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The Accessibility of Urban Parks and the Morphological Characters of Street Networks: A Case Study of Tangu Area in Tianjin, China

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Abstract: The paper proposes the natural movement of residents as references to improve the accessibility of urban parks through space syntax analysis on morphological characters of street networks. Different from using Integrity of streets to describe the accessibility in general, the results suggest the space syntax parameter, Normalized Angular Choice (NACH), as an indicator of accessibility of urban parks, as the area and the number of entrances of urban parks are positively correlated with NACH. The results indicate the accessibility of urban parks is under the inertia of urban planning ideas and policies in the past through their distribution and positions of entrances. The morphological character of street networks caused by the natural movement should be considered in improving the accessibility of urban parks through setting parks and their entrances at appropriate places in the whole street networks across scales.

Keywords: Urban Parks; Accessibility; Urban; Morphology; Space Syntax

1. Introduction

With the rapid urbanization and fast increase of people's living standards in China, the planning of urban green space system concerns both ecological and social benefits. The social benefits are explained as the potential for residents to get into the parks fairly and conveniently, which means the accessibility of urban parks (Liu, Li & Han, 2010). In general, the accessibility of urban parks describes as the resistance for people to enter the parks, measuring indicators like distance, time, or cost through several methods, like the Network Analysis, Buffer Zone Analysis, Gravity Model Method, etc. The Network Analysis is more accurate than the Buffer Zone Method suggests that the measurement of accessibility of urban parks should consider the characters of the street networks (Comber, Brunsdon & Green, 2008).

Bill Hillier and his colleagues investigated the morphological characters of street networks by space syntax, in which the movement of people along the pedestrians is caused by the morphology of urban grids (Hillier, 1999). Despite the characters of the routes to get into urban parks influence the utilization of parks (Dills, Rutt & Mumford, 2012), the relation between the parameters of space syntax and the distribution of urban parks remains insufficient research (Huang, Chiou & Li, 2020).

The paper aims to improve the accessibility of urban parks considering the characters of street networks to meet the design criteria. The first step is to find appropriate parameters from space syntax to describe the accessibility of urban parks. Then evaluate the accessibility of each type of urban park to figure out potential interventions to improve it. The results would provide references for the plan proposed by the government in Tianjin, 'the living circle in 15 minutes from 2020 in a post-pandemic scenario.

2. Methodology

2.1 Data

The basic data comes from Gaode Map and the official records. Urban parks are classified according to the *Standard for Classification of Urban Green Space (CJJ/T85-2017)*. There are five types of urban parks: Country Park (EG1), City Park (G11, larger than 10 ha), Community Park (G12, with the area between 1-10 ha), Specific Park (G13, with specific functions, like zoos and botanical gardens), Pocket Park (G14, smaller than 1 ha). The entrances are the summary of remote sensing images and POI data.

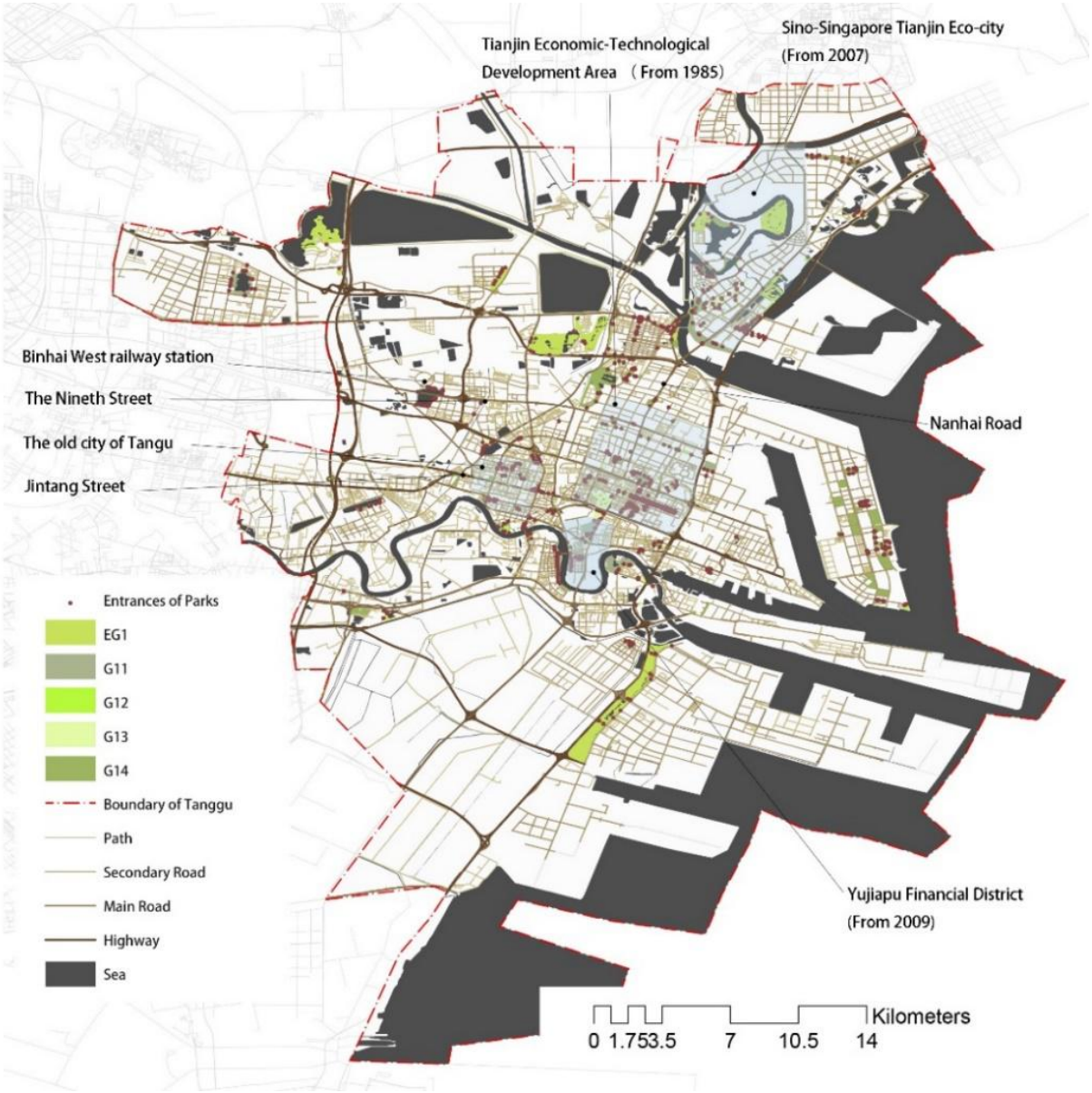

Figure 1 The Street Network and the Distribution of Urban Parks in Tanggu

2.2 Angular Segment Analysis of Space Syntax

The space syntax describes the streets through topology as the configurational characters which come from the behaviour of navigation and visual perception of human beings. In the navigation behaviour, the routes from one street to other streets in the network system can be measured by the least turns and the metric distance (Hillier & Iida, 2005), which calls the angular segment analysis in Depthmap.

Although the choice of destination involves individual preference and the attractiveness of destinations, when other factors are the same, natural movement means the movement of people will be decided by the allocation of the possibility to

arrive at the street with the least steps from other streets in the system. The configuration of streets itself causes natural movement (Hillier, et al., 1993). The space syntax measures the natural movement of people with two aspects: the movement to arrive at destinations (Integration) and the movement to go across the streets (Choice). The two parameters are related to the numbers of segments and hard to compare in different places across scales. The normalized parameters were proposed in 2012 (Hillier, Yang & Turner, 2012). The paper calculated the normalized angular integration (NAIN) and normalized angular Choice (NACH) in the scales of 1km, 2km, 5km, 50km, and global (n).

2.3 Integrate Space Syntax and the Accessibility Analysis

To find out the most correlative parameter with the accessibility, which is related to the inherent properties of urban parks, the area, and the number of entrances. The research region is divided into 200*200m fishnet grids, in each grid, calculating the sum of the entrances and the area of urban parks, the average value of space syntax parameters, NAIN and NACH, in different scales. Import the data into SPSS to calculate the correlation between each variable, figure out the most correlative parameter.

The design criteria are translated into space syntax parameters on the scales of 1km (walking scale) and 5km (urban scale) (Yang, 2017). EG1 should have high accessibility on the urban scale, G11 and G13 would be of high accessibility on both walking and urban scale, G12 and G14 need to have high accessibility on the walking scale. The accessibility of urban parks is measured by the average value of space syntax parameter around the entrances of urban parks. The average value of space syntax parameter around the boundary of urban parks indicates their distribution in the street networks and their potential to improve accessibility by adding entrances in higher accessible streets.

3. Result

3.1 The Space Syntax Parameter in Tanggu

The streets with higher NACH and NAIN are centralized at the northeast part of the city for industry and storage (Fig. 2). The secondary centres of high NAIN on the walking scale (1km) are embedded into the city on the global scale (n) through integrating or segregating the street network (Fig. 3). Urban parks would enhance or weaken the natural movement. In the old downtown, the secondary centres are located at the two sides of Jintang Street and show little merge. Urban parks far away from Jintang Street deteriorate the segregation. In TEDA, the secondary centre on the walking scale merges with the main centre along Nanhai Road on the global scale. Urban parks along the Nanhai Road attract people to enhance the integration of the street network.

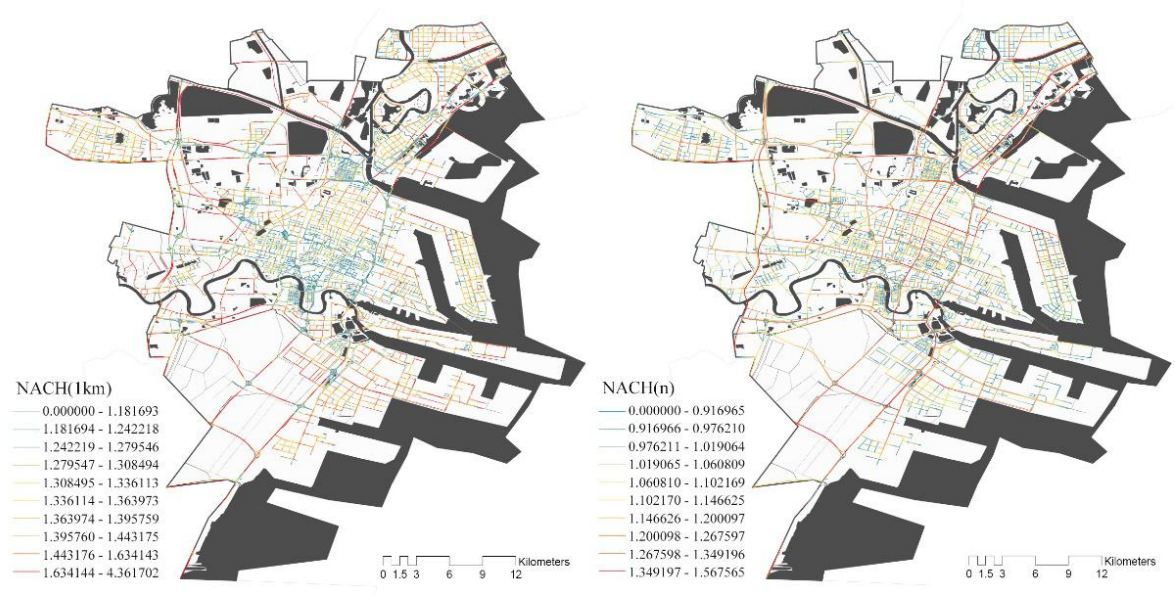

Figure 2 NACH in Tanggu (scale: 1km, n)

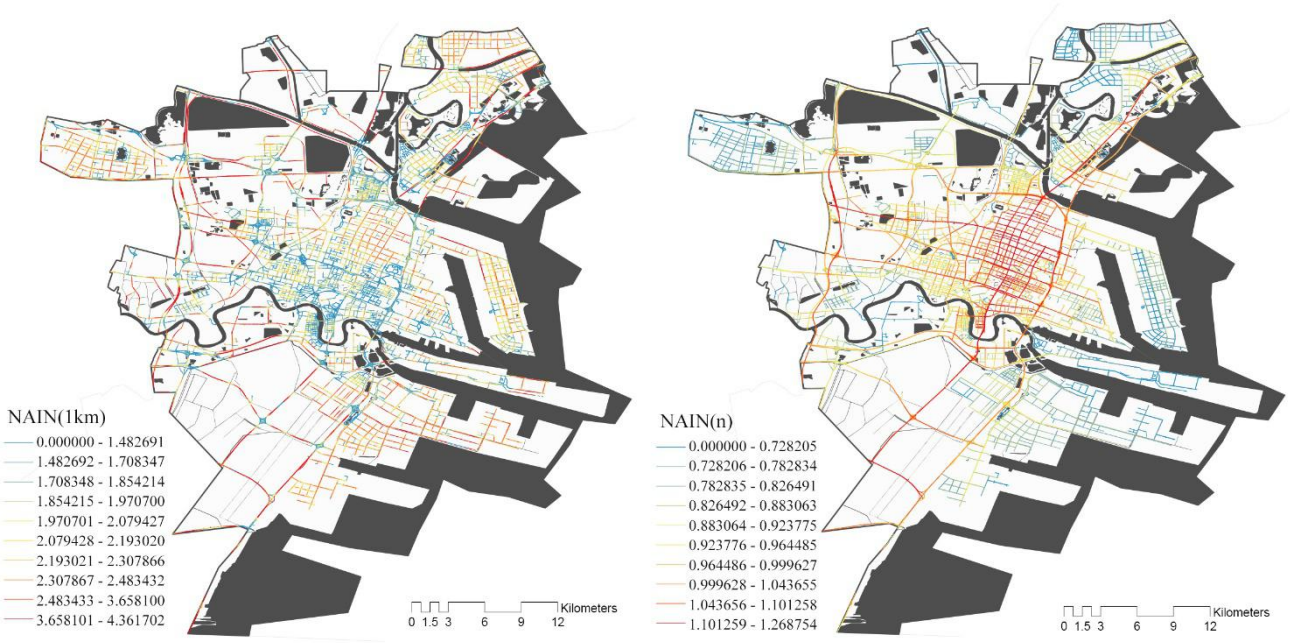

Figure 3 NAIN in Tanggu (scale: 1km, n)

3.2 The Correlation of Urban Parks and Space Syntax Parameter

The variables of urban parks significantly positively correlated to NACH in all scales and NAIN above the scale of 5km (Table 1, 2). Therefore, NACH is more appropriate for the subsequent analysis. Despite space syntax analysis recommends places with high integration as high accessibility, the space in a city is limited, different land uses compete with each other. Urban parks that provide public welfare without direct commercial profits would fail in the competition in a commercial leaded urban land use pattern and are uncorrelated with the integration.

Table 1 The Corelation between Urban Parks and NACH

NACH	1km	2km	5km	50km	n
Number of Entrances	0.102*	0.118*	0.128*	0.130*	0.130*
Area	0.057*	0.065*	0.075*	0.078*	0.078*

*. Significantly Correlated at 0.01 level

Table 2 The Corelation between Urban Parks and NAIN

NAIN	1km	2km	5km	50km	n
Number of Entrances	-0.003	0.001	0.125*	\0.148*	0.148*
Area	-0.007	-0.003	0.063*	0.075*	0.076*

*. Significantly Correlated at 0.01 level

4. Discussion

4.1 The Accessibility of Urban Parks

The average NACH (mnMACH) of the entrances indicates the accessibility of urban parks caused by natural movement (Table 3). G13 has the highest mnNACH on the walking and urban scales, while G14 has the lowest. It is reasonable for G13 to win the highest accessibility among urban parks for their commercial profits. But G14 fails to serve their neighbourhood for the poor accessibility on the walking scale. Similarly, G11, with low accessibility on the urban scale, could not well serve residents for the whole city. The historical urban morphology might influence the accessibility of G11, for they worked as ecological barriers and were located on the streets with low NACH in the past.

Table 3 The Average NACH of Entrances

Scale	G11	G12	G13	G14	EG1
mnNACH (1km)	1.306042	1.250050	1.383769	1.245484	1.369274
mnNACH (5km)	1.026308	1.064904	1.078855	1.023463	1.030893

4.2 The Distribution of Urban Parks and Their Potential to Improve Accessibility

The mnNACH around the boundaries is employed to describe parks' position in the street network, which means the distribution of urban parks. EG1 and G13 with high mnNACH boundaries win their position for their profits (Table 4). The G11 with low mnNACH boundaries in the urban scale shows the enduring and robust influence of historical urban planning on urban parks. G14 is located on higher NACH streets in the old city and new districts. The preference of planning small parks along busy roads due to the limited urban space also works as windows to demonstrate the ‘success’ of officers to lead a city to a ‘brilliant future’ (Long, Wu & Wang, 2015).

The accessibility of urban parks could improve by adding or changing the entrances to make the mnNACH of entrances higher than the boundaries. As G14 are usually located on busy streets, the low mnNACH entrances seem unreasonable and need improvement by changing their position to high NACH streets.

Table 4 The Average NACH of Boundaries

Scale	G11	G12	G13	G14	EG1
mnNACH (1km)	1.317327	1.242384	1.402928	1.295989	1.417347
mnNACH (5km)	1.036556	1.043585	1.104185	1.058780	1.088414

5. Conclusion

It is possible to employ the analysis of space syntax to evaluate the accessibility of urban parks. In practice, adding or moving the entrances of urban parks to higher NACH streets would improve accessibility.

The distribution and accessibility of urban parks show the influence and limitations of past planning and construction. However, the performance of urban parks in street networks is complex in reality; the factors that influence the activity of residents entering urban parks need further research, for example, human perception factors, psychological distance, etc.

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