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The Difference in Cultivating Vitality between Heritage and New Urban Areas

A case study assisted by the multi-sourced data and machine learning

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ABSTRACT

Urban vitality, as the assessment metric for the spatial quality and livable community, is always the goal of urban regeneration and design practice. Nowadays, most heritage areas in cities faced the challenge of vitality regeneration under the premise of heritage preservation. Considering the built environment factors influencing vitality may be different under specific environmental contexts, it deserves more attention to vitalize the heritage area. However, previous research lacks attention to this issue, thus their insights are not suitable for vitality-making in heritage areas. Moreover, the linear relationship between vitality and built environment features has often been assumed, which neglected the nonlinear effects. Recently, advances in machine learning methods combined with the availability of high-precision human activity data have made it possible to explore the complex relationships between environmental features and human spatial activities. This study takes a heritage district and a new area in Guangzhou as the cases, both located in the central area of Guangzhou with 7 km^2 and 15 km^2 respectively. Using the location-based service (LBS) data and gradient boosting decision tree (GBDT) model, this study found the difference between the nonlinear effects of built environment characteristics on vitality in the heritage with that in new town deserves more attention. Furthermore, the contributions of this study can provide a more precise guide for the vitality-oriented design of built environmental features in the Guangzhou heritage area.

KEYWORDS

Urban vitality, Heritage area, Built environment, Nonlinear method, Machine learning

1 INTRODUCTION

In the 20th century, many megacities, have moved from a phase of rapid expansion to urban renewal, witnessing a dynamic process of decline and revival in the heritage areas. Meanwhile, heritage preservation undergoing a paradigm shift from individual to group and regional conservation (Francesco and Ron, 2012). In this context, heritage preservation becomes the innovative urban strategy to generate new economic, cultural, and social values and support sustainable development (Della Spina, 2019). As a response, heritage adaptation (Meyer, 2020), with the awareness of adaptation to the changes in urban external conditions, such as climate and socioeconomics, has received widespread attention. It aims at facilitating social interaction and economic development through diversified use (Koohafkan and Cruz, 2011; Camargo et al., 2014). Vitality, as originally described, indicates the degree to which the form of spaces supports the vital functions, biological requirements, and capabilities of human beings. Therefore, cultivating or maintaining vitality in heritage areas while preserving heritage has become an important objective in urban regeneration and design practice.

The factors that influence urban vitality are widely discussed. In previous research, vitality is often regarded as a spatial representation of human social activities (Jacobs, 1961; Gehl, 2013) and determined by various socioeconomic features. On the other hand, it is also related to urban form features like land-use mixture, spatial network, and block size from the morphological theory (Ye et al., 2018; Long and Huang, 2019; Chen et al., 2021). Recently, with the emergence of various big data, some researchers have been expanding their attention to the human scale morphological features extracted from the street-view images like the vegetation or sky visual degree (Yang et al., 2021). Moreover, some researchers start to focus on the detailed functional features like the density and diversity of urban services assisted by big data, e.g., point of interest data (Yue et al., 2017). However, the relationship between vitality and various built environment features under the historical environment hasn't been fully discussed.

The influence of environmental characteristics on the vitality of heritage areas differs from those of other urban areas due to their differences in socio-economic, urban form, and function. First of all, the heritage district in urban central areas often exhibits highly mixed functions, overly commercialization, and excessive tourism. Although these characteristics bring about the popularity of the heritage areas, they also contribute to the increase of land values, and even lead to the loss of indigenous people and increased mobility of tenants. In addition, the heritage spatial pattern, which may be spontaneous or derived from earlier planning concepts, is significantly different from the new urban zones planned and built in recent years. In China, the heritage areas in the urban central areas are often characterized by low development intensity and high density, which are associated with high vitality. It also should be noted that the spatial form in heritage areas has strict planning restrictions that prevent them from changing. Therefore, much of the vitality relies on the social relationships established during the long-term urban development and the facilities provided in the short term. It is necessary to emphasize the interaction and coordination of form and function over the long term would influence the intensity of activities in heritage areas (Wang et al., 2018). Therefore, to vitalize the heritage areas, it is necessary to consider the characteristics of the historical environment, and the comparison of influence between different areas based on the case of heritage and new district can help to shed more light on this key issue.

In terms of the research methodology, there has been a considerable amount of empirical research that has provided quantitative insights into the impact of various indicators on vitality, however, most research was conducted based on the assumption of linearity (Long and Huang, 2019; Ye et al., 2018; Zeng et al., 2018). Given the prevalence of non-linear relationships between human behavior and spatial environments, such as diminishing returns to investment and collective behavioral choice models (Galster, 2018). There is a paucity of attention to the vitality of historic cities, although there has been a recent surge in research exploring the non-linear effects of built environments based on machine learning methods.

In response, this study aims to propose a more comprehensive strategy for the vitality regeneration of heritage districts. On the one hand, the non-linear machine learning approach is used to propose specific indicator guidance for the vitality regeneration in the heritage areas, revealing the significant built environment elements and their effective range. On the other, the study compares the development, socio-economic, and built environment features between heritage districts and the newly-built area. The influence patterns obtained from the regression analysis bring a more comprehensive view of the vitality-oriented urban design in the heritage area.

2 DATASETS AND METHODS

2.1 Research design and Study area

As suggested by Montgomery (1995), urban vitality is a concept, that reflects “the extent to which a place feels alive or lively”. That has also been further clarified by Mehta (2007), a lively place is where many people participate in a series of fixed or continuous activities. Therefore, the intensity of various social activities can be used to measure urban vitality. Besides, the urban vitality, is widely considered as a result of the multidimensional socio-economic and built environment factors. Thus, in this study, the intensity of vitality could serve as the dependent variable in the regression model to analyze the influence of built environment factors on vitality. Then, the independent variables were measured through built-environment characteristics in three aspects, i.e., the socio-economic, morphological, and functional features. The detailed reasons for the selection of each indicator are shown in section 2.2 below. Subsequently, a descriptive analysis was firstly conducted to reveal the characteristics of built-environmental features in the Beijing road heritage district and the Pearl_river newly-built area. Then, two GBDT models of regression analysis have been performed, to find the detailed influence of built-environmental features on vitality between the heritage area and the newly-built area.

This study takes the Beijing road heritage district (7.1 km²) and the Pearl_river new town (15.4 km²) as the sample. On the one hand, the Beijing road heritage district is a representative public center of the old urban area in Guangzhou, with a high mix of office, residential, and tourism services (Figure 1). The history of the Beijing road heritage district can date back to the 1920s. The texture of this area, i.e., the road network, cavalry streets, and water system was mainly formed before the 1950s. On the other hand, the Pearl_river new town is a typical newly-built central area in Guangzhou. It was planned and built-in 199the 0s, having many similarities to the Beijing road heritage district in functional and location characteristics. Thus, it could be used as the comparison sample (Figure 1) to reveal the differences in the influence of environmental factors on vitality in the heritage and newly-built areas.

In addition, the block is selected as the analysis unit for this study. One reason is that block is always the spatial unit to intervene in urban design practice. It is often designated with specific functions in statutory urban planning in China. In addition, the block is widely used as the research unit to quantify the urban form in the Conzenian approaches (Wu et al., 2019; Zhang et al., 2021). In the dataset of this study, the blocks have no functional facilities or building footprints, and those larger than 20ha, were deleted. That is because these blocks may be ecological green spaces or outdoor sports fields, thus they are not comparable to other block samples. Finally, there are 972 blocks in the heritage district and 573 blocks in the Pearl_river new town were selected as the formal dataset for the following analysis.

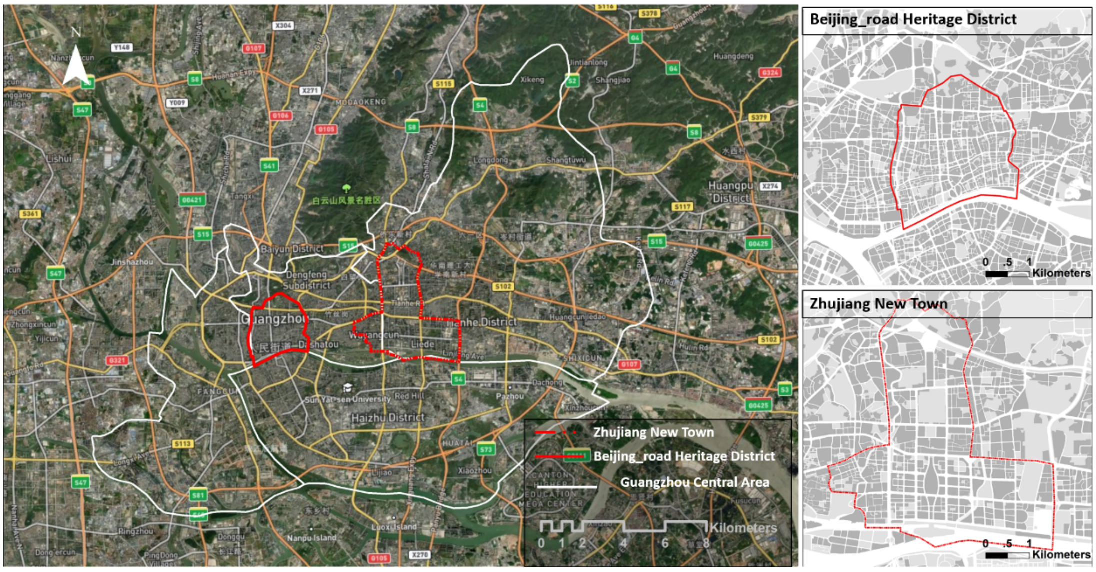

Figure 1. The location of Beijing road heritage district and Pearl river new town in Guangzhou.

2.2 Research design and Study area

Dependent variables

The availability of location-based service (LBS) data provides an alternative to the costly collection of the environmental behavior in many studies (De Nadai et al., 2016; Sulis et al., 2018). At present, various types of LBS data (such as mobile phones, bus cards, taxis, and taxi trajectory data) have been used to characterize social vitality, identify the characteristics of living space (Jin et al., 2017), and different travel modes (Csáji et al., 2013), and accurately establish large-scale spatial behavior patterns at the individual level (Hollenstein and Purves, 2010). Analyses based on spatial and temporal distribution patterns could measure the density of social activities as a quantitative indicator of vitality. Therefore, to a certain extent, LBS data can be used to measure street activity intensity.

Among the various types of LBS data, the mobile internet LBS data generated through GPS have a high spatial resolution. Meanwhile, this kind of data plays an increasingly important role in the study of street vitality (Zeng et al., 2018). Thus, the LBS location data used in this study are user anonymous geo-location data generated through GPS and provided by TalkingData – one of the largest data service providers in China. The data collected in this study cover more than 60% of the actual population contributing to street vitality (TalkingData, 2019). Besides, it covers a whole week (24 h × 7 days) in the second quarter of 2019, helping to reveal the spatiotemporal vitality of the site aggregated by the block. Then, given that the value remained stable during the day hours, the aggregate value of activity intensity from 6 am to 1 am was used as the dependent variable.

Independent variables

The independent variables include three groups, i.e., morphological, functional, and socioeconomic features. For morphological features, the street network accessibility, floor area ratio (FAR), building density, road density, block size, and land use mixture are included, which all have been proven to have associations with vitality in related research. For example, it has been proved that the street network accessibility measured by space syntax is an important factor to influence urban vitality (Hillier et al., 1993). Thus, the walking and driving accessibility was measured by angular segment analysis, with the radius being set as 500 m and 1500 m, respectively (Zhang and Chiaradia, 2019; van Nes and Yamu, 2021). In addition, the FAR, building density, and road density are essential indicators to measure the concentration degree of land use. Furthermore, the smaller block has always been regarded as an environmenfactortors to facilitate social contact (Long and Huang, 2019). Finally, the function entropy was calculated to characterize the land use mixture based on the points of interest (PoIs) data obtained from Amap (2019). It has been proved to be an important characteristic to attract public activities by providing various services (Yue et al., 2017).

The functional characteristics include multiple indicators in there sub-dimensions. First, the daily service availability has a tight association with human needs. The daily services like shopping, catering, leisure, and living facilities can gather social activity within a certain distance. Thus, the daily service availability is measured by the number of PoIs within the 1000m circle of the block, a distance that has been widely regarded as the 15-minute living cycle in China. Second, the proximity of public facilities like the subway, bus stations, cultural venues, hospitals, and primary schools, has also been proved significant to human activities. Considering the irreplaceability of these public services. the nearest accessible distance of the facility was used as a proxy for the indicator of public service proximity. Third, previous research emphasized the importance of functional diversity. Thus the diversity of catering, living, shopping, and leisure facilities was calculated respectively to further reveal the detailed impact of different categories. The specifics of each type of function are explained in table 1.

Table 1 Facility classification

Facility type	Specifics
Catering	Restaurants, Fast food shops, Cake and dessert shops, Cafes, Teahouses, etc.
Shopping	Shopping centers, malls, Supermarkets, Convenience stores, Small shops, etc.
Living	Post office, Laundry, Repair station, Pet service, Hairdressing, etc.
Leisure	Cinema, KTV, Theatre, Internet cafe, Baths and massage, Leisure plaza, Bar and nightclub, Fitness center, etc.

As to the socioeconomic features, the permanent population density was included and measured by the data extracted from the 6th census published by the government. It has been always considered an indicator of social concentration, and the most essential condition for generating urban activity. Moreover, the community average house price, as a popular indicator of the economic level, is also included based on the data collected by *Fangtianxia*, the largest residential sales and rental platform website in china. Apart from that, the community could also be obtained from this platform. Finally, the indicator of whether there is a historic site within the block was used as a dummy variable in this study to examine the direct impact of historical sites on urban vitality.

2.3 Nonlinear model

This study has built two models based on the dataset of the Beijing road heritage district and Pearl_river new town respectively, to find the difference of influences of built environment factors on urban vitality. Specifically, the GBDT model was employed to conduct the regression analysis to explore the association between variables. The basic principle of GBDT is to classify samples into sub-groups through decision trees, build many single decision trees, and then combine the results of these decision trees. Compared with the traditional multiple regression and the discrete choice model, the GBDT model does not require the response to follow any assumption, and it can accommodate variables with missing values, handle multicollinearity better, and offer more accurate predictions (Ding et al., 2018).

Then the “scikit-learn” package in the Python programming language has been applied to estimate the GBDT models. To obtain robust model results, we set key parameters to address potential overfitting, including the number of estimators, and learning rate, and used a five-fold cross-validation procedure. Specifically, the sample was divided into five subsets. The model was fitted using four different subsets (80% of the data), and validated by the remaining subset (20% of the data). This process was repeated five times. The mean square error of the final two models were shown in table 2.

Table 2. The parameters and results of the GBDT models.

		Beijing_road Heritage district	Pearl_river New Town
Parameters	n_estimaters	5000.00	3000.00
	Learning rate	0.05	0.01
Results	MAP	12423.38	24644.40
	R2	0.77	2.76

3 RESULTS

3.1 The description of built environment features and vitality.

The value range of socioeconomic, morphological, and functional features is plotted in figure 2, from which we can compare the difference of multi-dimensional indicators in the heritage district with those in the Pearl_river new town and the central area of Guangzhou.

For the socioeconomic aspects, the house price, building age, and population density have the almost same average at around 40,000 yuan/㎡, 20 years, and 16,000 people/km² respectively. Except that the range of population density and building age in the Beijing road heritage district is slightly higher than that in the new town, the overall range of them in these two areas is similar.

As to the morphological group, the corresponding indicators show more obvious differences. Specifically, the network accessibility, mixture, and block size, and is lower in the heritage district than in others, while the building density is much higher than in the new town. The average block size, FAR, road density, and building density deserves attention in practice, which is around 0.3 hectare, 2.5, 23 km/km2, and 0.45 respectively.

In terms of the functional features, firstly, all kinds of daily service availability indicators in the historical area are generally higher, and the shopping facilities show a larger gap when compared with other areas. Secondly, for the public service proximity, the value of primary school and hospital proximity in the heritage district is a little bit lower than that in the new town. Finally, as to the functional diversity, the range between the heritage district and the new town in the diversity of leisure, living, and shopping facilities, except for the diversity of catering facilities in the new town is larger than that in the heritage district, which also Validates the fact that both are mixed areas. As to the average for the diversity of these four types of service, compared to the new town, the heritage district is slightly higher for the diversity of living and leisure facilities but lower for the diversity of catering and shopping facilities.

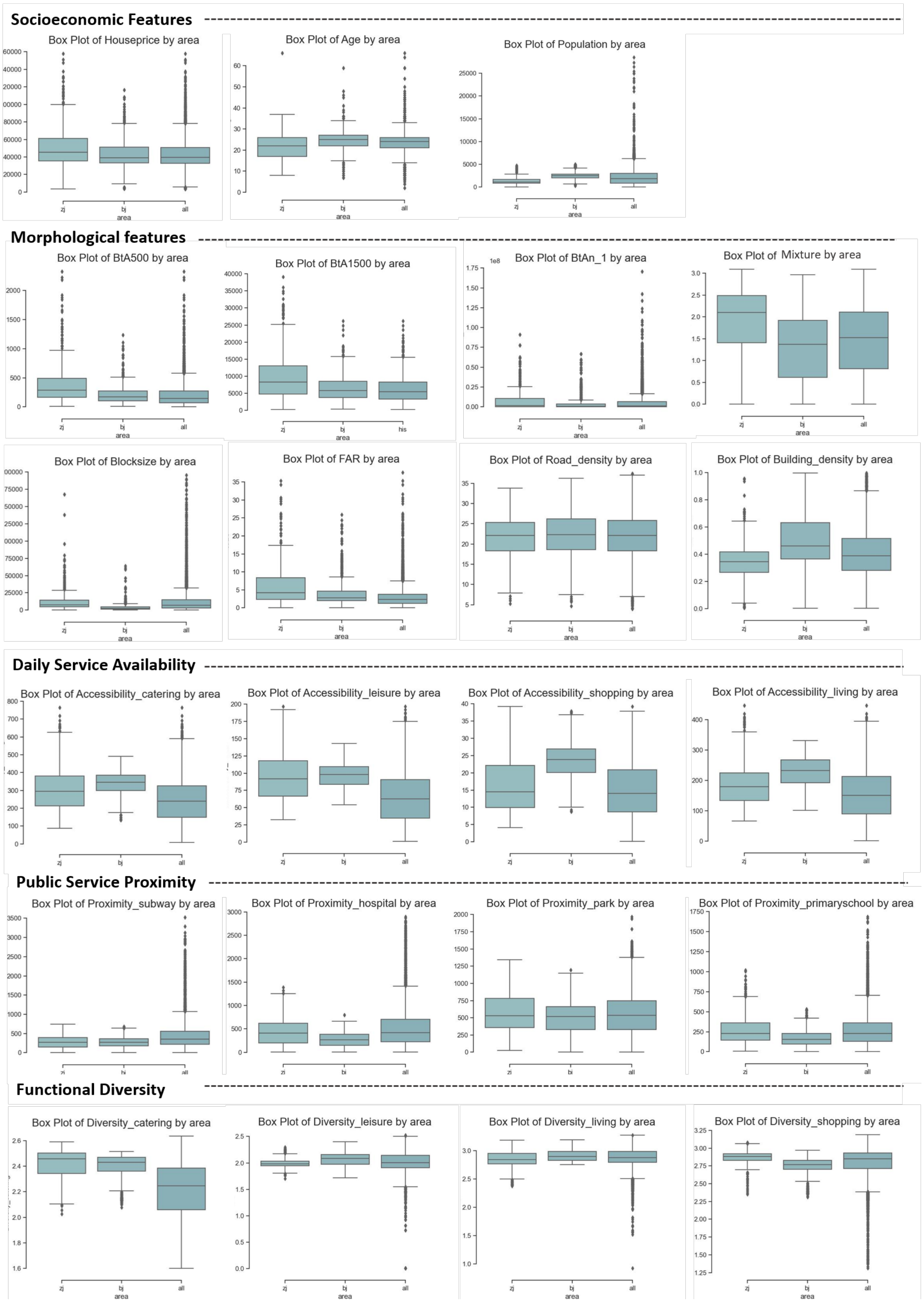

Figure 2. the descriptive analysis of independent variables. ("bj" for Beijing Road Heritage District; "zj" for Pearl_river New Town; "all" for Guangzhou Central Area.)

3.2 The comparison of the relative importance of features between two areas.

The relative importance of independent variables is shown in table 3. First of all, there are several commonplaces between these two models' results from the overall perspective of the relative importance of each group indicator. Specifically, the accessibility of the daily service is the dominant group of features for vitality, followed by public service proximity and morphological groups. The functional diversity indicators and socio-economic indicators rank bottom. In terms of each group of indicators, pedestrian network accessibility is the highest among the morphological indicators, followed by block size, vehicular accessibility, FAR, building design, and finally road density. Among the daily service accessibility indicators, the relative importance of catering accessibility is the highest. For the group of public service proximity indicators, subway proximity is the most important feature. Among the group of facilities diversity, the prominent one is the level of small categories. Finally, for the demographic and economic indicators, the residential density is the decisive factor, followed by building age and house price.

As to the difference between these two areas, the overall relative importance of morphological features is lower than that of the function features, and the gap between these two groups of indicators is narrow in the Beijing road heritage district. In terms of each group, among the urban services availability indicators, the relative importance of shopping facilities is higher than living facilities' availability in Beijing Road Heritage district, with the opposite rank for Pearl_river New Town. In terms of public service proximity, the Beijing Road Heritage district ranks in the top three for proximity to the subway, park, and hospital, higher than that of primary school and bus station, while the Pearl River New Town ranks higher for subway proximity with a lower value for the park, and hospital. For the group of socioeconomic indicators in the Beijing road heritage district, the relative importance of housing price is almost twice higher than of building age, with the opposite rank for Pearl_river New Town.

Table 3 The relative importance of independent indicators.

Categories	Indicators	Beijing road Heritage district		Pearl River New Town	
		Relative Importance	Rank	Relative Importance	Rank
Socioeconomic Features	Population density	0.053	8	0.024	15
	Community_age	0.011	22	0.029	12
	House price	0.024	17	0.012	22
	Land use	0.006	23	0.005	23
	Historical site	0.001	24	0.000	24
		0.10		0.07	
Morphological Features	BtA500	0.122	2	0.059	5
	Block size	0.032	12	0.038	10
	BtA_n	0.031	14	0.044	9
	BtA1500	0.015	19	0.051	6
	FAR	0.022	18	0.022	16
	Building density	0.011	21	0.024	14
	Road density	0.012	20	0.014	20

		0.25		0.25	
Daily Service Availability	catering	0.129	1	0.235	1
	shopping	0.073	4	0.043825	8
	leisure	0.060	6	0.060165	4
	living	0.032	13	0.073464	3
		0.29		0.41	
Public Service Proximity	subway	0.084	3	0.103	2
	park	0.046	9	0.014	21
	hospital	0.034	10	0.016	18
	primary school	0.027	16	0.016	17
		0.19		0.15	
Functional Diversity	catering	0.060	5	0.047	7
	shopping	0.053	7	0.015	19
	living	0.032	11	0.024	13
	leisure	0.028	15	0.031	11
		0.17		0.12	

3.3 The comparison of nonlinear effects of features on vitality.

In this study, the partial dependence plot could be used to show the influence of one factor on the intensity of vitality. In another word, it demonstrates how the intensity of urban vitality change with the change of one of the indicators while the other variables remain unchanged. Thus, the x-axis indicates the value of the corresponding independent variables. The y-axis indicates the predicted intensity of urban vitality.

1) Morphological features

As shown in figure 3, first of all, the pedestrian network accessibility has a positive effect in both areas, with the vitality of the Heritage district increasing rapidly at the beginning, and fading away at 400, while the vitality of New Town continues to rise. The vehicular accessibility has a positive effect on vitality in both areas at the beginning, jumps at certain thresholds, and transformed into a negative effect when exceeding a point. And the turning point in the heritage district occurs earlier with the vitality in the new town remaining stable when beyond 2. The block size has a negative effect with a threshold beyond which the marginal effect fades away in both areas. With the increase in Floor area ratio, the vitality of both area increase when exceeding a certain point, while that point occurs earlier in the heritage district.

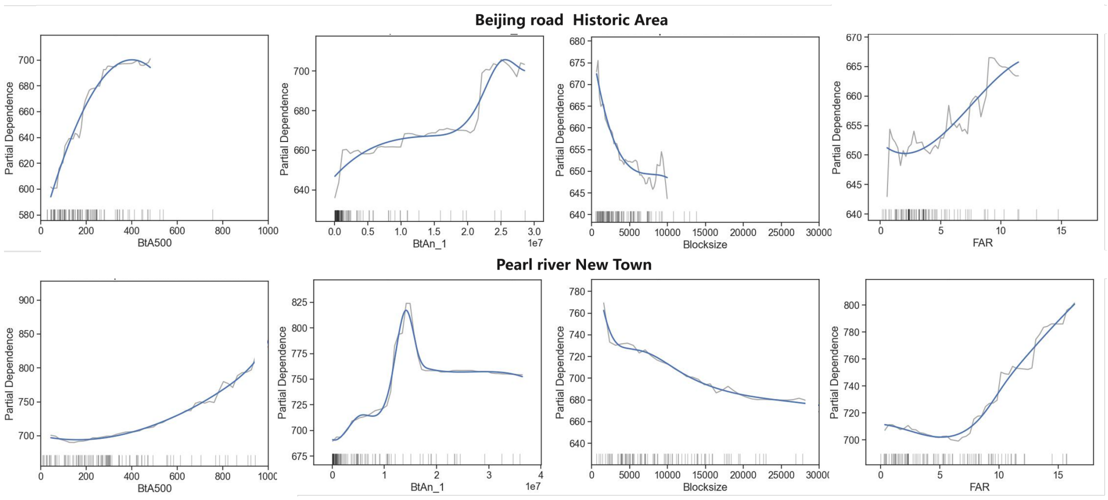

Figure 3. The comparison of the effects of morphological features between two areas.

2) Availability of daily service.

As shown in figure 4, the availability of daily service shows a prevalent nonlinear effect on vitality in both areas. For the availability of catering facilities, both areas have a threshold, beyond which vitality rises rapidly, while the threshold in the Heritage district appears later than that of New Town. The first rise of vitality in the New Town occurs at 250-320 and then remains stable. As to leisure facilities, there is a similar trend in these two areas within the range of 60 to100, except that the turning point in the Heritage district appeared earlier at 80. When beyond 100, the vitality of the Heritage district rises rapidly while that of New Town continues to fall. The availability of shopping facilities, in both areas, show a similar upward and then downward trend within 10-18, while the change the turning point in the Historic Urban area occurring earlier. Then, the vitality of both areas increased significantly after 27, while the vitality of the Historic Urban area shows a stable trend after 30. As for the availability of living facilities, the turning point for both is 170, with the impact moving from positive to negative. The difference occurs when exceeding 250, that a continuous decline in Heritage district but a slight increase in New Town.

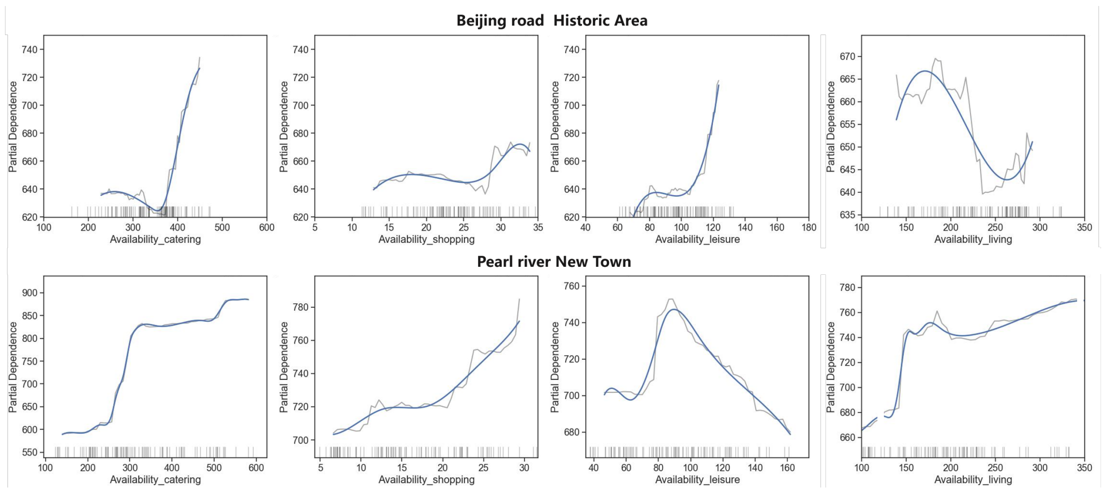

Figure 4. The comparison of effects from the indicators of daily service availability.

3) Proximity to public service

The effects of proximity to public facilities on vitality are plotted in figure 5. First, the proximity to subway stations shows an almost identical impact on the vitality of both areas, with a steady increase from 0.002-0.01 (i.e., the nearest distance to the subway station is from 500m to 100m), while when exceeding 0.1 (the corresponding distance less than 100m) there are two dramatic increase of vitality in the Heritage District and a stable trend in the new town. Second, the effect of proximity to a park on vitality has a similar varying trend in these two areas. In the Heritage district, it turns from negative to positive at 0.002 (i.e. the closest distance to the park is greater than 500m) while the turning point occurs at 0.005 in the new town. Third, the proximity to the hospital and primary school has a similar tendency to climb and then remain stable for both areas. Compared to that for the Pearl_river new town, the threshold in the Heritage District is smaller for the proximity to the park at around 0.005 (200m) while larger for the proximity to primary school at around 0.01.

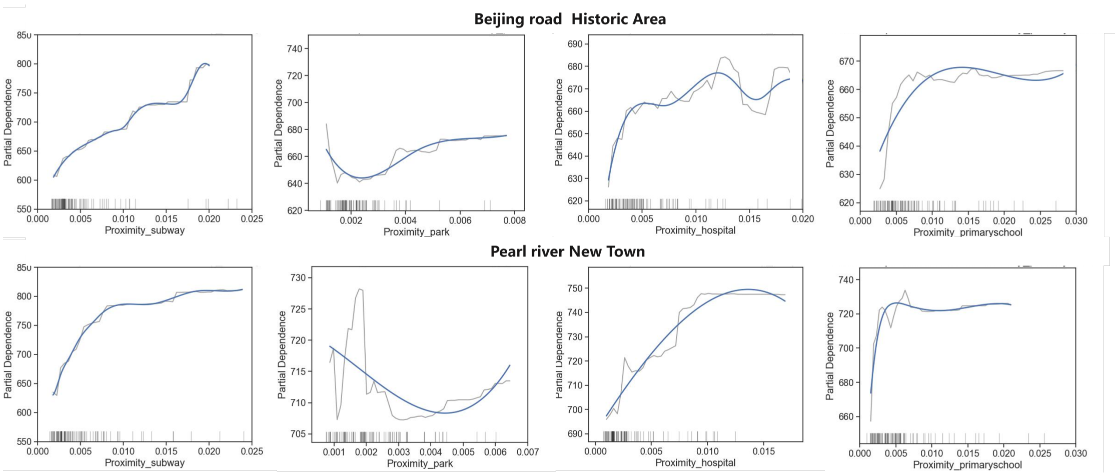

Figure 5. The comparison of effects from the indicators of proximity to public service.

4) Functional diversity

The effect of the indicators related to the functional diversity is shown in figure 6. In terms of the diversity of catering facilities, both areas show a downward first and then an upward trend, except that the turning point of the Heritage district occurs later. In addition, the diversity of shopping facilities in both areas shows an opposite trend, with general a decrease in the heritage district but an increasing trend in the new town. Furthermore, the diversity of leisure facilities has almost no effect on vitality in the historical district but has a significant boost in the new town at the beginning, and then remains stable. Finally, the diversity of living facilities witness a similar first fall and then climb trend in these two areas, except that the change of vitality in the heritage districts is more moderate.

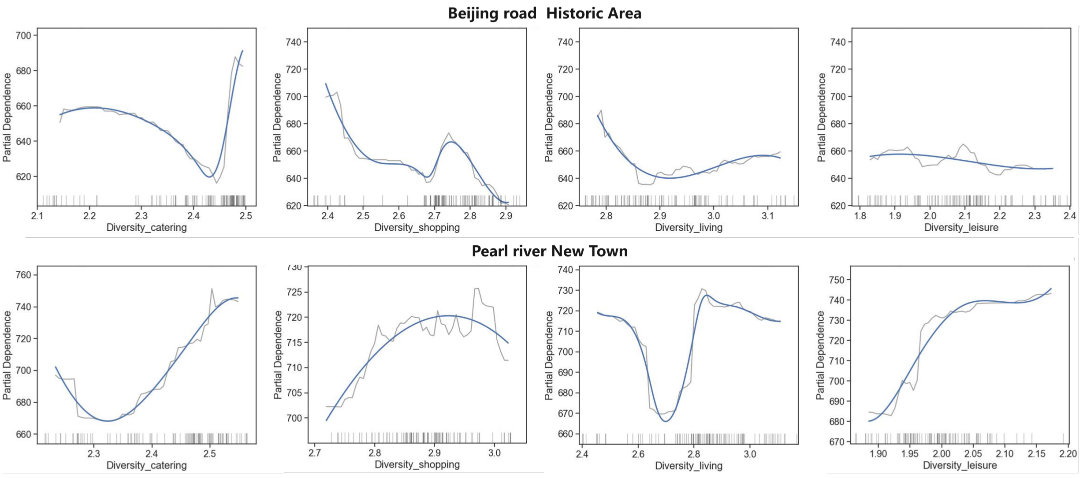

Figure 6. The comparison of effects from the indicators of functional diversity.

4 DISCUSSION

4.1 The important factors influencing the vitality in heritage districts.

The top third of elements in terms of relative importance were considered to be the more important indicators. The accessibility of the pedestrian network, the diversity and accessibility of catering services, the accessibility of shopping services, and the proximity to the subway station are all important factors for both areas. The impact of these factors has also been validated in many studies, for example, catering service is the most conducive to gathering popularity; as well as the accessibility to shopping service, which is easy to attract activities; The pedestrian network accessibility reflects a good spatial network pattern and is conducive to triggering pedestrian flow.

In terms of the differences between the two areas, firstly, the relative importance of population density and house price in the heritage district is higher, which may be attributed to the fact that because the Pearl_river new town, as a newly developed area, has generally lower and more evenly distributed residents, which is difficult to have a significant impact on vitality. The relative importance of community age is higher in Pearl_river’s new town because it's more mixed of the old and the new communities, thus the age brings a greater difference in vitality. As to the functional aspect, the diversity and accessibility of shopping facilities are more important in the Beijing road heritage districts than that in Pearl_river new town. The accessibility of living services, on the contrary, is less important in the heritage districts, which is due to the lack of living services in Pearl_river new town, with the living facilities concentrated in the residential areas. In addition, the relative importance of the proximity to the park and hospital is much higher in the heritage district than in the New Town. Probably because the parks around the Beijing Road heritage district are mainly historical sites, with a deeper history, thus more likely to gather public activities.

Finally, in terms of morphology indicators, both vehicular accessibility and cycling accessibility rank relatively low in the historical district, as the roads in the new district were built under specific guidelines in urban planning to create a clearer hierarchy of roads and a functional arrangement beside the road, so that these indicators have a clearer difference of impact on vitality in the Pearl_river new town.

4.2 The influence of important factors on vitality in the heritage district.

The influence of the multi-dimensional factors on vitality can be inferred from the partial dependence plots. First of all, the variables can be divided into two categories according to whether they have a similar impact trend in the two areas. Most of the important factors have a similar overall impact on the two areas, including proximity to the subway station, accessibility to catering and shopping services, and diversity of catering services. Firstly, proximity to the subway tends to increase and then stabilize after a certain threshold in both areas, which is reasonable as this variable means more popularity, while when beyond a point will conclude mostly transit traffic behavior. Secondly, the accessibility of catering and shopping services in both areas tends to increase rapidly above a certain threshold, as both areas have a greater diversity of services in the whole of Guangzhou. Therefore, the two indicators have a more significant effect on social activities when the facilities reach a certain level of aggregation to form a business district. The diversity of catering and shopping services shows a decreasing first and then increasing trend in both areas. Finally, pedestrian accessibility has an overall positive effect in both areas, as a block with higher pedestrian accessibility is mostly smaller and adjacent to open public spaces or services.

As for the differences in influences, although the overall impact of the indicators in the Heritage district discussed above is similar to that in the new town, the thresholds may be smaller or larger. To summarise, the thresholds for subway proximity, availability of catering, and shopping services emerge later in the Heritage District, which is reasonable as the smaller block size in a heritage district may lead to more sustainable improvements of vitality with the corresponding functional characteristics are enhanced. By contrast, the thresholds for pedestrian accessibility emerge earlier in the Heritage District, which is attributed to the fact that changes in morphological factors may not have much impact in heritage districts due to its stricter controls in urban planning. This can also be confirmed by the comparison of influences on the impact of block size and floor area ratio (figure 3).

5 CONCLUSIONS

The main research questions in this study are how the built environment affects the vitality of the heritage area, and what are the differences in the influence between heritage and new urban areas. Therefore, the nonlinear effect of socioeconomic, morphological, and functional features on vitality with the data in the Beijing road heritage district was analyzed based on the machine learning method. Meanwhile, the Pearl_river new town was selected as a comparison case, to capture the characteristics of the vitality and its related factors in the heritage district by analysing the differences of the nonlinear models in these two areas. With empirical evidence from the analysis, the following conclusions can be drawn.

Firstly, several important factors are important in both heritage and new town areas, like the walking network accessibility, availability of catering and shopping services, proximity to the subway station, and diversity of catering facilities. However, some built environment features that affect the vitality of the heritage area differ from those that affect the vitality of the new urban area in Guangzhou, which deserves more attention. The population density, availability, and diversity of shopping services are relatively more important to vitality in the heritage area, but they may have a wide range of rankings in different urban areas.

Second, the nonlinear effects of the built environment on vitality are common. It is important to focus on the important variables in the heritage district having different influencing trends with the new town, including accessibility to leisure facilities and diversity of shopping facilities. While the important features with consistent influencing characteristics include the resident population density, accessibility to catering and shopping services, proximity to subway station diversity of catering facilities, and pedestrian network accessibility. Those indicators deserve attention to their specific thresholds. And generally, the thresholds for the morphological features occur earlier in the heritage area than that in the new area.

Overall, the understanding of the factors influencing the vitality of the heritage district and their nonlinear effects can help to guide a better urban renewal and design practice. However, there are several limitations to this study. The study results may be biased or possibly vary due to the case characteristics, but these two cases are the representation of heritage and new areas in a megacity. Focus on the factors affecting the vitality of heritage areas on the block scale is rare in the previous study, and this study is the first to compare those with the new town area. In the future, this study can be used as evidence to provide references for planning and design to improve the vitality of heritage areas and revitalize cities.

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