Research on the construction of the heritage corridor dynamic tour system: the Grand Canal (Hangzhou section) as an example

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Abstract

The traditional heritage corridor is considered as one strategy of regional heritage preservation, which is linked with urban green space system. However, as a large-scale and linear urban public open space, heritage corridor landscape has a dynamic tour system that is closely linked with citizens' life and tourists visit experience. We introduced the concept of landscape visual attention-degree in the former related research. And then through the study of visual evaluation criteria of heritage corridor landscape and dynamic sightseeing features, we established a quantitative visual evaluation system influenced by multi-factor interactive model. Based on that, we take the Grand Canal (Hangzhou section) as an example, deepen at methodology level and practice at the operational level. On the one hand, we optimized heritage corridor landscape visual evaluation method under different movement modes by establishing a pairwise-comparison quantization scheme of landscape visual attention-degree, and also we improved a quantitative visual evaluation model under the influence of multi-factor. On the other hand, through analysing the urban environment around the heritage corridor and combining computer visualization technology, we construct the dynamic tour system, so as to enhance the overall landscape visual perception and landscape image of the heritage corridor.
Keywords: visual perception, the Grand Canal, dynamic tour system, visualization, landscape visual attention-degree.

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1 Introduction

The heritage corridor concept has roots in USA, which means a linear landscape has a special set of cultural resources including river valleys, canals, roads, railway lines and so on. It can also refer to a linear corridor with a certain historic value connecting single heritage point in series.

The traditional heritage corridor is considered as one strategy of regional heritage preservation and method of constructing urban green space system. However, heritage corridor landscape is not only seen as one independent landscape with heritage preservation value but also closely bound up with human activities and social conversations. The landscape of the heritage corridor, i.e., the urban space around the riversides, has historic and landscape features. It is also the centre of the future city life, city tourism and urban industrial development. After the Grand Canal has been placed on the World Heritage List, the government and citizens start to focus more on its landscape function.

Compared with the static observations, dynamic tour system has the landscape visual perception by the movements under different motion modes, thus forming the perception of urban landscape [1]. As a large-scale and linear urban public open space, heritage corridor landscape has a dynamic tour system that is closely linked with citizens' life and tourists visit experience.

The construction of dynamic tour system consists of optimization of the existing slow system tourist routes and planning new ones, which is mainly related to two factors. One is the visual evaluation of different movement modes under the ideal condition. Another is the environmental influence of the urban space around the heritage corridor including public traffic transfer, landscape resources, basic visiting unit and existing tourist routes.

Based on the authors' former related research [2], where established a quantitative visual evaluation system under the influence of multi-factor interactive model, we deepen the research at methodology level and practice at the operational level. Then, we put forward the optimization of heritage corridor landscape visual evaluation method and the strategy of heritage corridor landscape dynamic tour system. One side, we improve the mathematical model of heritage corridor landscape visual evaluation under different movement modes. On the other side, we consider more about the influence of urban environment, combining computer visualization technology, to construct the dynamic tour system, so as to enhance the overall landscape visual perception and landscape image of the heritage corridor. We believe that the method will contribute to the objective and accurate research on dynamic tour system of heritage corridor with strong operability and universality.

2 Materials and methods

2.1 Study area

The Beijing-Hangzhou Grande Canal is the world's longest ancient canal, and is also one of the oldest heritage corridors. It is more than 2500 years old, and is still in use. After the Grand Canal has been placed on the World Heritage List, the governments and citizens start to focus more on its landscape function.

This paper focuses on Hangzhou section of the Grand Canal, which is 54 km long and around 45 to 150 meters wide, starting from the Sanbao navigation lock in the south to the boundary of Hangzhou in the north (as shown in Figure 1). The region studied in this paper is 500–1000 metres wide on both sides of the Grand Canal which covers about 94 square kilometres land and is connected with 7 inland rivers and two artificial intake channels.

Figure 1: The Grand Canal location map.

The Grand Canal, complementing with other river systems of Hangzhou, traverses the main urban area, and is also the main body of the Hangzhou water network system. In addition, the Grand Canal has closely and important contact with historic context, future development, citizens' life and city image of Hangzhou. It passes through different boroughs, connects urban and rural areas. The riverside areas have composite city functions, which have a certain complexity and diversity. Also, it has plentiful coastal landscape elements. From north to south, there exists evolution tendency from outskirts landscape to metropolis landscape. Through the field study, we found that the dynamic tour system is consisted of pedestrian system, slow-bicycle system and sightseeing boat system. However, the current status cannot satisfy these functional requirements fully. Therefore, the research on the dynamic tour system of the Grand Canal has important practical value.

2.2 Research methodology

We introduce the concept of landscape visual attention-degree in the former related research [2], that is, the degree of visual attention to different landscape elements. Through the study of visual evaluation criteria [3] of heritage corridor landscape and dynamic sightseeing features (as shown in Figure 2), we establish a quantitative visual evaluation system influenced by multi-factor interactive model. Based on that, we attempt to improve the mathematical model of heritage corridor landscape visual evaluation under the influence of surrounding urban environment through the quantization method of landscape visual attention-degree. Using visualization technology [4], we finally construct the dynamic tour system for the Grand Canal (Hangzhou section).

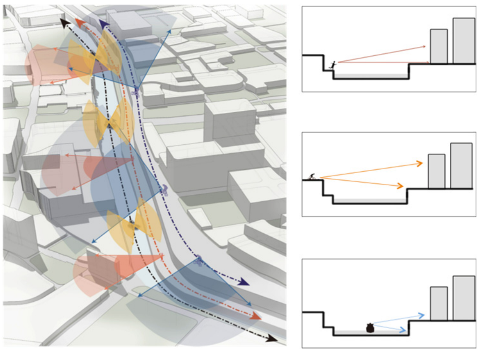

Figure 2: Illustration of vision characters in different movement systems.

2.2.1 Landscape visual evaluation in different movement system

According to the landscape composite characteristics of heritage corridor, as well as considering the basic idea of visual aesthetics and ecological aesthetics [5], we divide landscape evaluation elements into three category layer elements and nine system layer elements [2]. And then, we convert the landscape visual evaluation of heritage corridor into the evaluation of its two-side urban façade and establish corresponding quantized evaluation criteria. After that, we score every element involved to get the visual evaluation value T of that. Therefore, T_{UO}, T_{AF} *and* T_{VP} denote the score of urban outline, architectural form and visual perception, respectively. Notation S_{UO}^{n} is used to denote the score of evaluation elements in urban outline, when $n=1,2,3$ represents the contour rhythm, contour recognition and contour fluctuations, respectively. Similarly, S_{AF}^{n} and S_{VP}^{n} are defined as the score of each element in architectural form and visual perception.

The highest score is 10, which means no modification is needed, and the lowest score is 0, which means the modification is inevitable. The T_{UO}, T_{AF} *and* T_{VP} could be calculated by summing up the score of all elements as $T_{UO}=\sum_{n=1}^{3}S_{UO}^{n}, T_{AF}=\sum_{n=1}^{3}S_{AF}^{n}, T_{VP}=\sum_{n=1}^{3}S_{VP}^{n}$. In the meanwhile, we introduce notion E_{m-c} to indicate the landscape visual attention-degree, i.e. the weight of each element for landscape visual evaluation in different movement system, where m stands for the movement patterns and c for different category layer elements, e.g. E_{bi-uo} denotes the landscape visual attention-degree of urban outline in slow-bicycle system. We have the relation as Equation (1). In the meanwhile, the visual evaluation of heritage corridor landscape subsection X in different movement system is defined in the following Equations (2)–(4), respectively.

$$E_{p\text{-}uo}+E_{p\text{-}af}+E_{p\text{-}vp}=E_{bi\text{-}uo}+E_{bi\text{-}af}+E_{bi\text{-}vp}=E_{bo\text{-}uo}+E_{bo\text{-}af}+E_{bo\text{-}vp}=1. \quad (1)$$

$$X_{Pedestrian}=E_{p-uo}\times T_{UO}+E_{p-af}\times T_{AF}+E_{p-vp}\times T_{VP}. \quad (2)$$

$$X_{Slow-bicycle}=E_{bi-uo}\times T_{UO}+E_{bi-af}\times T_{AF}+E_{bi-vp}\times T_{VP}. \quad (3)$$

$$X_{Sightseeing-boat}=E_{bo-uo}\times T_{UO}+E_{bo-af}\times T_{AF}+E_{bo-vp}\times T_{VP}. \quad (4)$$

Therefore, the visual evaluation of heritage corridor landscape subsection X in different movement system is defined as Equations (2)–(4), respectively.

We could see that the landscape visual evaluation in different movement systems is not only related with objective landscape quality but also landscape visual attention-degree. Besides, through generating quantitive visual evaluation system under the influence of the objective multi-factor interactive model, we quantize the result of landscape visual evaluation and make the preparation for the subsequent establishment of dynamic tour system.

2.2.2 Quantization of landscape visual attention-degree

In different movement systems, people may have distinct attention-degree to each landscape visual elements; in the meanwhile, the environmental differences of surrounding cities will also influence these attention-degrees, i.e. the three category layer factors may occupy different proportion in the landscape visual evaluation. To quantize the landscape visual attention-degree, based on the factors analysis in decision making, we carry out pairwise comparisons of relative importance to build the judgment matrix. The eigenvector calculated represents the relative weight of these visual elements in different environments and movement systems, and could be assigned as the value of corresponding landscape visual attention-degree $E_{m\text{-}c}$. Here, a_{ij} is used to denote the relative importance of visual elements X_i and X_j for the visual evaluation in specific movement system, its judgment matrix is represented by $A=(a_{ij})_{n\times n}$ where n denotes the number of elements involved and in this paper n=3. We utilize the nine-point scale and their reciprocals as the scale of a_{ij} to represent the relative importance shown in Table 1.

Table 1: The scale of landscape visual attention-degree.

Scale	Explanation
1	Two factors are equal important
3	The former factor is **moderately** more important than later one
5	The former factor is **strongly** more important than later one
7	The former factor is **very strongly** more important than later one
9	The former factor is **extremely** more important than later one
2, 4, 6, 8	Intermediate values between adjacent scale
Reciprocals of above	If factor i has one of the above numbers assigned when compared with factor j, then j has the reciprocal scale when compared with i

For generalization, we see the urban outline, architectural form and visual perception as factor X_1, X_2 and X_3, respectively. Therefore, parameter a_{23} denotes the importance degree of architecture form compared with visual perception and

a_{21} denotes its importance degree compared with urban outline. Similarly, the importance degree of visual perception compared with urban outline is represented by parameter a_{31}.

In every movement system, through 3-time pairwise comparisons, we can construct judgment matrix and get the quantitative weight of every visual elements as E_{m-c} through calculating its eigenvector. We take pedestrian system of one landscape subsection as an example for illustration. Among three category layer factors, architecture form is extremely more important than urban outline ($a_{21}=9$) and is very strongly more important than visual perception ($a_{23}=7$). Visual perception is moderately more important than urban outline ($a_{31}=3$). So the constructed judgment matrix A is shown as following, the eigenvector of this matrix is (0.069, 0.776, 0.115).

$$A=\begin{bmatrix} 1 & \frac{1}{9} & \frac{1}{3} \\ 9 & 1 & 7 \\ 3 & \frac{1}{7} & 1 \end{bmatrix}$$

To check the rationality of the process and avoid the contradictory or inconsistent result, we need to do consistency check. The consistency index (CI) for the matrix can be calculated through $CI=(\lambda_{max}-n)/(n-1)$, where λ_{max} is the max-eigenvalue of the matrix. The consistency ratio (CR) for this set is $CR=CI/RI$. The RI stands for random index and represents an average CI for a huge number of randomly generated matrices of the same order. Since n=3 in our system, the RI is 0.58. When CR<0.1, the consistency is considered as acceptable, so that the weight we got through matrix can be used as the perception of visual elements E_{m-c} to indicate the effect of each visual element objectively.

In the above example, the max-eigenvalue of the judgment matrix A is $\lambda_{max}(A)=3.082$ so that we get $CI=0.041$. Its consistency ratio $CR=0.0708<0.1$, indicating that the consistency is acceptable. Therefore, we assign $E_{w-uo}=0.069$, $E_{w-am}=0.776$ and $E_{w-ve}=0.155$ as weight of visual elements in pedestrian system.

Therefore, utilizing the judgment matrix built through pairwise comparisons among elements in different movement system, we can get the weight values of different elements which have passed consistency check to determine the value of visual attention-degree E_{m-c}, and then we can calculate the result of landscape visual evaluation to heritage corridor in different movement systems.

2.2.3 Construction of dynamic tour system

The construction of dynamic tour system consists of optimization of the existing slow system tour route and planning new ones. Considering the characteristics of heritage corridor of landscape, we know the motion modes of dynamic tour system mainly include: pedestrianism, slow-bicycle, sightseeing boat, cable car and tour bus etc. Due to the difference in visual perception in different movement systems, the construction of dynamic tour system is primarily related with two factors. One is the visual evaluation in different movement systems under the ideal condition.

Another is the environmental influence of the urban space around the heritage corridor, which includes public transport transfer points, landscape resources, basic visiting unit and existing tourist routes.

Through establishing multi-factor quantitative visual evaluation system and determining different parameters and weights, we can get the score distribution of heritage corridor landscape visual evaluation results. When the score is above 21, we define it as the first-class area, where we encourage people to tourist in this area. When the score is between 9 and 21, we define it as the second-class area, where we recommend planning appropriate tourist route there only after improving landscape quality. When the score is below 9, the subsection needs special landscape renovation, and is not suitable to tourist for the moment.

We pay more attention to connect the first-class areas based on score distribution of visual evaluation in different movement system. Then considering about the public traffic transfer point, landscape resources, basic visiting unit and existing tourist routes, we plan the new tourist routes for different movement systems. Therefore, we can improve the overall landscape visual perception and landscape image of the heritage corridor via scientifically and effectively construction of dynamic tour system of heritage corridor.

3 Analysis and result

According to the difference of city function and current situation, we divide this section of the Grand Canal into landscape subsection every 1000–2000 meters, resulting in 38 landscape subsections in total. Along the flow direction, we use the R to represent the west side of the canal, and L to represent the east side. We utilize the mathematic model above to conduct practice and validation at operation level, and then we would select classical subsection to illustrate the whole process in the following section.

3.1 Research on classical subsection

The east side of the Grand Canal from Changwang road to Wenhui road subsection, whose label is L31, is shown in Figure 3. It is 1200 m long and 50 m wide, where buildings are mainly commercial and residential. Most participants are surrounding residents and a few tourists. The main movement patterns in this subsection are pedestrianism, slow-bicycle and sightseeing boat. Based on the mentioned landscape visual evaluation criteria, we score all the three category layer factors and nine system layer elements as shown in Table 2.

According to the quantization method of landscape visual attention-degree and considering the factors such as river width, riverside building height and its

Figure 3: Urban continuous façade of L31 subsection.

Table 2: Scores of landscape visual elements for L31 subsection.

Urban outline			Architecture form			Visual perception		
Contour rhythm	Contour recognition	Contour fluctuations	Building façade	Building materials	Building roof	Visual plaque	Visual hierarchy	Visual color
$S_{UO}^{1}=7$	$S_{UO}^{2}=7$	$S_{UO}^{3}=6$	$S_{AF}^{1}=6$	$S_{AF}^{2}=8$	$S_{AF}^{3}=8$	$S_{VP}^{1}=6$	$S_{VP}^{2}=8$	$S_{VP}^{3}=6$
$T_{UO}=20$			$T_{AF}=22$			$T_{VP}=20$		

openness, we determine the relative importance among all landscape visual elements in different movement systems (shown in Table 3), so that we could obtain the quantized value of landscape visual attention-degree and landscape visual evaluation score.

Table 3: Relative importance scale among visual elements in the slow-bicycle system and sightseeing boat system.

Slow-bicycle system			
	UO	AF	VP
UO		5	9
AF	1/5		3
VP	1/9	1/3	

Sightseeing boat system			
	UO	AF	VP
UO		1/3	1/9
AF	3		1/7
VP	9	7	

According to the quantization method of landscape visual attention-degree and considering the factors such as river width, riverside building height and its openness, we determine the relative importance among all landscape visual elements in different movement systems (shown in Table 3), so that we could obtain the quantized value of landscape visual attention-degree and landscape visual evaluation score.

In the above example, in pedestrian system, we get $E_{w\text{-}uo}$=0.069, $E_{w\text{-}am}$=0.776, $E_{w\text{-}ve}$=0.155. To check the consistency, we calculate the *CR* and get the result that *CR*=0.0708<0.1, which indicates that its consistency is good, the result is acceptable. Therefore, bringing these parameters into Equation (2), we know that the score of landscape visual evaluation in pedestrian system is 21.552 which is higher than the standard values 21. We should encourage planning pedestrian tourist route in his area.

In the same way described above, we get the landscape visual attention-degree as $E_{bi\text{-}uo}$=0.748, $E_{bi\text{-}am}$=0.181, $E_{bi\text{-}ve}$=0.071 in the slow-bicycle system from left part of Table 3 and its consistency is good (*CR*=0.025<1). Using Equation (3), the score of landscape visual evaluation in slow-bicycle system is 20.362, which is below standard value 21. Therefore, we should plan the slow-bicycle tourist route only after improving landscape quality to fit this movement pattern.

We could also derive landscape visual attention-degree from right part of Table 3 that $E_{bo\text{-}uo}$=0.069, $E_{bo\text{-}af}$ =0.155, $E_{bo\text{-}vf}$ =0.776 and its *CR*=0.0708<0.1

indicating its good consistency. The landscape visual evaluation score in sightseeing boat system $X_{sightseeing\text{-}boat}$ is 20.31. The sightseeing boat tourist route should be planned here after improve its landscape firstly.

In consideration of the surrounding city environment of this subsection, we found that although landscape scale meets the basic requirement of landscape unit in pedestrian and slow-bicycle movement patterns, and both the landscape resource around and public transport transfer point are relative abundant, this subsection only suits to plan pedestrian but not the slow-bicycle tourist route due to the lack of slow-bicycle transfer point. On the other hand, the score of landscape visual evaluation in sightseeing boat system is less than standard value but we still advise to retain the sightseeing boat tourist route that already exists. We expect that improving the riverside greening rate and colour richness of plants can enhance the landscape visual perception in sightseeing boat system.

3.2 Construction of dynamic tourist system for the Grand Canal

The construction of dynamical tourism system for the Grand Canal (Hangzhou section) includes the optimization to the existing tourist route of slow-traffic system and planning some new tourist routes. The main dynamic ways for visiting are pedestrianism, slow-bicycle and sightseeing boat.

Along the riverside of the Grand Canal, pedestrianism is the main dynamic visiting way, which has the convenience and flexibility that no other transport tool equips. The active crowd are mainly nearby residents supplemented by tourists with relaxation and taking a walk as their main objectives.

Given the differences of landscape status and environment of surrounding cities among different landscape sections (as shown in Figure 4), we utilize the mathematical model in [2] to calculate corresponding score for these landscape sections, and then we can get the distribution of the Grand Canal landscape visual evaluation score and in pedestrian system (as shown in Figure 5).

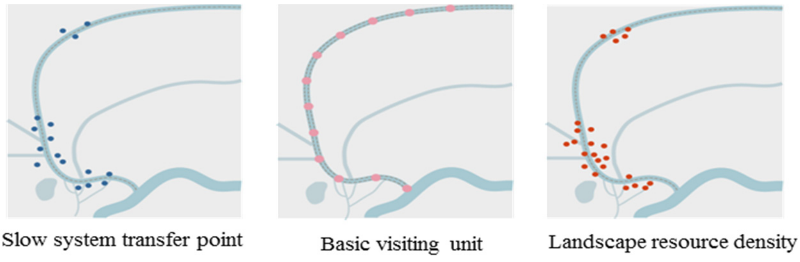

Figure 4: Landscape elements analysis in pedestrian system.

In consideration of the existing pedestrian tourist routes and other factors, such as public transport transfer points around the riverside, the distribution of landscape resource and basic visiting unit of pedestrianism, we add extra four tourist routes as shown in Figure 5, which from Zongguantang to Anqiao, from Yujingdu to Wangjiacun, from Xiecun to Gongchenqiao and from Pujia to Nijiacun.

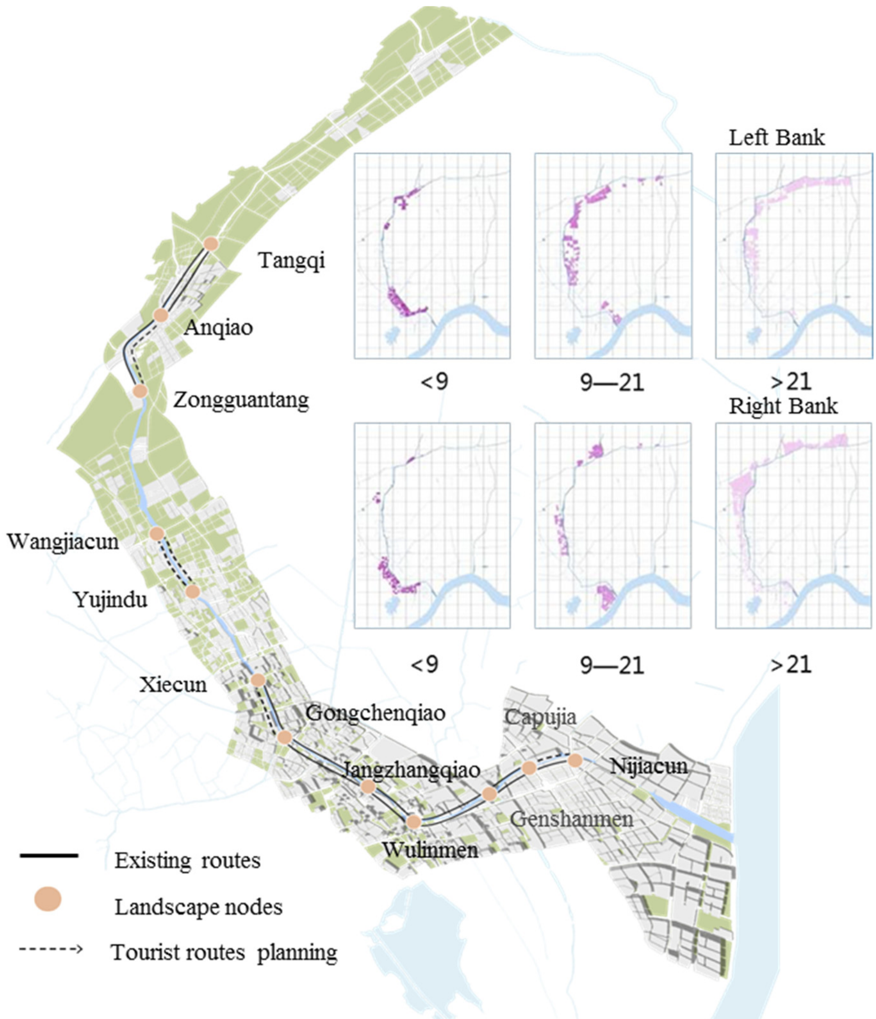

Figure 5: Score distribution of visual evaluation and tourist routes planned.

Using the same method, we analyze the slow-bicycle and sightseeing boat systems in the similar way. We also obtain the score distribution of the Grand Canal landscape visual evaluation and evaluation result in these system so as to plan more reasonable tourist routes for slow-bicycle and sightseeing boat systems. Due to space limitations, we no longer detail them here but only present the tourist routes planning in Figure 6.

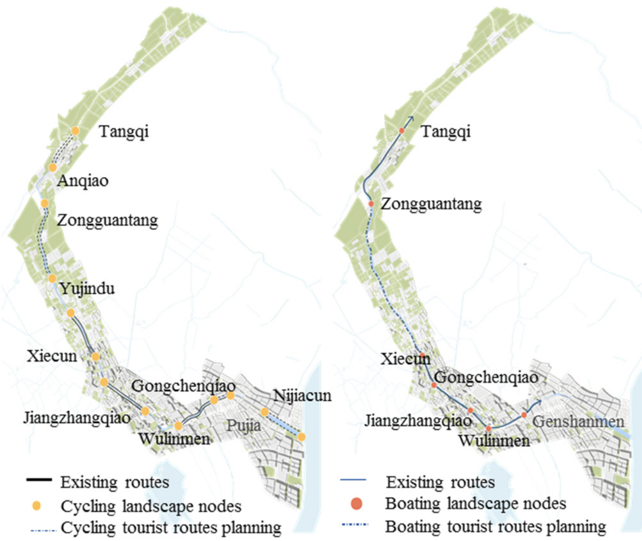

Figure 6: Slow-bicycle and sightseeing boat tourist routes planning.

3.3 Result

Through the analysis and calculation of the visual evaluation score distribution in research area in three different movement system, including pedestrianism, slow-bicycle, sightseeing boat, we focus on connecting the first-class areas. Then considering the public traffic transfer point, landscape resources, basic visiting unit and existing tourist route, we construct the dynamic tour system of the Grand Canal (Hangzhou section) (as shown in Figure 7). Meanwhile, we optimize the existing slow system tourist route and plan some new ones.

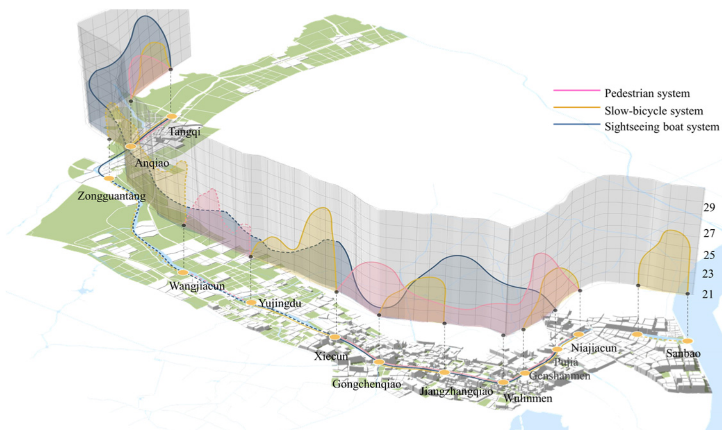

Figure 7: Tourist routes overlay and score distribution of landscape visual evaluation in different movement systems.

This dynamic tour system can establish the relationship between the visual landscape evaluation elements and urban movement systems, and then enhance advantage and avoid disadvantage of landscape via scientific and effective operation. Thus, it can improve the overall landscape visual perception and landscape image of the heritage corridor. In addition, it enjoys good adaptability in city function because that it fully takes into account of environmental influence of the urban space around the Grand Canal.

4 Conclusions

Based on the author's former related research, in this paper we deepen at methodology level and practice at the operational level. In one aspect, we put forward the optimization of heritage corridor landscape visual evaluation method in different movement systems by establishing a landscape visual attention-degree pairwise-comparison quantization scheme and improving a quantitative visual evaluation model under the influence of multiple factors. In this way, the complex urban relationships could be illustrated with visualized result data, which provides technical support for subsequent optimization design. In another aspect, through the analysis of the urban environment around the heritage corridor and utilizing computer visualization technology, we construct the dynamic tour system so as to enhance the overall landscape visual perception and landscape image of the heritage corridor.

In addition, the method of visual evaluation and the heritage corridor dynamic tour system construction are scientific and general applicable, and can be applied to large scale, continuous linear urban open public space. We can adjust the corresponding factors in the landscape visual evaluation, movement system, and the factors of the surrounding urban environment influence according to the specific situation and requirements. It is worth mentioning that, although the quantification process has demonstrated the certainty and the clarity, it still inevitably reduces the complexity of the research object, which originates from the quantization research itself.

Acknowledgements

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