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An Analysis of the Requirements for Smart Guiding Services in Museums Using the Kano-AHP Method

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Abstract: This study aims to enhance the visiting experience in museums by investigating visitor demands for a smart guiding service system. Through the utilization of semi-structured interviews and field observations, the research explores visitor needs comprehensively. The Kano model is employed to categorize the various requirements, and the hierarchical analysis approach (AHP) is used to determine attribute weights, ensuring a thorough evaluation. By creating a hierarchical structure model for the smart guiding service system in museums and obtaining a comprehensive weight ranking for each indicator, the study provides a solid foundation for the development of effective solutions. Based on the ranking, several proposals are generated, presenting actionable insights for the implementation of a smart guiding service system. The findings emphasize the value of the Kano-AHP model in analyzing visitor demands, offering valuable guidance for museums aiming to establish an efficient and user-centric smart guiding service system.

1. Introduction

As an important carrier for the inheritance and communication of human civilization[1], museums possess important cultural and social values. In museum services, the guiding service plays a significant role in connecting visitors, exhibits, data and environment, which provides a convenient visiting experience for visitors; thus, the guiding service's performance in this area directly affects visitors' pleasure and experiences. However, there are still some issues with the conventional museum guiding services, including the single content display, lack of interactivity and personalization, which make it challenging to meet the varied needs of visitors and further affect their experience and satisfaction[1,2].

With the development of information technology (IT), smart guides provide effective solutions to the above problems. It can offer users self-service, personalized, and high-quality guiding services through IT and improve the experience and pleasure of visitors. In the context of fostering digital growth and establishing a digital China, smart guides will be the development direction and emphasis of the museum's smart construction and guiding service, where the key point of smart construction is people-oriented[3]. The coordination of service functions with visitor expectations can only be ensured after a comprehensive understanding of visitors' needs and preferences for visiting contents and services. However, there is a lack of comprehensive design and evaluation for the museum's smart guiding service concentrating on visitor requirements. Therefore, the goal of this study is to explore the demands of museum visitors, which will give designers more scientific references for the functional configuration of a smart museum's guiding service design through evaluation and analysis.

To learn more about users' requirements and preferences, domestic and foreign experts frequently employ the Kano model to analyze user needs[4,5] and evaluate the impact of service quality on user satisfaction[6], while the Analytic Hierarchy Process (AHP) method is frequently applied for resource evaluation or screening of influence factors[7,8]. Both approaches can improve the validity of results from user research. Nevertheless, these methodologies have not been used together before in the majority of museum studies, particularly in smart guiding services, which lack integrated research from numerous viewpoints. Hence, this study incorporates the aforementioned methods, and analyzes the demands of various visitors for museum guiding services by the Kano model, followed by the AHP to classify and rank these needs. Finally, recommendations for the functional configuration of smart museum guiding services are proposed.

The paper is organized as follows: Section 2 contains a literature review of smart guiding services in museums, as well as the Kano model and AHP methods and applications, while Section 3 illustrates the Kano-AHP process and methods. Section 4 presents the evaluation results of the visitor requirements for smart guiding services. Then, Section 5 provides the functional configuration recommendations based on the results, and Section 6 presents the conclusions.

2. Literature Review

2.1. Smart Guiding Services System in Museums

Through the technologies of big data, the Internet of Things (IoT), and artificial intelligence, smart guides are focused on the needs of visitors which offer individualized and high-quality guiding services using intelligent environment composition, smart devices, and mobile applications[9]. The quality of smart guiding services will directly affect visitors' satisfaction. Therefore, personalized service functions can be provided based on different visitor demands and optimized by combining them with corresponding information technologies.

The development of smart guide construction is people-oriented, with a thorough grasp of the diverse demands of visitors. Until the date, museum researches have been conducted which possess remarkable achievements in visitor experience enhancement. Zheng revealed the benefits of the demassification services concept in increasing tourist enjoyment by creating a smart service system[10]. Wang demonstrated that visitors' pleasure would decline when access to museums' public cultural services became more expensive[11]. Feng et al. put forward the strategy of upgrading the software and hardware to satisfy the requirements of different tourists[12]. In addition, Wu and co-workers designed the smart guiding system for the Chengdu Jinsha Museum after carefully considering technological difficulties, information display style, and user demands, which raised the standard of guiding services[13].

The rapid development of IT has broadened the way of guiding systems optimization, which further improves the user experience. Alletto et al. created and evaluated a system based on an indoor location-aware architecture. It utilized wearable devices, image recognition, and positioning technologies to supply exhibit-related content in order to increase the accuracy of exhibition interpretation[14]. A smart multimedia guiding system was created by Angelo that detected the distance between the visitor and the exhibit to put exhibit information[15]. On the basis of visitor sensory characteristics and behavioral patterns, Guo and colleagues investigated information presentation, content, and functions in museum augmented reality (AR) applications to create a high-quality, high-cognition, and cost-effective guiding tour experience to enhance the experience and interactivity of the exhibition[16]. Besides, Li et al. proposed a hybrid AR and virtual reality (VR) technology for developing a museum interactive display system that could achieve an immersive exhibition experience[17]. And Muhammad et al. created a smart navigation and information system to improve the effectiveness of indoor navigation in museums[18].

According to the aforementioned studies, there is a dearth of systematic studies about the demands of museum visitors, with the majority of existing smart guiding researches concentrating on IT field. However, it is necessary to comprehensively investigate the visiting needs of various museum visitors first, followed by a weighting analysis of those needs, in order to develop a general smart guiding service system. Consequently, a thorough exploration of museum visitor preferences is essential for offering functional configuration recommendations for the smart guiding service system.

2.2. Kano and AHP

The Kano model, a user requirements analysis approach, is employed to investigate the connection between product characteristics and customer satisfaction[19,20] The model is put forward by Professor Noriaki Kano at the Tokyo Institute of Technology, which categorizes user needs into five attributes (must-be, one-dimensional, attractive, indifferent, reversal, and questionable) based on user responses to various products and prioritizes these attributes[21,22].Since the discovery of the Kano model, several studies have been constantly emerging for product evaluation. Qu and co-workers exploited the Kano model to establish a hierarchical tower of passengers' waiting demands and ranked the facility demands according to the calculation of the user satisfaction index coefficient and sensitivity[23]. A design strategy that integrates the Kano model with robust design was advised by Chen et al., which determined the weight of each product criterion for achieving the desired customer satisfaction performance[24]. Based on a quantitative Kano model identifying the relationship between user requirements and user satisfaction, Zhao et al. proposed a new strategy to link the requirements mapping phase with the product configuration design phase[25]. However, the traditional Kano model is a qualitative analysis method where the preferences of product features are classified by the degree of selection of positive and negative issues in the Kano model requirements classification assessment table. Thus, there are no quantitative criteria in the Kano model to quantitatively analyze the user requirement weights[4].

AHP is a multilevel decision analysis technique that may divide an issue into several levels and determine the ultimate choice result using both qualitative and quantitative investigation[26]. Thomas Saaty, an American operations researcher, created this approach to resolve complicated multi-criteria decision issues by rating various solutions and choosing the best one when the decision maker is faced with numerous objectives or criteria[27]. AHP is used in many domains where decision-making is involved since logical judgments are extremely organized and scientific in the judgmental decision-making process of AHP. Han et al. utilized AHP to enhance the process of evaluating the design of products for elderly home healthcare and to encourage the growth of such items[28]. Hou et al. created a similar index system after analyzing the weight values of the functional requirement indicators of smart baby strollers made by AHP[29]. Furthermore, Luo et al. solved the pain points and needs of tower crane drivers using AHP and calculated the weight values of each demand element, which helped to develop a smart tower crane cab solution based on user requirements and anticipated growth trends for tower cranes[30].

Combined with the Kano model and AHP, user requirement weights could be determined by AHP, followed by the establishment of a hierarchical analysis model, which will increase the accuracy of weights and the distinction of user need types. Wei et al. increased the rationality of design solutions using the Kano-AHP model to scientifically categorize user need characteristics and precisely determine requirement prioritization[31]. Bing et al. utilized AHP to create a hierarchical structure model for evaluating the composition factors of agricultural machine modeling and screen the best scheme after analyzing the gathered design criteria of agricultural machinery using the Kano model[32]. In terms of need determination, weight analysis, and product creation, the aforementioned studies achieved respectable results. In conclusion, the combination of the Kano model and AHP is a logical and practical approach for studying user needs, which may enhance the objectivity of hierarchical qualitative analysis[32].

3. Research Methods based on Kano-AHP

Excellently smart and personalized guiding service design is difficult to balance and presents a challenge for design-method management. In the current study, research procedures are followed by the Kano-AHP model. First, the necessary, desirable, and charming factors of guiding services are clarified by the Kano model, which is taken as a reference for the implementation of future guiding system designs. Subsequently, AHP is applied to divide the hierarchy into diverse layers to efficiently extract user preferences for core attributes that have multiple-level specifications, which finally determine the weighting of each type of requirement. After that, suggestions for the smart guiding services of museums are proposed based on the analysis results. The research scheme is shown in **Figure 1**.

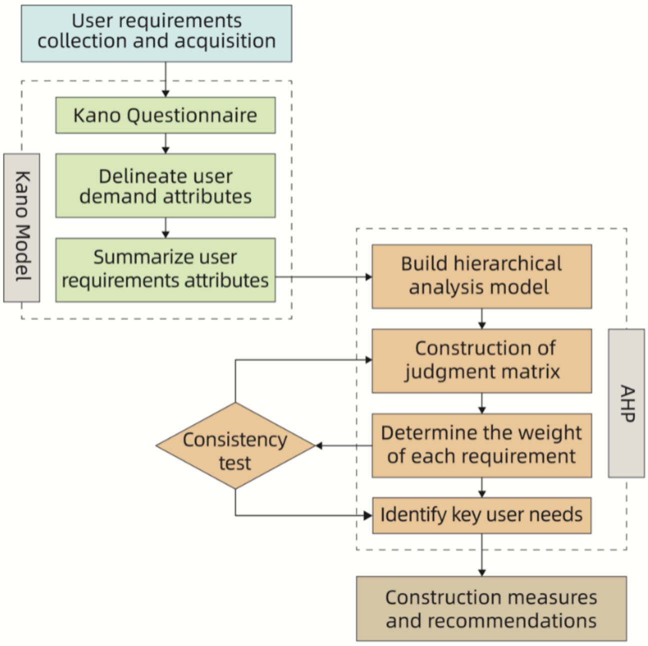

Figure 1: Scheme of User Requirements Research Process.

3.1. Kano Model

Due to the differences in visiting demands among various populations, there is almost no instruction in the design of guiding services. However, by collecting the preferences of users, designers can distinguish whether the need meets the general users' expectations. In this study, visitors were recruited to finish the Kano questionnaire, a matrix scale rating the guiding services at the museum positively and negatively, as well as evaluating the alternatives from "dissatisfied" to "satisfied" on a scale of 1 to 5 in descending order. Therefore, the Kano questionnaire could capture users' responses in both scenarios for a particular feature. The list of queries is shown in **Table 1**.

Table 1: The Kano questionnaire.

Demand items	Dissatisfied	Live with	Indifferent	Must-be	Satisfied
Positive	1	2	3	4	5
Negative	1	2	3	4	5

The Kano evaluation table consists basically of a template where each pair of answers for the positive and negative questions is allocated, and the user requirement could be placed in one of the five Kano requirement categories. According to the statistical proportions, the questionnaire results were combined with the Kano model evaluation classification table to determine the type to which each demand belongs. M, O, A, I, R, and Q were used to represent the must-be attribute, one-dimensional attribute, attractive attribute, indifference attribute, reversal attribute, and suspicious attribute, respectively, which enhanced the sensitivity of requirement classification. Besides, the Better-Worse coefficient calculation method, expressing how much an increase or reduction in a need has an impact on satisfaction, was introduced to prevent misclassification of requirement attributes, particularly when the statistical values of two requirement types were close to each other. For a certain demand item, the better coefficient, abbreviated as B, reflects the increment of user satisfaction; conversely, after removing an item, the decrement of satisfaction is represented by worse coefficient, abbreviated as W, which were calculated using formulas (1, 2).

$$B = \frac{A+O}{A+O+M+I} \tag{1}$$

$$W = -\frac{O+M}{A+O+M+I} \tag{2}$$

All requirements' Better-Worse coefficients were identified, and their mean value was computed, which served as the basis for all subsequent calculations. The desirable attribute is in the first quadrant, the charming attribute is in the second quadrant, the undifferentiated attribute is in the third quadrant, and the important attribute is in the fourth quadrant.

3.2. AHP

Table 2: 1-9 scale for AHP preference.

Importance Intensity	Explanation
1	Two activities contribute equally to the objective
3	Experience and judgment slightly favor one over another
5	Experience and judgment strongly favor one over another
7	Activity is strongly favored and its dominance is demonstrated in practice
9	Importance of one over another affirmed on the highest possible order
2,4,6,8	Used to represent compromise between the priorities listed above
Reciprocal of above non-zero numbers	If activity *i* has one of the above non-zero numbers assigned to it when compared with activity *j*, then *j* has the reciprocal value when compared with *i*

A hierarchical model of the smart guiding service system in the museum was built, consisting of a target layer, a criterion layer, and a solution layer, in accordance with the four-quadrant diagram of the Kano model requirements. The requirements of undifferentiated attributes were removed, while the requirements of essential attributes, desired attributes, and charming attributes were retained. In order to determine the demand index weights of the criteria layer and the solution layer in the system using AHP, first, the $n \times n$ pairwise comparison matrix for a two-by-two comparison was built, where aij represented the importance value of factors i and j relative to the target, and n was the number of indicators of the level. The value of aij was usually given by experts in the field. And the standard numeric scale used for AHP was 1-9 scale, which lied between "equal importance" to "extreme importance" (**Table 2**)[33].

Table 3: Random consistency index.

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.52	0.89	1.12	1.26	1.36	1.41	1.46

Then, the consistency needed to be verified. In the formula (3), n denoted the order of the evaluation scale corresponding to the judgment matrix, and RI denoted the average random consistency index, whose values are shown in **Table 3**. The consistency ratio CR could be used to assess whether or not the consistency test passes. When CR ≤ 0.1, the consistency test has passed; if CR > 0.1, the consistency test has failed, and the judgment matrix must be checked and any required repairs and adjustments made before running the analysis again.

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (3)$$

$$CR = \frac{CI}{RI} \quad (4)$$

After the pairwise comparison matrix, the weight vector was then solved using the geometric mean approach. The judgment matrix's values for each row were cumulatively multiplied to produce the final product, as shown below:

$$M_i = \prod_{j=1}^{n} a_{ij} \quad (i, j = 1, 2, \ldots, n) \quad (5)$$

$$b_i = \sqrt[n]{M_i} \quad (i, j = 1, 2, \ldots, n) \quad (6)$$

$$\omega_i = \frac{b_i}{\sum_{i=1}^{n} b_i} \quad (i, j = 1, 2, \ldots, n) \quad (7)$$

$$\lambda_{max} = \frac{1}{n} \sum_{i=1}^{n} \frac{A\omega_i}{\omega_i} \quad (i, j = 1, 2, \ldots, n) \quad (8)$$

where a_{ij} denoted the demand indicator in the i row and j column, while n denoted the total number of demand indicators, priority weight $A\omega_i$ represented the i component of the vector $A\omega$.

4. Smart Guiding Services Needs in Museums by Kano-AHP

4.1. Initial Demands Survey of Visitors

This study first investigated the requirements of museum visitors through literature researches and interviews in order to acquire a full grasp of their guiding needs. The visitor types were separated into three groups: local visitors, international visitors, and professional scholar visitors, with five members from each group chosen for additional semi-structured interviews regarding their visiting needs. It was discovered that the demands of museum visitors could be split into three stages: before, during, and after the visit, where various categories of visitors varied significantly. A description of the needs and keywords was developed for the guiding functions by summarizing and evaluating the particular demands of the visitors' input, and the specific findings are shown in **Table 4**.

Table 4: The initial needs of guiding service from visitors visiting museums.

Number	Guiding service	Requirements	Stage
X_1	Exhibition hall consultation	Get information on museum openings and exhibitions	Before the visit
X_2	Ticket reservation	Learn how to purchase tickets and make reservations at the museum	
X_3	Route navigation	Plan your route and travel to the museum	
X_4	Sub-flow into the museum	Conveniently access to the museum, check the ticket, and avoid crowding	
X_5	Item storage	Conveniently store the belongings	
X_6	Route recommendation	Understand the distribution of venues to determine the navigation path	During the visit
X_7	Route customization	Customize personal tours	
X_8	Real-time positioning	Locate real-time position	
X_9	Exhibit search	Quickly search where important exhibits located	
X_{10}	Crowd distribution	Avoid crowding during the tour	
X_{11}	Explanatory mode	Choose the presentation mode for your needs	
X_{12}	AR explanatory	Easily access to exhibit information details	
X_{13}	Exhibit gallery	Conveniently record the exhibit information	
X_{14}	VR experience	Provide 360^o immersive experience	
X_{15}	Interactive games	Interactively experience the games for the popularization of cultural relics	
X_{16}	Toilet cubicle inquiry	Quickly find the nearest restroom	
X_{17}	Real-view navigation	Quickly find rest areas, restaurants, and creative stores	
X_{18}	Path review	Organize the contents of exhibit records	After the visit
X_{19}	Tour record generation	Review the tour photos	
X_{20}	Tour notes	Share tour guide	
X_{21}	Feedback	Give points about the browsing experience	

4.2. Attributive Classification of Guiding Service Demand by Kano Model

Based on the visitors' initial requirements, the Kano questionnaire with a standardized format was created. It recognized the features of the visitors' guiding service needs, which were determined by asking both positive and negative questions. There were 120 questionnaires sent out, and 103 valid surveys were returned. The total reliability coefficient was 0.947, in which positive questions had a reliability value of 0.884 and negative questions of 0.982, both more than 0.8, suggesting that the survey's findings were reliable. The forward and backward questions' KMO values in the validity test were 0.752 and 0.945, respectively, and the *P*-values of Barlett's spherical tests for both were less than 0.001, which met the requirements that the KMO value was greater than 0.6 and the *P*-value of the Barlett's spherical tests was less than 0.05, indicating that the research results had high validity.

The preliminary attribute classification of the gathered research questions was carried out in accordance with the Kano model classification control table. Since most of the demand types in the initial attribute classification of Kano presented the attractive type, which might be attributed to the fact that visitors were accustomed to the status quo of museum guiding services and had low expectations for them, it was necessary to introduce the Better-Worse coefficient calculation method to help identify the types of demands to which they belong. Taking the worse as the horizontal axis and better as the vertical axis established the coordinate axis, and using the mean values drew the as reference lines. **Table 5** and **Figure 2** display the data and categorization of the 21 visitor guiding service demands for museums.

Table 5: Kano model analysis results.

Number	A/%	O/%	M/%	I/%	R/%	Q/%	B/%	W/%	Category	B-W Category
X_1	9.71	21.36	34.95	25.24	0.00	8.74	61.70	-34.04	A	M
X_2	8.74	25.24	35.92	20.39	1.94	7.77	67.74	-37.63	A	M
X_3	4.85	22.33	45.63	17.48	0.00	9.71	75.27	-30.11	A	O
X_4	5.83	28.16	42.72	15.53	0.00	7.77	76.84	-36.84	A	O
X_5	6.8	27.18	38.83	19.42	0.97	6.80	71.58	-36.84	A	M
X_6	4.85	24.27	49.51	11.65	0.97	8.74	81.72	-32.26	A	O
X_7	1.94	17.48	48.54	22.33	0.97	8.74	73.12	-21.51	A	I
X_8	0.97	17.48	51.46	19.42	0.97	9.71	77.17	-20.65	A	A
X_9	1.94	18.45	54.37	15.53	0.00	9.71	80.65	-22.58	A	A
X_{10}	2.91	21.36	52.43	13.59	0.00	9.71	81.72	-26.88	A	A
X_{11}	0.97	20.39	50.49	20.39	0.00	7.77	76.84	-23.16	A	A
X_{12}	2.91	21.36	50.49	18.45	0.00	6.80	77.08	-26.04	A	A
X_{13}	3.88	20.39	50.49	16.50	0.00	8.74	77.66	-26.6	A	A
X_{14}	0.97	17.48	51.46	20.39	0.97	8.74	76.34	-20.43	A	A
X_{15}	0.97	14.56	46.6	27.18	0.97	9.71	68.48	-17.39	A	I
X_{16}	9.71	38.83	35.92	6.80	0.97	7.77	81.91	-53.19	O	O
X_{17}	2.91	28.16	43.69	16.5	0.97	7.77	78.72	-34.04	A	O
X_{18}	0.00	17.48	45.63	29.13	0.97	6.80	68.42	-18.95	A	I
X_{19}	0.97	18.45	42.72	29.13	0.00	8.74	67.02	-21.28	A	I
X_{20}	0.97	12.62	47.57	28.16	0.97	9.71	67.39	-15.22	A	I
X_{21}	0.97	13.59	37.86	39.81	0.00	7.77	55.79	-15.79	I	I

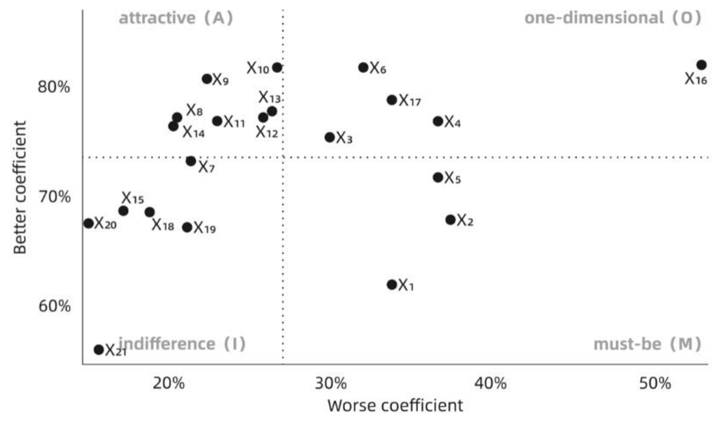

Figure 2: Quantitative Kano model decision matrix.

Figure 2 shows that among the visitor guiding service requirements, X_3, X_4, X_6, X_{16}, X_{17} belong to the one-dimensional attribute, which are positively correlated with user satisfaction; X_8, X_9, X_{10}, X_{11}, X_{12}, X_{13}, X_{14} belong to the attractive attribute, which will significantly increase user satisfaction; X_1, X_2, X_5 are for must-be attribute, which are the basic requirements of the guiding service system. X_7, X_{15}, X_{18}, X_{19}, X_{20}, X_{21} are requirements with no differentiated qualities unrelated to user pleasure.

Hence, the development of the museum's smart guiding service system should fulfill the needs of X_3, X_4, X_6, X_{16}, X_{17} as much as feasibly possible based on the needs of X_1, X_2, X_5, and further meet the needs of X_8, X_9, X_{10}, X_{11}, X_{12}, X_{13}, X_{14}.

4.3. The Hierarchical Analysis of Guiding Service Needs by AHP

The needs of non-differential characteristics were screened out by the Kano model, while the demands of must-be, attractive, and one-dimensional attributes were preserved. The 15 requirements and 3 attributes were classified to construct the hierarchical structure model of the smart guiding service system in a museum (**Figure 3**). The smart guiding service system function in the museum was of the goal layer, the 3 attributes were of the criterion layer, and the 15 requirements under each attribute were of the alternative layer.

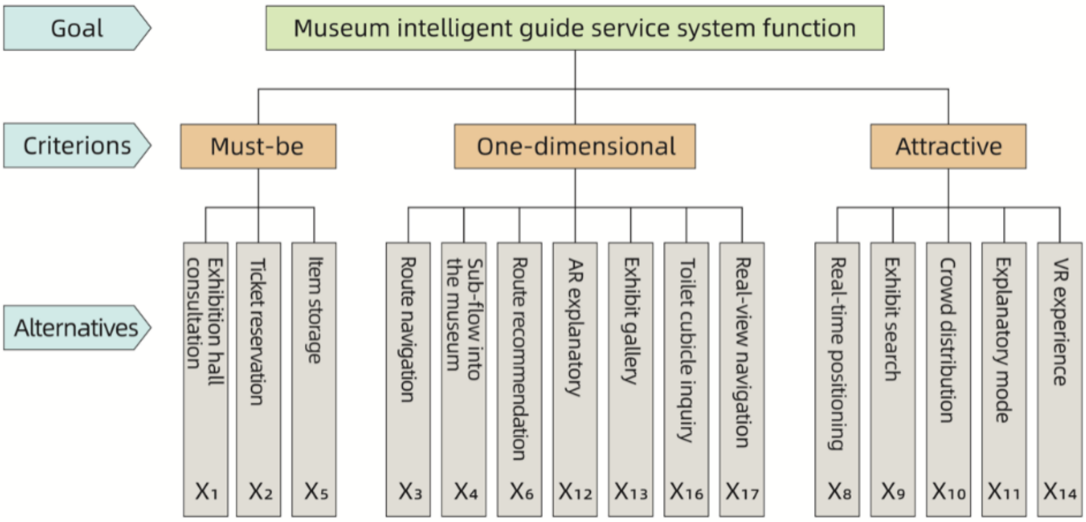

Figure 3: Hierarchical model of museum smart guiding service system.

The expert group evaluated the indicators of the criterion layer and the alternative layer two by two on the basis of the hierarchical structure model. The weight of each layer was then calculated using the geometric mean method (**Tables 6-9**). The CR values were 0.0176, 0.0633, 0.0202, and 0.0540, respectively, all of which were less than 0.1 and satisfied the consistency test criteria.

Table 6: Criterions indicator weights.

Criterions indicator	M	O	A	ω
M	1	3	6	0.6530
O	1/3	1	3	0.2510
A	1/6	1/3	1	0.0960

Table 7: Must-be indicator weights of alternatives.

Must-be indicator	X_1	X_2	X_5	ω_X
X_1	1	1/7	1/3	0.0833
X_2	7	1	5	0.7235
X_5	3	1/5	1	0.1932

Table 8: One-dimensional indicator weights of alternatives.

One-dimensional indicator	X_3	X_4	X_6	X_{12}	X_{13}	X_{16}	X_{17}	ω_X
X_3	1	1/2	1/7	1/4	1/3	1/6	1/3	0.0368
X_4	2	1	1/3	1/2	1/2	1/3	1/2	0.0711
X_6	7	3	1	2	3	2	3	0.3006
X_{12}	4	2	1/2	1	2	1/2	2	0.1583
X_{13}	3	2	1/3	1/2	1	1/2	2	0.1193
X_{16}	6	3	1/2	2	2	1	2	0.2153
X_{17}	3	2	1/3	1/2	1/2	1/2	1	0.0985

Table 9: Attractive indicator weights of alternatives.

Attractive indicator	X_8	X_9	X_{10}	X_{11}	X_{14}	ω_X
X_8	1	1/3	2	1/4	1/2	0.0996
X_9	3	1	4	1/2	2	0.2688
X_{10}	1/2	1/4	1	1/5	1/3	0.0629
X_{11}	4	2	5	1	2	0.3910
X_{14}	2	1/2	3	1/2	1	0.1777

To clearly present the importance of the needs in the must-be, attractive, and one-dimensional attributes in the criterion layer, which have impacts on visitor satisfaction, the comprehensive weights were calculated by multiplying the corresponding weights of the criterion layer and alternative layer, and ranked to further identify the key needs (**Table 10**).

Table 10: Indicator weights for alternatives requirements index.

Requirements properties	Weights of criterions layer	Alternatives index	Weights of alternative layer	Comprehensive weight	Comprehensive ranking
M	0.6530	X_1	0.0833	0.0543949	4
	0.6530	X_2	0.7235	0.4724455	1
	0.6530	X_5	0.1932	0.1261596	2
O	0.2510	X_3	0.0368	0.0092368	14
	0.2510	X_4	0.0711	0.0178461	11
	0.2510	X_6	0.3006	0.0754506	3
	0.2510	X_{12}	0.1583	0.0397333	6
	0.2510	X_{13}	0.1193	0.0299443	8
	0.2510	X_{16}	0.2153	0.0540403	5
	0.2510	X_{17}	0.0985	0.0247235	10
A	0.096	X_8	0.0996	0.0095616	13
	0.096	X_9	0.2688	0.0258048	9
	0.096	X_{10}	0.0629	0.0060384	15
	0.096	X_{11}	0.391	0.037536	7
	0.096	X_{14}	0.1777	0.0170592	12

According to **Table 10**, the comprehensive weights of visitors' smart guiding service demands for museums are as follows in descending order: ticket reservation (X_2), item storage (X_5), route recommendation (X_6), exhibition hall consultation (X_1), toilet cubicle inquiry (X_{16}), AR explanatory

(X_{12}), explanatory mode (X_{11}), exhibit gallery (X_{13}), exhibit search (X_9), real-view navigation (X_{17}), sub-flow into the museum (X_4), VR experience (X_{14}), real-time positioning (X_8) , route navigation (X_3) , crowd distribution (X_{10}). The must-be attribute needs are all at the top of the comprehensive weight ordering, followed by the one-dimensional and attractive attribute needs, which are consistent with the Kano model analysis results.

5. Suggestions of the Functional Configuration for Museum's Smart Guiding Service System

It is well known that an essential embodiment of the intelligent construction of museums is the smart guiding service, of which creation should take "user-centered" as its core principle and reform the functions of the traditional guiding service. In order to improve the user experience, smart guiding services ought to realize the transition from a one-way transmission pattern to a two-way interactive pattern, as well as the change from a content tour to visit planning[34]. The results of the aforementioned study indicate that the one-dimensional and attractive attribute of visitor needs must be paid much attention, in addition to the necessity of giving priority to the must-be attribute. To create a smart guiding service system for museums, the following recommendations are offered.

1) Enriching the functions of the guiding service

The smart guiding service system configurations should focus on the entire process of visitors visiting the museum and open up the connections among visitors, exhibits, data, and the environment to provide visitors with a guiding service in visit planning. According to the analysis results, ticket reservation (X_2), item storage (X_5), and exhibition hall consultation (X_1) in the comprehensive weight ranking of demand indicators are ranked first, second, and fourth, respectively. All of them belong to the must-be attribute with a significant influence on visitors and should be prioritized for consideration. Therefore, the establishment of an integrated guiding service system should include the functions of ticket reservation, item storage, and exhibition hall consultation so that visitors may easily complete the preparation before the visit[35]. For instance, the ticket reservation could be set at the information push window of the exhibition hall consultation to streamline visitor interaction and improve convenience. Ticket reservations can be divided into different time periods to avoid traffic congestion through the function of sub-flow into the museum (X_4). After booking the tickets, visitors can make an appointment for the storage service to avoid the situation where the storage box is full after arriving at the museum. Besides, adding the function of route navigation (X_3) in the consulting reservation information window help visitors choose an appropriate transportation mode. The integrated guiding service system will facilitate the visiting plans of visitors and extend the guiding service to before arriving at the museum.

2) Improving the personalized guiding service

Since the goals and requirements of museum visitors vary widely, the museum guiding service must offer customized two-way interactive functions to meet various demands. Route recommendation (X_6) comes in first in one-dimensional attribute and third in comprehensive weight ranking. In terms of explanatory mode (X_{11}), it is ranked seventh in comprehensive weight ranking while first in attractive attribute. And exhibit search (X_9) is placed second in attractive attribute and ninth in comprehensive weight ranking. Once the above three demands are met, visitors' satisfaction will be greatly improved. Nowadays, the individualized tour guidance has become the dominant trend in guiding services. The guiding service system can offer visitors individualized functions through information exchange between visitors and the guiding system. As an example, the guiding service system can collect visitors' personal preferences, including visiting time, content preference, personal interests, etc., and recommend paths that meet their needs through big data analysis. Meanwhile, visitors can search for target exhibits for path planning during the path guide process, and the guiding service system should also offer a variety of explanatory modes (X_{11}), such as general mode, professional mode, and children's model. Additionally, visitors may use AR technology to scan the displays to access an AR explanation (X_{12}). During the explanation process, the guiding service system would offer browsing and downloading functions for the exhibit gallery (X_{13}) in order to help visitors observe exhibitions and records more naturally.

3) Combining new technologies to optimize the visiting experience

Smart guiding services in museums could optimize functions to improve visiting experiences of visitors by new technologies like the IoT, big data, VR, AR, and radio frequency identification (RFID). One of the crucial demands is the toilet cubicle inquiry (X_{16}), which is ranked second in one-dimensional attribute and fifth in comprehensive weight ranking. It will negatively impact visitors during their whole visiting experience if this guiding service function is substandard. Thus, to prevent crowding and queuing in the restroom, adding the toilet cubicle inquiry feature is essential to assist visitors in checking the available toilet location in real time. Visitors could rapidly find functional areas in the museum with the function of real-view navigation (X_{17}) and real-time positioning (X_8) by GPS and AR technologies, which enhances the precision and effectiveness of indoor navigation. Additionally, real-time positioning (X_8) could achieve the automatic detection of exhibits and push explanations in conjunction with RFID technology to provide the accompanying guide. Moreover, visitors can plan a tour route utilizing the crowd distribution (X_{10}) function of IT, which efficiently avoids crowded venues and further increases tour efficiency. Combining AR interpretation (X_{12}) and VR experience (X_{14}), smartphone applications offered by the guiding service system achieve an immersive visiting experience and 3D scenes for visitors, which contributes to boosting the experience and pleasure of visitors.

6. Conclusion

This study explores the museum guiding service demands of visitors using the Kano-AHP model. A hierarchical model of the museum smart guiding service system is obtained with 15 indicators after using the Kano questionnaires to complete attribute categorization at first. Then, the weight ranking of indicators is conducted by AHP, followed by the comprehensive weight ranking and obtaining the comprehensive weight of alternative layer indicators in the hierarchy of the museum smart guiding service system. Finally, this study offers several recommendations for the design of a museum smart guiding service system based on ranking results, which is expected to increase visiting experience and pleasure and provide a theoretical foundation for the establishment of smart museums.

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