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Research Paper

Analysis and Graphical Expression of Vitality Spatial Planning for a Lowland Healthy Campus Community

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ABSTRACT

Based on the literature on campus space, this paper reviews the existing theories on the vitality of public space.Five indicators of public space vitality are obtained: accessibility, visibility, functional mixing, spatial form and green visibility.Through the form of questionnaire survey, the importance and opinions of the masses on the existence of each indicator in campus activity space are understood, and relevant information of spatial cognition is collected.This paper takes the campus public space of Zhejiang Gongshang University as an example to conduct quantitative analysis, quantify the contents of five evaluation indexes of campus spatial characteristics, and analyze the influence of campus public space on users' outdoor activities.Through the establishment of relevant mathematical models, it can be concluded that the change of spatial vitality index (independent variable) will affect the behavior and activities of users (dependent variable), thus obtaining the quantitative calculation method of campus public space vitality.

1. Introduction

Campus construction is the result of continuous evolution with the development needs of the times, society, politics and economy. The campus is not only a scenic park, but also a center of society and culture (Gumprecht, 2007). In the 1990s, the knowledge economy promoted the construction of the campus into a white-hot stage. The university town is formed by the expansion, reconstruction and construction of the university campus. The university campus of this period formed a pattern of divergent spatial networks separated by living areas, teaching areas and sports and leisure areas. The university campus was originally a place full of vitality. However, in the process of development, the contradiction between high-density buildings and low-density human activities has become increasingly prominent, leading to the shortage of campus space vitality.

1.1 Composition of vitality in campus public space

Although some study evaluates the campus-downtown relationship (Adhya, 2009), this paper focus on the relationship between campus community and its internal environment. Keeton R (2011) believes that the lack of campus space function and unreasonable layout, lack of culture characteristic and other issues, that lead to the space, that cannot meet the needs of students, is the reason for the lack of vitality of campus public space. Ujang (2010) suggests that place attachment constructs and place attributes can be used as assessment indicators for future redevelopment of local urban places. Hao Xinhua et al. (2016) found that improving functional density and functional diversity can effectively promote the vitality of residential streets. Ye Yu et al. (2016) have proved that street accessibility, building density and architectural form, and functional mixture are the influencing factors for users to choose outdoor activities.

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It can be seen that the vitality of the campus public space is consistent of two aspects: one is the behavior of people on campus and the other is the material characteristics of the campus space environment. By quantifying the characteristics of campus public space environment the relationship between the physical characteristics of the space environment and the user's behavior activities is found, as well as the corresponding relationship between the material environment and the user's behavioral activity.

1.2 Attribute of vitality of public space in campus

Space does not have vitality, space as a container of activity, its material characteristics are the manifestation of spatial externalization of space. “Vigor” has been used as a key to measuring the quality of public space for a long time. Shan Wenhui (1998) believes that urban vitality comes from the gathering of people and is the inner structure of the city composed of groups and individual activity networks. The public space has several benefits in the view of users (Aziz, 2012). Jiang Difei (2016) put forward that vibrant space could provide humanized life for citizens and improve their quality of life. Ian Bentley (2002) interprets “vigor” as a feature that affects the diverse functions of space spaces, making space a versatile venue for multiple uses. The “vigor” of public space is a physiological and psychological positive reaction to describe the space, it is a description of the positive change of spatial activities, the maintenance and renewal of facilities, and the distribution and organization of the venue.

2. Analysis of vitality of public space in campus

For the study of the vitality of public space, many scholars have given the understanding of vitality in qualitative aspects and proposed environmental characteristics that have an impact on spatial vitality, which can be applied to the dynamic design of campus public space. Schwander (2012) sets up a spatial benchmarking system for university campuses by analyzing the configuration of different campuses and the distribution of open space. Yaylalı-Yıldız B(2013) analyzes the socio-spatial construction of Aegean University and finds that the campus space configuration has a considerable impact on interaction between students by combining students' outdoor activities. Kim(2009) studied difference of place vitality in two central plazas.

Assume that the proposition "Campus space has smooth road accessibility, good visibility, suitable spatial form, sufficient functional mix, and harmonious green landscape five-level indicators, the user's selective activity intensity has increased" was established. Then, in order to find the inner relationship between the two, the quantitative results of the material characteristics of the campus environment are compared with the number of users to form a specific quantitative relationship between human and space materials. Finally, the calculation method of the vitality value of the public space of the university campus and the calculation formula of the vitality of the research object are obtained.

2.1 The source of vitality index in campus

By summarizing the factors affecting the vitality of public space at home and abroad, as the main reference elements in the qualitative and quantitative research of campus public space vitality, it can be concluded that, a part of the qualitative description is still lack of effective data support, and is different from user's real needs and spatial experience. This study is based on the quantitative analysis of the vitality indicators in the campus space. Through literature summarization, questionnaire survey, photographic records and on-site research combined with GIS software, there are five vitality indicators suitable for the campus public space have been screened, namely, spatial form, functional mixture, accessibility, visibility and green looking ratio. Take these as factors that may affect vitality of campus public space. This is used as a key to grasping the “vigor” of the space to verify the campus public space design.

2.2 Composition of Campus Vitality Index

Vitality is embodied in people's selective activities. The level of selective activities represents the frequency of space use. Therefore, the appropriate campus space environment will provide a good place for activities, promote and attract the occurrence of activities, and produce rich space vitality. Hanan (2013) analyzed the use of various open spaces in the ITB campus and found that open space around the classroom play a significant role in outdoor activities and recess activities. The environmental vitality of campus space depends primarily on the environmental characteristics of campus space, for the better activities and communication of the users. The index of public space vitality that can affect user's activities can be grouped into five categories: accessibility, visibility, functional mixture, spatial form and green looking ratio. Here, we briefly describe vibrant public space of environmental characteristics and quantitative methods.

(1) Accessibility: refers to the extent to which a certain site can be reached, having a good road foundation can lead to the purpose;

(2) Visibility: space can be seen or can be perceived and accessed;

(3) Functional mix: a variety of activities and multi-purpose space types in the event venue;

(4) Spatial form: describe the scale, size, shape, height and undulation, enclosure, and site boundary of a space;

(5) Green looking ratio: The environmental composition of the natural elements visible in the field of view;

(6) User activity: The number of selective activities of the user is used to test whether the environmental characteristics of the public space have an impact on the spatial vitality.

3. Attribute analysis of vitality indicators in campus public space

Zhejiang Gongshang University is a typical campus case developed with the rise of Xiasha University Town. Its spatial layout, characteristics, scale and function all accord with the common characteristics and basic mode of campus construction in this period. Therefore, the campus public space of Zhejiang Gongshang University is selected as the object of this study.

The campus public space vitality value (H) is composed of accessibility (A), visibility (V), functional mixture (M), spatial form (S), and green visibility (G), such as Table 1. The spatial activity value H=x1A+x2V+x3F+x4S+x5G, where H is the sum of the number of users in the activity field by observing the after-school period. A (accessibility) is the reachability of the site expressed as 1/ d by the mean distance to the site or the reciprocal formula of time required to reach the site. V (visuality) is the formula for calculating the ratio of the visual area of the site to the total area of the site is V%. F (functional mixture) means the formula for calculating the average number of activities that can be carried out and the number of facilities in the site is (a+F)/2. S (space form) is the surrounding pattern of the site, shape, size and relief of the site and the change of elevation height of the building envelope expressed in terms of the sum of the area of the plane area and the ratio of the perimeter to the aspect of the perimeter, that is, (sh/ch)+s/c. G (green space and water space) in space, the proportion formula of the area of vertical greening within the whole field of vision is g%. Xn refers to the normalized coefficients of the five activity indexes, Xn is the unknown number equation between the quantized values of each index and the number of site users, and the value of Xn is calculated. The calculation formula can be applied to the prediction and evaluation of regional construction activity and to simulate the frequency of users in a certain space. Taking the Xiasha Campus of Zhejiang Gongshang University as an example to carry out quantitative analysis of 40 sample spaces on campus (Figure 1), the expression of campus public space vigor of Zhejiang Gongshang University was obtained.

3.1 Analysis of Accessibility of Campus Public Space

The spatial reachability map of each public space of the Xiasha Campus of Zhejiang Gongshang University is generated, basing on the GIS software, using the O-D cost matrix tool, based on the traffic network, and taking the walking time as the calculation cost. (Figure 2). The impact factors of accessibility (A) mainly include site opening time (t) and average distance (average time) (d), GIS software is used to construct campus road network information, including road length, walking time, and activity space, distribution and attributes (attraction points), distribution and attributes of the dormitory and school building (starting point). By calculating the distance and time of all the dormitory buildings and teaching buildings on the campus to the event venue, we get the "relative accessibility" values of the various activity points on the campus. The larger the result, the further the average distance to the site or the longer the average time, in other words, the resulting value is

Tab.1 Vitality indicators and material characteristics of campus public space

	abbr.	index	impact factor			formula
public space vitality value (H)	A	accessibility	time (t)	mean distance/time (d)		1/d
	V	visibility	visual area (v)	signage system (g)		v
	F	functional mixture	average number of activities (a)	facilities type (f)		(a+f)/2
	S	spatial form	perimeter of the plane (c)	area of the plane (s)	perimeter and area of the profile (ch& sh)	(sh/ch)+s/c
	G	green visibility	area of vertical greening (g)	plant species (p)	water area (w)	g

Fig.1 Campus demand points and public activity space distribution

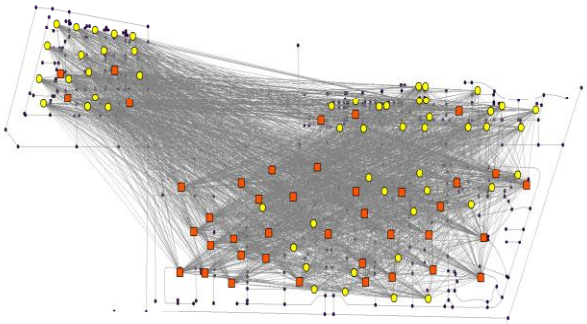

Fig.2 ArcGis O-D cost matrix analysis results

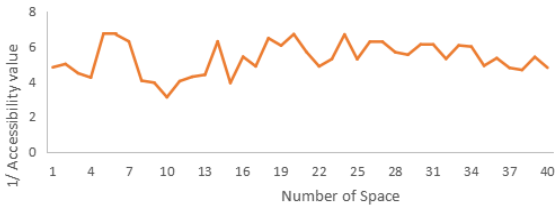

Fig.3 Sample space time accessibility analysis

Fig.4 Campus public space visibility analysis

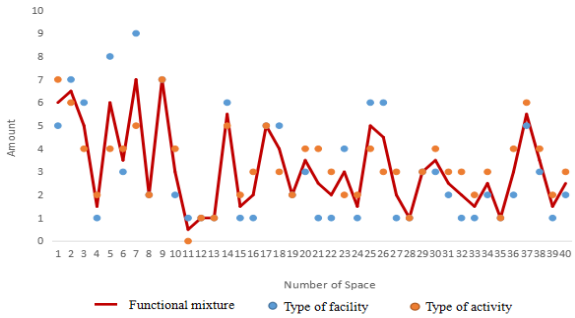

Fig.5 Functional mixture analysis result

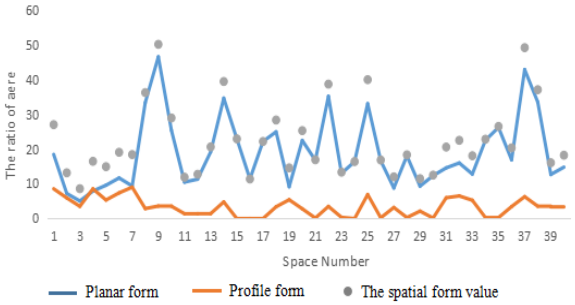

Fig.6 Spatial morphological value analysis result

inversely related to the reachability.Therefore, in order to achieve the positive correlation between the numerical value and the accessibility value, the reciprocal of the accessibility value is used to express the positive correlation degree of the activity site (Fig. 3), which reflects the relative accessibility value of a certain space within the campus.

3.2 Visibility Analysis of Public Space on Campus

Visibility (V) is the visible range of a point in the campus public activity space and the ease with which it is seen. The main constituent element is the area of the field of view (v), and it is also affected by the pilot system (g) and other factors. The area of view is the area of the visible environment of the active site and is influenced by elements such as the surrounding buildings, trees and walls. The visibility calculated in the text is the percentage of the total area (line of sight) by the visible area (the number of lines of sight). In this paper, space syntax and Arcscene software are used to construct thecampus simulation surface with the building as the blocking factor, and the construction line of sight is calculated one by one (all the sights of the entire area seen at a height of 1.5 meters from the ground). All sight lines on the entire surface of the area seen) and site visibility (the number of lines of sight that are not blocked by the building) are obtained for visibility analysis of the public space on campus (Fig.4).

3.3 Functional mixing analysis of campus public space

The functional mix (F) of the campus public space is mainly composed of two aspects, namely, type of activity (a) and type of facility (F). Type of activity (a) refers to the activities of the person, focusing on various behaviors carried out by the person in the place, and the type of facility (f) emphasizes the material constituents present in the site. Different facilities can meet the requirements of people with different activities, facilities and of cross-infiltrated activities. Facilities bring the same activity to people in the venue, or the same facility bring different activities. In summary, the functional mixture of vitality indicators is more reasonable with F=(a+F)/2 as the expression. After on-site observation and statistics, the

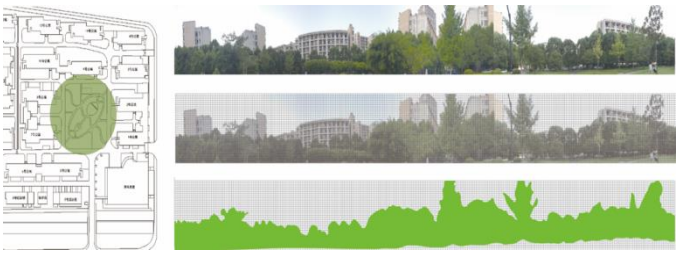

Fig.7 Quantification of vertical green area of space

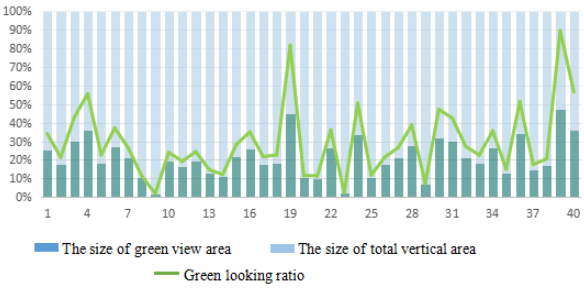

Fig.8 Ratio of green space to space elevation of each sample space

Fig.9 Changes in user activity in different time and space

Tab 2. Vitality index regression model results

Analysis R		Coefficients		t Stat
Multiple R	0.84	Intercept	-36.05	-2.07
R Square	0.74	X Accessibility	4.91	1.52
Adjusted R Square	0.64	X Visuality	97.66	3.3
SE	9.03	X Functional mixture	4.55	2.97

types of facilities and activities in each space site were obtained, and the functional mixed quantitative values of the sites were calculated (Fig. 5).

3.4 Analysis of Spatial Form of Campus Public Space

The spatial form (S) is represented by the perimeter and area ratio. Assuming that the proposition “a rounded field, has a high vitality value” is established, the circumference of the circle is the shortest, when the area is equal, meanwhile, the ratio of the area to the circumference is the largest, when the spatial shape is close to a circle. The shape change of the field is represented by the area and the perimeter ratio. If the ratio of the area to the circumference is larger, the shape of the space is closer to the circle and the rule. The campus is a three-dimensional space consisting horizontal space and vertical space. The campus space is divided into a horizontal space form (planar form) and a vertical space form (profile form) to represent the spatial form of the campus site. The plane shape is represented by the ratio of the plane area (s) to the plane circumference (c): s/c. The profile is the ratio of the cross-sectional area (sh) to the perimeter of the profile (ch): sh/ch to indicate the undulation and height difference of the ground. Therefore,the space form expression of the site is: S = (sh / ch) + s / c. The spatial form value of the site is obtained by site measurement and calculation (Fig. 6).

3.5 Analysis of green looking ratio of campus public space

Green looking ratio (G) is used to indicate the degree of greening of the activity site and the green elevation area (G). Appropriate plants, different plant species and water features help to attract people. On the contrary, the majority of plants or waterscapes reduce the area of the event site, which is not conducive to people's activities. More important in the event venue is the space of the activity itself. Greening serves the space and plays a role of segmentation and shading to promote the vitality of the site. The species and waterscape of the plant are more to provide a quiet and leisure activity space, which has less influence on the vitality of creating space. Here, the ratio of the green area of the facade to the total area is expressed as g%, and the value is larger. It indicates that the area occupied by greening in the week of the human eye is larger. The green visual calculation is based on the green area as the vertical greening. The gray rectangular grid is the space area recorded by the camera at a height of 1.5 meters on the center of the field. The sample space is photographed and patterned in turn, and the green coverage area ratio is calculated(Fig. 7). Green looking ratio (G) is calculated according to the size of the green view area and the total vertical area obtained by the shooting. It is not calculated according to the actual size, therefore, the error in the conversion is reduced. The area in the picture and the green area ratio are more intuitively obtained (Fig. 8).

3.6 Density analysis of user behavior activities in campus public spaces

The density analysis of user behavior in the public space of the campus is to record the overall situation and spatial distribution of the user's activities to illustrate the density of user activities. The weather-appropriate rest period was selected to observe the campus user activities regularly. Also the user's activity track, attributes, behavioral activities, and the use of the space were marked.

The recorded contents include:(1) user's attributes, mainly gender and age group; (2) user's activities, including activity type, number of activities and stay time; (3) spatial distribution characteristics of user activities; (4) informal interviews to understand feelings and intuitive evaluation of users. The superimposed spatial distribution maps of user activities at different time and types are obtained (Fig. 9). The information data, reflecting the sample space and user behavior activities, was recorded into the information base, where it is screened, sorted, classified and analyzed.

3.7 Analysis and Conclusion

According to the preliminary judgement and calculation analysis, there is a big error between the index data, the R is 0.4, the relationship is not significant. Considering the strong influence of the unoccupied sample space and the non-selective activity logarithm, the sample data with low numerical confidence is eliminated, and the correlation coefficient between the vitality index and the user activity is recalculated. Comparative analysis found that spatial morphology, green looking ratio and human selective activity are nonlinear, there is a certain range of influence on the amount of user activity. Excessive or insufficient can not bring a comfortable experience. The linear correlation between accessibility, visibility and functional mixture is highly compatible with the user's activity per moment.

Regression analysis is carried out with the common effective space value of each index and the average number of people at four time points in each space of the campus, and the final statistical result is obtained. The R value is close to 1, indicating that the model has a high degree of fitness with the actuality. The F value is less than 0.05, the confidence level is above 95.5%, and the error t value is small (see Table 2). The relationship model between campus sample space accessibility, visibility, functional mixture and user activity at each moment is formed: Hn=4.91An+97.66Vn+4.55Fn-36.05, where "n" represents different space venues, "H" represents prediction the number of users, "A" represents the accessibility quantified value, "V" represents the visibility quantified value, and "F" represents the visibility quantified value and the functional mixed quantified value.

4. Conclusion

This paper quantifies the physical environment characteristics of campus public space from five aspects of accessibility, visibility, functional mixture, spatial form and green visibility, and observes the behavioral trajectory and density of campus users. Quantitative records, comparative analysis are used to verify the validity of the hypothesis. The verification results are obtained: the environmental feature accessibility, visibility and functional mixture of the public space in the campus are linearly related to the user's selective activities. The spatial form, the green visuality and the user's selective activity are in a downward parabolic relationship.

The vitality of the campus public space is a measure of the relationship between the frequency of campus usage and the components of campus space. A vibrant campus is conducive to enhancing and increasing the user's outdoor activities. The campus public space is an indispensable part of the campus life of all teachers and students. The quality of the space environment plays a decisive role in the overall spatial image and quality of the campus. Under the new people-oriented campus relationship, the contribution of vitality to the planning and construction of the campus public space environment deserves high attention.

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