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Sightseeing Train Exterior Design and Evaluation Methodology Grounded in the Extension Semantics of Regional Cultural Graphics

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Abstract. As a multifunctional conveyance within picturesque locales, sightseeing trains serve vital roles in facilitating tourism transportation, showcasing regional culture, and integrating various tourism components, thereby fostering the amalgamation of regional tourism industry chains. This study introduced an innovative methodology, hinging upon the extended semantics of regional cultural graphics, for the aesthetic design and appraisal of sightseeing trains. By employing extension theory, the semantics of regional cultural graphics were extracted and analyzed, thereby optimizing their incorporation into the sightseeing train's exterior design. Using the Han Dynasty-themed sightseeing train project at Xi'an Kunming Lake Heritage Park as a case study, the initial step entailed extracting and scrutinizing cultural primitives and graphic semantics native to the local Han Dynasty. This analysis yielded extension interval sequencing and corresponding graphic semantics. Subsequently, the sequence of extension values for characteristic words guided the selection of highly recognizable regional cultural feature elements for the train's exterior design. Ultimately, a Fuzzy Comprehensive Evaluation method was employed to assess the design proposal. The findings of this paper demonstrated that the proposed methodology effectively integrated regional cultural elements into the appearance design of sightseeing trains, offering valuable insights for the development and evaluation of similar design trajectories.

Keywords: Sightseeing train, Extension semantics, Appearance design, Regional culture, Design evaluation.
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1 INTRODUCTION

Diverging from conventional public transportation, which is primarily utilized for the daily commutes of local residents, and from tourism-specific transport, which exclusively connects urban attractions, the urban sightseeing train serves as a "promotional showcase" for regional culture. This form of urban tourism landscape transport emphasizes sightseeing while also providing supplementary transportation. The challenge has emerged to devise a train exterior design that not only embodies regional cultural characteristics but also seamlessly integrates with the urban landscape environment, presenting a pressing issue to address.

Therefore, scholars have extensively investigated the exterior design of public transport. Li Jingjing et al. [1] extracted color and graphic elements from regional culture concepts, employing the example of the Sanxingdui culture in ancient Shu, and applied these elements to tram exterior design. Wang Wei and Wang Zhe [2,3], using rail transit examples from France, Australia, and South Korea, analyzed their exterior design methodologies and practices across five dimensions, including regional culture display and urban environment integration, providing valuable insights for similar rail transit design projects. Quan Yi [4] explored the regional cultural transfer path and design approach of tram design by extracting regional cultural factors from Luodai in Southwest China. He Sijun et al. [5] incorporated the "Shannon Weaver" communication model, deriving the cultural transmission mechanism of train exteriors and proposing an expression method for regional culture in train exterior design. Tang Shan [6] synthesized the transformation model of regional culture and subway exterior elements, proposing a subway exterior design method that transfers regional culture. Zhang Lidan [7] constructed the process for transferring regional cultural elements and conducted design research on Chengdu tram exteriors. Liang Zhe et al. [8] developed an evaluation system to assess the impact of regional cultural factors on train exteriors. Using the Chengdu Metro Line 9 as an example and employing the analytic hierarchy process (AHP), they proposed a train exterior design scheme imbued with a strong regional cultural connotation.

To amalgamate the appearance of sightseeing trains with the regional culture in operation and enhance the cultural identity of citizens, this paper proposed a method for the exterior design and evaluation of sightseeing trains based on the extension semantics of regional cultural graphics: firstly, by introducing the extensible semantic theory, a framework for extensible semantic analysis and representation in the exterior design of sightseeing trains was constructed. Secondly, utilizing the Fuzzy Comprehensive Evaluation method, a cultural-characteristics-based evaluation process for the exterior design of sightseeing trains was established. Finally, using the Xi'an Kunmingchi Heritage Park sightseeing train exterior design as an example and combining expert and user surveys, the feasibility of the proposed method was validated through three aspects: extraction and representation of cultural connotations, scheme design, and evaluation.

2 EXTENSION SEMANTIC THEORY AND REPRESENTATION METHOD IN SIGHTSEEING TRAIN APPEARANCE DESIGN

2.1 Extension Semantic Theory

The extension theory, introduced by Chinese scholar Cai Wen [9-11], serves as a technical method for tackling contradictory problems and an effective approach for examining matter elements, transformation laws, and addressing incompatibilities in the real world [12]. Extension theory asserts that matter elements, event elements, and primitives are the foundational elements for characterizing objects, events, and relationships, thereby constituting the logical components of extensions. At present, extension theory has been applied in a wide array of fields. In design, it delves into the principles of creativity and methods for fostering creativity, investigating the utilization of computers and networks to facilitate creative output.

Extension semantics stem from extension theory, utilizing matter elements and graphic thinking to quantify the symbolic attributes of entities [13]. In accordance with extension theory, the matter-element R serves as the logical building block of extensions and the fundamental element for formalizing object descriptions. It can be represented by an ordered ternary group composed of entity N, attribute name C, and quantity value V:

$$R=\left(N,C,V\right) \tag{1}$$

When multiple attribute elements are involved, Equation (1) can be expanded to a multidimensional representation:

$$R=(N,C,V)=\begin{bmatrix} N & C_1 & V_1 \\ & C_2 & V_2 \\ & \cdots & \cdots \\ & C_n & V_n \end{bmatrix} \tag{2}$$

Indeed, extension semantics actualize the property transformation process by quantifying the attributes of entities using semantic symbols, offering a novel approach for the exterior design of sightseeing trains.

2.2 Extension Semantic Representation Method

In line with extension theory, this study established an extension semantic representation method for sightseeing train exterior design, with the following steps:

(1) Based on extension theory, *P* is defined as the cultural connotation of the regional cultural graphics, *O* represents the graphics themselves, *F* corresponds to the semantic characteristic words of the graphics, and *T* denotes the extension interval of the semantic feature. Utilizing Equation (2), the regional cultural connotation *P* can be articulated as:

$$P=(O,F,T)=\begin{bmatrix} O & F_1 & T_1 \\ & F_2 & T_2 \\ & \cdots & \cdots \\ & F_n & T_n \end{bmatrix} \tag{3}$$

In Equation (3), graphics *O* can be represented by multiple characteristic words *F*, and extension interval *T* serves as the corresponding quantity value of characteristic words *F*.

(2) The extension interval *T* of semantic features in Equation (3) is decomposed into t_x and t_y. Then, t_x is used to describe the degree of association between the graphic semantic characteristic words *F* and the graphic *O*, $t_x \in (0,1]$, $t_{x_1}+t_{x_2}+\cdots t_{x_n}=1(n\geq 1)$. The closer the value of t_x is to 1, the higher the correlation between the characteristic words *F* and the graphic *O*. If the score interval of each characteristic word is $[1,\alpha]$, the number of people participating in the evaluation is β, and the number of each characteristic word with a score of a is d_a, then the expression of t_x is:

$$t_x=\frac{\sum_{\alpha=1}^{\alpha} a d_a}{\beta\cdot\frac{\alpha(\alpha+1)}{2}}, a\in[1,\alpha], d_a\in[1,\beta] \tag{4}$$

(3) t_y represents to the regional cultural connotation of the characteristic words in the sightseeing train appearance design. The larger the value, the higher the regional cultural connotation of the characteristic words in the train exterior design. Let the *n*th evaluator rate the cultural connotation of the characteristic words as b_n, then the expression of t_y is:

$$t_y=\frac{\sum_{n=1}^{\varphi} b_n}{\varphi}, b_n\in[1,\theta], n\in[1,\varphi] \tag{5}$$

The extension interval *T* of the regional cultural graphics for sightseeing train is:

$$T = t_x t_y \tag{6}$$

The greater the *T* value in Equation (6), the higher the correlation between the characteristic words and the regional cultural connotation, which should be preferred in design and application.

(4) The semantic graphic of the characteristic words with regional cultural connotation is created, which is expressed by *h*. Let the extension interval of the graphic be T_h ; Similarly, V_h is decomposed into t_{h_x} and t_{h_y} , where t_{h_x} is the identification of the graphic and t_{h_y} is the cultural value of the graphic, where T_h expression is:

$$T_h = t_{h_x} t_{h_y} \tag{7}$$

(5) Similarly, the greater the T_h value in Equation (7), the higher the semantic recognition of the graphic, and the more regional cultural connotation can be displayed in the exterior design of sightseeing trains.

3 EVALUATION OF SIGHTSEEING TRAIN EXTERIOR DESIGN SCHEME UTILIZING THE FUZZY COMPREHENSIVE EVALUATION METHOD

The Fuzzy Comprehensive Evaluation method, based on fuzzy mathematics, is a comprehensive evaluation strategy that transforms qualitative evaluations into quantitative ones using the membership theory of fuzzy mathematics. In essence, it utilizes fuzzy mathematics to perform overall evaluations of entities or objects constrained by numerous factors. Notable for producing clear results and demonstrating strong systematic properties, this method is adept at addressing fuzzy and hard-to-quantify problems, making it suitable for resolving various types of uncertain issues.

In this paper, the Fuzzy Comprehensive Evaluation method was employed to assess whether the sightseeing train's appearance design scheme reflected regional cultural connotations. The evaluation steps are as follows [14,15]:

(1) The hierarchical structure model of the evaluation of sightseeing train appearance design scheme is constructed by using the AHP;

(2) The scale value obtained from the questionnaire survey of experts in the design field is used to construct the fuzzy judgment matrix M , namely:

$$M = \begin{bmatrix} A_{11} & A_{12} & \cdots & A_{1n} \\ A_{21} & A_{22} & \cdots & A_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ A_{n1} & A_{n2} & \cdots & A_{nn} \end{bmatrix} \quad (i, j = 1, 2 \cdots, n) \tag{8}$$

Where, element A_{ij} is the importance of index *i* over index *j*;

(3) Calculate index weight value *W*:

1)First, multiplied the elements in each row of the fuzzy judgment matrix *M* to get:

$$M_i = \prod_{j=1}^{n} A_{ij} \tag{9}$$

2)Relative weight W_i obtained by normalization:

$$W_i = \sqrt[n]{M_i} \Big/ \sum_{i=1}^{n} \sqrt[n]{M_i} \tag{10}$$

(4) The fuzzy evaluation matrix *R* of the sightseeing train appearance design scheme is constructed by using the questionnaire method. The evaluation grades are set as satisfied, average and dissatisfied, and the values are 1.0, 0.5 and 0 respectively.

(5) Calculate the evaluation vector *B* of sightseeing train design scheme:

$$\boldsymbol{B} = WR \tag{11}$$

(6) Calculate the satisfaction score *V* of each index reflected in the design scheme as:

$$V = \boldsymbol{B}H \tag{12}$$

Wherein, *H*=(satisfied, average, dissatisfied).

4 APPEARANCE DESIGN AND EVALUATION PROCESS OF SIGHTSEEING TRAIN

Derek Dekirkhoff [20] vividly conveyed the materiality of design in relation to culture with the phrase, 'Design is the skin of culture.' Regional cultural characteristics mirror the local humanistic spirit, encapsulate local folk customs, represent a consensus on indigenous culture, and manifest as attributes with a distinct, culturally significant color reflected by a region. Only by identifying and skillfully incorporating regional cultural characteristics into design can one accurately and effectively evoke a city's regional culture.

Taking the appearance design of the sightseeing train in the Xi'an Kunming Lake Heritage Park as an example, this paper divided the design and evaluation process into three stages: the extraction and characterization of regional cultural elements, the design of the appearance scheme, and the evaluation of the design. The process is as follows:

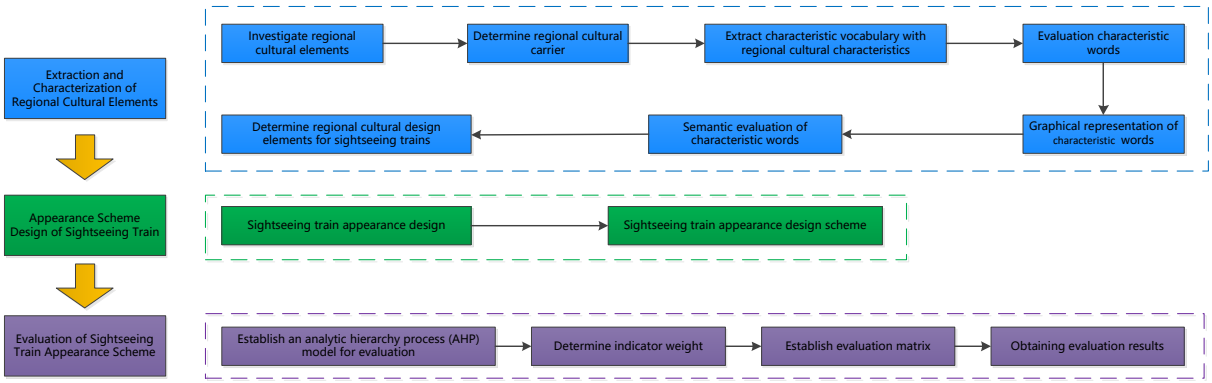


Figure 1: Appearance design and evaluation process of sightseeing train based on extension semantics of regional cultural graphics.

5 CASE STUDY

5.1 Project Overview

Kunming Lake Heritage Park was rebuilt on the original site of Kunming Lake from the Han Dynasty. As depicted in Figure 2, it stands as China's first large-scale royal garden-style cultural theme park, comprehensively showcasing the forest garden style of Kunming Lake during the Han Dynasty. The design requirements for the sightseeing train's special line within the park are in harmony with the natural landscape. It not only connects the scenic spots but also satisfies citizens' needs for tourism, leisure, and sightseeing, among other activities.

Figure 2: Rendering of Kunming Lake Heritage Park.

5.2 Extraction and Representation of Regional Culture

(1) Investigation on regional cultural elements

According to local historical records, in 120 BC, the State of Kunming—located in what are today's Yunnan and Guizhou provinces of China—often disrupted the Western Han Dynasty's strategy in the south and southwest. Emperor Wu of the Han Dynasty desired to launch a military expedition, yet the necessary passage through Dianchi Lake (known as Kunming Lake at that time) presented a challenge due to the incomplete naval system and suboptimal combat effectiveness. Consequently, Emperor Wu ordered the acceleration of naval training. Simultaneously, an old marsh pool (today's site of the Kunming Lake Heritage Park) was designated to create an artificial lake mirroring Dianchi Lake. Numerous turreted warships were constructed to facilitate naval training and test the results.

Furthermore, Kunming Lake developed into a large scenic spot, adorned with artificial islands, the Yuzhang Platform, and Lingbo Hall. Emperor Wu, a frequent visitor, would order palace ladies to launch their canoes, raise colored flags, and sing songs. He himself would ascend to the Yuzhang Platform to drink and admire the scenery of this unique northern water town.

Kunming Lake was gradually abandoned after the Han Dynasty. During the early Tang Dynasty, issues related to water usage in Chang'an city became prominent. Emperor Xuanzong, Emperor Dezong, and Emperor Wenzong of the Tang Dynasty organized multiple dredging efforts to divert the Fenghe River into Kunming Lake. However, by the late Tang Dynasty, it had gradually dried up due to a lack of maintenance. Following the Song Dynasty, it transformed into a wetland.

In recent years, the Xi'an Municipal Government has comprehensively renovated the main rivers in the territory. In 2015, the Doumen Reservoir project was built at the site of Kunming Lake. On one hand, it serves as a new water source for Xi'an. On the other hand, it aims to recreate the historical features of Kunming Lake during the Han and Tang Dynasties, establishing a cultural tourism exhibition window.

(2) Define the carrier of regional culture of Kunming Lake

Kunming Lake, an unprecedented water conservancy project at the time, played a pivotal role in the Han Dynasty. It not only served as a crucial training ground for the water army but also contributed significantly to stabilizing water transport, enriching water sources, and irrigating farmland. With a history spanning nearly 2000 years and spanning 13 dynasties, including the Zhou, Qin, Han, and Tang, Kunming Lake effectively addressed the issues of water storage, water supply,

flood control, and drainage in Chang'an city. It is clear that Emperor Wu of the Han Dynasty made remarkable contributions in this regard.

Today, the image of Emperor Wu of the Han Dynasty during the navy drilling exercises has become a hallmark of the scenic spot's external promotion. Consequently, the image of Emperor Wu of the Han Dynasty and turreted warships has been chosen as the cultural centerpiece for the design of sightseeing trains in the area, as depicted in Figure 3.

a) Emperor Wu of the Han Dynasty

b) Turreted warship

Figure 3: Cultural carrier of sightseeing train appearance design.

(3) Extracting words with regional cultural characteristics

According to the cultural connotation conveyed by Emperor Wu of the Han Dynasty when he drilled the navy, this paper established the cultural primitive *Q* of Kunming Lake and the regional cultural carrier *O* of Kunming Lake. The characteristic words describing object *O* include: Emperor, Turreted Warship, Spray, Victory and Prosperity, namely:

$$Q = the\ culture\ of\ Kunmimng\ heritage\ lake = \begin{bmatrix} Regional\ culture\ carrier & Emperor & T_1 \\ & Turreted\ Warship & T_2 \\ & Spray & T_3 \\ & Victory & T_4 \\ & Prosperity & T_5 \end{bmatrix} \quad (13)$$

5.3 Evaluation of Extension Semantics of Regional Cultural Primitives

(1) Evaluation of words with regional cultural characteristics

Through an expert questionnaire, 10 experts who were well-versed in the history and culture of Kunming Lake were selected to assess the regional cultural significance of the five characteristic words. The evaluation criteria were developed to rank these words based on their ability to effectively reflect the degree of relevance to the regional cultural symbol of Kunming Lake. The strongest degree of relevance was assigned 5 points, and the weakest degree of relevance was assigned 1 point. The extension interval t_x was calculated according to the investigation results and Equation (4). The questionnaire results and extension interval t_x are shown in Table 1:

Characteristic Words	The Number of People					Extension Interval t_x
	5 Points	4 Points	3 Points	2 Points	1 Point	
Emperor	5	1	3	1	0	0.267
Turreted Warship	2	3	3	1	1	0.277
Spray	2	4	2	0	2	0.227
Victory	3	2	4	1	0	0.247
Prosperity	1	3	3	3	0	0.213

Table 1: Evaluation of the relevancy of words with regional cultural characteristics in Kunming Lake.

10 employees, who were familiar with the local culture and the design industry, were selected to assign cultural value scores to words associated with the regional cultural characteristics of Kunming Lake. The scoring system ranged from 1 to 10 points, where higher scores indicated a higher cultural value for the characteristic words. Additionally, the extension interval was calculated using Equation (5). Table 2 presents the evaluation results of the cultural value of the characteristic words along with the computed extension interval.

Characteristic Words	Practitioners in the Design Industry										Extension Interval t_y
	1#	2#	3#	4#	5#	6#	7#	8#	9#	10#	
Emperor	9	3	6	9	3	5	9	9	9	10	7.2
Turreted Warship	9	7	9	7	4	8	8	8	10	6	7.6
Spray	5	6	6	7	4	9	8	8	10	8	7.1
Victory	8	6	5	1	1	6	9	8	8	6	5.8
Prosperity	5	9	7	7	1	6	8	7	10	4	6.4

Table 2: Scoring and evaluation of the cultural value of Kunming Lake's regional cultural characteristic words.

According to Equation (6), the extension range T of the regional cultural primitive of Kunming Lake was calculated, as shown in Table 3.

Extension Interval	Emperor	Turreted Warship	Spray	Victory	Prosperity
T	1.922	2.105	1.612	1.433	1.363

Table 3: Calculation results of extension interval of regional cultural primitives of Kunming Lake.

According to the calculation results in Table 3, the extension intervals of cultural characteristic words in the Kunming Lake are arranged in descending order, as follows: Turreted Warship, Emperor, Spray, Victory and Prosperity.

(2) Graphical representation and evaluation of characteristic words

Differing from the characteristic words, the graphic expressions are more intuitive. To ensure close alignment between graphics and the characteristic words, five design industry practitioners were invited to select five graphics related to the cultural connotation of Kunming Lake for each characteristic word, and 10 design industry practitioners were invited to select the three pictures with the highest voting rate for each characteristic word, as shown in Table 4.

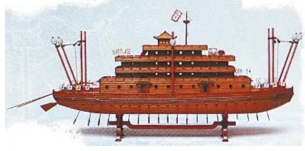
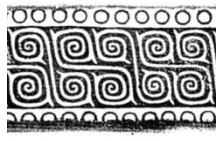
Characteristic Words	Graphical Representation of Characteristic Words		
	h_1	h_2	h_3
Emperor			
Turreted Warship			
Spray			
Victory			
Prosperity			

Table 4: Graphical representation of characteristic words.

Then, three designers were invited again to score the schematic semantics of Table 4, and then evaluated by Equation (4) and (5). The results are shown in Table 5 and Table 6.

Designer	Graphics Number	Graphic Evaluation of Characteristic Word				
		Emperor	Turreted Warship	Spray	Victory	Prosperity
1#	h_1	0.6	0.8	0.3	0.6	0.2
	h_2	0.9	0.4	0.8	0.9	0.5
	h_3	0.4	0.2	0.4	0.5	0.8
2#	h_1	0.6	0.9	0.2	0.4	0.4
	h_2	0.8	0.4	0.8	0.8	0.9
	h_3	0.7	0.5	0.4	0.3	0.6
3#	h_1	0.5	0.8	0.1	0.5	0.4
	h_2	0.8	0.4	0.9	0.8	0.7
	h_3	0.6	0.5	0.2	0.5	0.8

Table 5: Semantic evaluation results of characteristic words.

Designer	Graphics Number	Evaluation of Cultural Value of Characteristic Words				
		Emperor	Turreted Warship	Spray	Victory	Prosperity
1#	h_1	7	9	2	7	2
	h_2	8	2	9	8	7
	h_3	4	2	1	2	8
2#	h_1	6	8	2	4	4
	h_2	9	1	7	7	8
	h_3	5	2	2	4	6
3#	h_1	6	10	4	6	4
	h_2	10	4	8	8	7
	h_3	4	4	4	2	8

Table 6: Evaluation results of cultural value of different characteristic words.

(3) Determine the cultural elements of Kunming Lake sightseeing train appearance design

According to the evaluation results in Table 5 and Table 6, the mean values of semantic recognition and cultural value of each diagram were calculated. The calculation results are shown in Table 7. Then, the graphic semantic extension interval T_h of each characteristic word was calculated by Equation (7), as shown in Table 8.

Graphics Number	t_{h_x}	Emperor	Turreted Warship	Spray	Victory	Prosperity
h_1	$t_{h_{x1}}$	0.567	0.833	0.200	0.500	0.333

	$t_{h_{y1}}$	6.333	9.000	2.667	5.667	3.333
h_2	$t_{h_{x2}}$	0.833	0.400	0.833	0.833	0.700
	$t_{h_{y2}}$	9.000	2.333	8.000	7.667	7.333
h_3	$t_{h_{x3}}$	0.567	0.400	0.333	0.433	0.733
	$t_{h_{y3}}$	4.333	2.667	2.333	2.667	7.333

Table 7: Mean value of graphic semantic evaluation of each characteristic word.

Graphics Number	Emperor	Turreted Warship	Spray	Victory	Prosperity
h_1	3.591	7.497	0.533	2.834	1.110
h_2	7.497	0.933	6.664	6.387	5.133
h_3	2.457	1.067	0.777	1.155	5.375

Table 8: Schematic semantic extension interval of each characteristic word.

According to the calculation results in Table 8, the semantic extension intervals of characteristic words are arranged in descending order: Emperor h_2, Turreted Warship h_1, Spray h_2, Victory h_2 and Prosperity h_3. Therefore, this evaluation result can be used as the regional cultural reference element of the appearance design of Kunming Lake sightseeing train.

5.4 Appearance Design of Sightseeing Train Based on Regional Culture

The design of Kunming Lake sightseeing train fully took into account the emotional and regional characteristics of people. Based on the above graphic semantic analysis of Kunming Lake, and in combination with the extension value ordering of the characteristic words in Table 3, the turreted warship, emperor and spray with large semantic connotation, cultural value and high recognition were selected as the elements of the appearance culture of Kunming Lake sightseeing train for design and creation.

Figure 4: Appearance design of Kunming Lake sightseeing train.

5.5 Evaluation of Sightseeing Train Appearance Design Scheme Based on Regional Culture

In order to verify whether the appearance design of Kunming Lake sightseeing train could reflect the regional cultural connotation, this paper used the Fuzzy Comprehensive Evaluation method to evaluate its design scheme.

5.5.1 Analytic hierarchy process model

This paper adopted the analytic hierarchy process to build the evaluation model of sightseeing train appearance design, as shown in Figure 5.

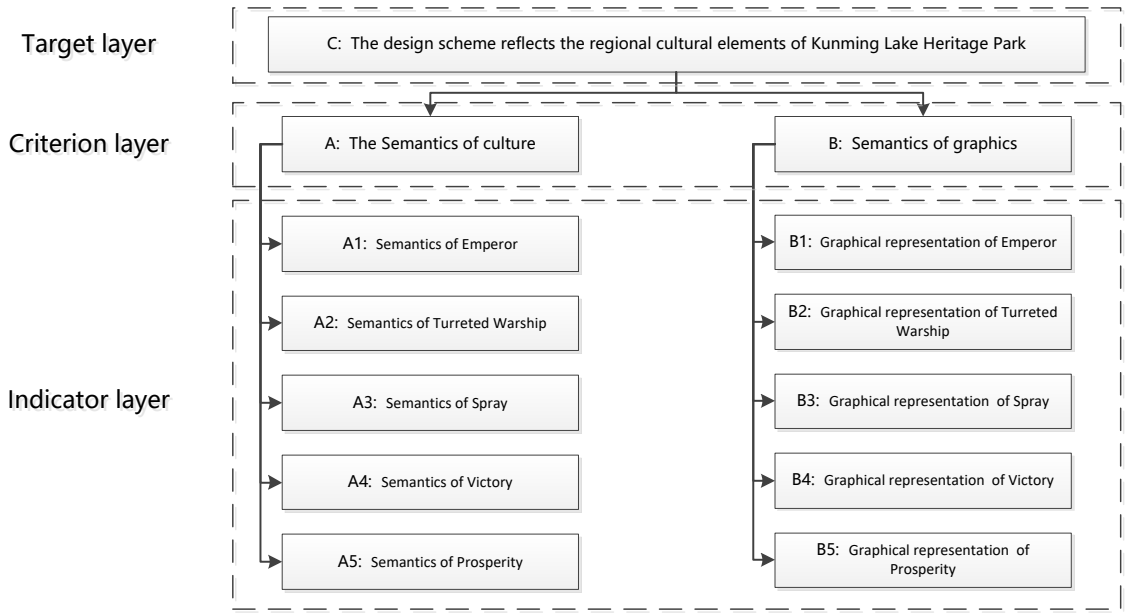


Figure 5: Evaluation model of sightseeing train appearance design scheme.

5.5.2 Calculation of index weight

Ten experts were invited to conduct pairwise comparisons of the design scheme evaluation criteria. According to the relative importance scale in Table 9, a fuzzy judgment matrix *M* was constructed, and the weight values of indicators at all levels were subsequently calculated.

Scale value	Explanation
1	Both factors are equally important
3	The former element is slightly more important than the latter
5	The former element is significantly more important than the latter
7	The former element is strongly more important than the latter
9	The former element is extremely more important than the latter
2,4,6,8	Intermediate value of the above adjacent judgments
Reciprocal	The ratio of the importance of the next element to the previous factor is the reciprocal of the above scale value

Table 9: Relative importance scale.

According to the basic principle of the Fuzzy Comprehensive Evaluation method, combined with the evaluation results of experts on indicators at all levels of the design scheme evaluation system, the indicator layer judgment matrices M_A, M_B and target layer M_C were obtained by using Equation (8):

$$M_A = \begin{bmatrix} 1 & 0.78 & 2.34 \\ 1.28 & 1 & 5.27 \\ 0.43 & 0.19 & 1 \end{bmatrix} \quad (14)$$

$$M_B = \begin{bmatrix} 1 & 1.75 & 0.83 \\ 0.57 & 1 & 3.71 \\ 1.20 & 0.27 & 1 \end{bmatrix} \quad (15)$$

$$M_C = \begin{bmatrix} 1 & 3.17 \\ 0.32 & 1 \end{bmatrix} \quad (16)$$

According to Equation (9) - (11), the weight values of indicators at all levels that could reflect regional cultural elements in Kunming Lake sightseeing train design were calculated, as shown in Table 10.

Goal layer	Criterion layer	Weight of criterion layer	Indicator layer	Weight of indicator layer
Design elements of Kunming Lake regional culture C	Cultural semantics A	0.76	Emperor A_1	0.35
			Turreted Warship A_2	0.53
			Spray A_3	0.12
	Graphical semantics B	0.24	Emperor B_1	0.37
			Turreted Warship B_2	0.41
			Spray B_3	0.22

Table 10: Weight values of indicators at all levels in the evaluation system of sightseeing train appearance design.

5.5.3 Evaluation matrix

This paper utilized a questionnaire format primarily targeted at undergraduate and graduate students majoring in art and design at colleges and universities. Additionally, a random sample of ordinary individuals was included, totaling 133 participants. The evaluation categories for the sightseeing train's appearance design were set as 'Satisfactory,' 'Average,' and 'Dissatisfied.' The questionnaire results are presented in Table 11.

Evaluation level	Category	Number of people (%)		
		Satisfactory	Average	Dissatisfied
Overall evaluation of design scheme	Reflect the regional culture of Kunming Lake	97 (72.93)	31 (23.31)	5 (3.76)

Cultural semantics	Reflect the semantics of Emperor	101 (75.94)	19 (14.29)	13 (9.77)
	Reflect the semantics of Turreted Warship	88 (66.16)	30 (22.56)	15 (11.28)
	Reflect the semantics of Spray	85 (63.91)	40 (30.08)	8 (6.01)
Graphical semantics	The graphical relevance of the Emperor	112 (84.21)	18 (13.53)	3 (2.26)
	The graphical relevance of the Turreted Warship	108 (81.20)	20 (15.04)	5 (3.76)
	The graphical relevance of the Spray	98 (73.68)	24 (18.05)	11 (8.27)

Table 11: Questionnaire results of sightseeing train appearance design.

According to the questionnaire in Table 11, a fuzzy evaluation matrix R_A and R_B were constructed:

$$R_A = \begin{bmatrix} 75.94 & 14.29 & 9.77 \\ 66.16 & 22.56 & 11.28 \\ 63.91 & 30.08 & 6.01 \end{bmatrix} \quad (17)$$

$$R_B = \begin{bmatrix} 84.21 & 13.53 & 2.26 \\ 81.20 & 15.04 & 3.76 \\ 73.68 & 18.05 & 8.27 \end{bmatrix} \quad (18)$$

5.5.4 Evaluation results

Use Equation (11) to calculate the evaluation vector $\boldsymbol{B}$ of sightseeing train design scheme, namely:

$$B_A = W_A R_A = \begin{bmatrix} 0.35 & 0.53 & 0.12 \end{bmatrix} \times \begin{bmatrix} 75.94 & 14.29 & 9.77 \\ 66.16 & 22.56 & 11.28 \\ 63.91 & 30.08 & 6.01 \end{bmatrix} = \begin{bmatrix} 69.31 & 20.57 & 10.12 \end{bmatrix} \quad (19)$$

$$B_B = W_B R_B = \begin{bmatrix} 0.37 & 0.41 & 0.22 \end{bmatrix} \times \begin{bmatrix} 84.21 & 13.53 & 2.26 \\ 81.20 & 15.04 & 3.76 \\ 73.68 & 18.05 & 8.27 \end{bmatrix} = \begin{bmatrix} 80.66 & 15.14 & 4.20 \end{bmatrix} \quad (20)$$

$$B_C = W_C \begin{bmatrix} R_A \\ R_B \end{bmatrix} = \begin{bmatrix} 0.76 & 0.24 \end{bmatrix} \times \begin{bmatrix} 69.31 & 20.57 & 10.12 \\ 80.66 & 15.14 & 4.20 \end{bmatrix} = \begin{bmatrix} 72.03 & 19.27 & 8.70 \end{bmatrix} \quad (21)$$

According to Equation (12), the satisfaction score *V* reflecting each index in the design scheme was calculated as:

$$V_A = B_A H = 79.60 \quad (22)$$

$$V_B = B_B H = 88.23 \quad (23)$$

$$V_C = B_C H = 81.67 \quad (24)$$

Therefore, the final evaluation results of the appearance design of Kunming Lake sightseeing train are shown in Table 12.

Goal layer	Satisfaction (%)	Criterion layer	Satisfaction (%)	Indicator layer	Satisfaction (%)
Design elements embodying the regional culture of Kunming Lake C	81.67	Cultural semantics A	79.60	Emperor A_1	83.09
				Turreted Warship A_2	77.44
				Spray A_3	78.95
		Graphical semantics B	88.23	Emperor B_1	90.98
				Turreted Warship B_2	88.72
				Spray B_3	82.71

Table 12: Evaluation results of Kunming Lake sightseeing train appearance design.

According to the evaluation results in Table 12, the overall satisfaction with the appearance design of the Kunming Lake sightseeing train, as determined through the questionnaire survey, stands at 81.67%. Furthermore, the satisfaction rates for the cultural semantics of characteristic words and graphic semantics are 79.60% and 88.23%, respectively. These findings affirm that the design scheme effectively reflects the regional cultural characteristics of Kunming Lake.

6 CONCLUSION

As the window of the city's external exhibition, the appearance design of the sightseeing train plays a vital role in the promotion of the city's regional culture. This paper puts forward a method of sightseeing train appearance design and evaluation based on the extension semantics of regional cultural graphics, and realizes the visual graphic expression of the regional cultural carrier of Kunming Lake. The research results show that the design method proposed in this paper can better integrate the regional cultural characteristics of Kunming Lake with the appearance design of sightseeing trains, and the design and evaluation method proposed in this paper can provide reference for the appearance design of similar products.

By introducing relevant theories of extenics, this paper had paved the way for explicitly expressing cultural connotations in product exterior design and rational evaluation pathways. Throughout the entire analysis process, it utilized diagrammatic thinking to evaluate the diagrammatic semantics of features and tried to enhance the objectivity of the evaluation by collecting evaluation information through multiple objectives. In the future, relevant theories of extenics in the application of product exterior design can conduct more in-depth research in the extensics mining of implicit knowledge as well as in intelligent assistance.

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