatory power q of visual proportion of architectural landscape is 0.15; (2) In the natural landscape, both the visual proportion of greenery landscape and that of sky landscape have influence on crowd aggregation and the explanatory power q are 0.09 and 0.05 respectively; (3) The interaction between the visual proportion of architectural landscape and that of greenery landscape or between the former and that of sky landscape show a two-factor enhancement (greater than the maximum of the two, but less than the sum of the two explanatory power) and the interaction between the visual proportion of greenery landscape and that of sky landscape shows non-linear enhancement (greater than the sum of the two explanatory power); (4) There is significant two-factor enhancement effect in the interaction between the visual proportion of architectural landscape and concentration of POI facilities, between that of greenery landscape and concentration of POI facilities and that of sky landscape. Among them, the interaction between the visual proportion of architectural landscape and concentration of POI facilities has the greatest explanatory power whose q value is 0.76. (5) None of the five theoretical hypotheses mentioned above are rejected.

4. Discussions

The results of this study reveal the driving mechanism and explanatory power of the visual proportion of various cultural landscape in urban streets on crowd aggregation. From the research result, we can find that the points of interest (POI) is the main driving force for crowd aggregation, but we can add appropriate cultural landscape to further enhance or reduce crowd aggregation. Among the pairwise interaction, the combination of architectural landscape and points of interest (POI) attracts the most crowds. We will find that there are many buildings and shops in Chunxi Road and Taikoo Li neighborhood, although the visual proportion of greenery landscape and that of sky landscape is very small. Therefore, for blocks that are not popular in the city, we can consider appropriately reducing greenery planting and highlighting buildings so that people can more easily perceive the diversified facilities in the streets, thereby enhancing the vitality of the block.

For roadways and sidewalks, our traditional understanding is that they can attract people and need more construction. But the above conclusions tell us that building roads alone can not gather people, only when roads can better connect the buildings and facilities points, can their attraction be reflected. This also explains why many roadways and sidewalks in the streets are well-renovated but few people move around.

Greenery and sky landscape are also important indicators to describe the quality of street space. However, through research, it is found that although simply increasing greenery and sky landscape can increase the flow of people, it can not greatly increase the popularity. This explains why some modern large green parks or rural tourist areas generally lack popularity. Although there are large areas of walking space, dense greenery landscape, and open sky, the lack of points of interest (POI) inside and around it makes it difficult to constantly attract people. Comparatively speaking, traditional parks, such as Chengdu People's Park, are very lively every day because there are more points of interest (POI) inside and around, roads and facilities are closely combined and the distribution of greenery and sky landscape is appropriate. We'll also find that many of Europe's popular street squares don't have greenery landscape, and the close combination of architecture and points of interest (POI) may be a very

important reason. Take, the famous city square in Europe, San Marco Square in Venice as an example, which is mainly composed of historical buildings, walking square and sky. The buildings with beautiful facade make a good representation of the function and history of related facilities. People can talk with history, perceive religion, and visit the rich small boutiques around.

This research is an expansion based on the analysis of street view pictures and POI facilities, focusing on the correlation analysis of more accurate crowd aggregation data. In the past, the analysis of street view pictures only studied the street landscape structure, landscape evolution characteristics, spatial quality measurement and other aspects [31-33], while the research on POI facilities also paid more attention to the urban functional structure and urban boundary problems represented by POI facilities [34, 35], and there was little research on the driving role of cultural landscape and POI facilities. This study, however, further turns to the problem of crowd aggregation at the theoretical level and quantitative empirical level, deeply explores the driving mechanism, and obtains some valuable results.

5. Conclusions

Based on the above analysis, we can determine that the visual composition of urban street cultural landscape has a certain impact on the regional crowd aggregation, in which the visual proportion of sky, greenery, architecture has a positive impact, and the impact gradually increases, but their individual influence is not strong. Only when they are closely integrated with POI facilities can they maximize their role in gathering people. Based on this, we can imagine an ideal popular urban block: featured by rich points of interest (POI); with the largest visual proportion of architectural landscape, which can clearly represent all kinds of facilities; with the streamlined roadways and sidewalks closely linked to facilities points; with the proper greenery landscape; occasionally with open sky landscape.

The following issues remain to be discussed further in this study. First of all, the range of 500 meters living circle can be further optimized and the delineation based on buffer zone is not fine enough. Thus the real 15-minute walking life circle range can be calculated according to the road network and actual travel characteristics combined with Baidu API route planning function and the evaluation of facility points and crowd aggregation can be carried out on this basis. Secondly, the interaction of different types of points of interest (POI) with different cultural landscape can be further explored. Finally, because the waterscape can not be identified in the existing training set, and there are few waterscapes in the streets of the study area, so this important landscape is missing in this study, and it is necessary to select a more suitable study area in the follow-up study and use a better identification method for supplementary research.

Finally, it is expected that this study can provide quantitative research reference for the reconstruction practice of urban street cultural landscape.

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