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Combining Combinatorial Optimization Algorithms for Diversity of Traditional Cultures in Cruise Ship Interior Designs

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Abstract As an important symbol of technological progress and a specific consumption space for daily life, cruise ships are an important medium for national power competition and traditional culture dissemination. The article innovatively proposes a model of cruise ship interior design based on field theory, which relies on the transformation and expression of modernity of traditional culture to promote the diversified development of interior design. The mathematical model of cruise ship interior design is established by rasterizing cruise ship interior design through the raster method and introducing the discount factor. The genetic algorithm and simulated annealing algorithm are combined to construct the GSA algorithm, which is used to solve the cruise ship interior design layout optimization model. The coefficient of variation method and the fuzzy comprehensive evaluation model are introduced to realize the comfort evaluation model for the integration of traditional culture expression in cruise ship interior design, which provides data support for the diversity of traditional culture expression in cruise ship interior design. When the scale of the cruise ship interior design layout scheme gradually increases, the fluctuation range of the GSA algorithm is within [0.81%,2.47%]. The width of the accessible pathway of the double bed in the accessible cabin on the side of the porthole in the layout optimization scheme actually takes the value of 1020mm, which meets the calibration requirement of the minimum limit (900mm). The weight of culture in cruise ship interior design can be up to 0.2648, and the comprehensive evaluation score of comfort is 7.581, with an evaluation grade of average. To carry out the diverse expression of traditional culture in cruise ship interior design, it is necessary to fully extract Chinese style elements and combine with green decorative materials to enhance the culturality of cruise ship interior design.

Index Terms field theory, building layout, genetic algorithm, layout optimization, cruise ship interior design

I. Introduction

In recent years, China's large-scale cruise industry has entered its initial stage. The national strategic level has introduced policies to promote the development of the cruise industry in the fields of study, research and application. In terms of international cooperation, foreign-funded cruise ships participate in domestic competition, and the trend of industrial diversification has increased, and in terms of market demand, the demand for cruise ships in the Asia-Pacific region, represented by China, has surged, and domestic and international routes have become increasingly abundant [1]-[3]. The function and mobility of the cruise ship determines that it is a window for displaying the national image and a natural carrier of national culture, and all circles have high expectations for the cultural inheritance of Chinese cruise ships, and the application of traditional Chinese cultural elements in the space of the cruise ship has become an important topic [4], [5]. Cruise ship is regarded as a “giant mobile vacation city on the sea”, which integrates the complex functions of residence, shopping, sightseeing, tourism, leisure and entertainment, etc., and is characterized by large capacity, complete types, and relative closure and independence. Different from the daily life style of urban space, cruise ship not only serves as a tool for vacation, but also a destination for vacation, in which there are often intensive commercial consumption, entertainment experience, and face more interaction activities with strangers [6]-[8]. Therefore, compared with the ethical order of traditional space, cruise ship space design is more based on consumption, experience and communication, which requires the expression of traditional spatial elements must be transformed accordingly. So in the tourism and leisure-oriented cruise ship interior space, what kind of logical structure should be used to complete the reorganization of the formal language of traditional cultural elements, how should traditional cultural elements adapt to the background of the media society, and how to implement the experiential nature of the space [9]-[11]? Based on the above problems, the use of combinatorial optimization algorithms to design a cruise ship that contains Chinese traditional culture and is in line with the international standards can not only greatly promote the development and adjustment of the ship manufacturing industry, but also promote the development of the tourism service industry, promote the development of related marine industries, and also promote the exchange of Chinese and foreign culture and technology and the enhancement of cultural cultivation [12]-[14].

Cruise travel has changed people's travel habits, transportation has become part of the journey, and cruise tourism has become a new type of tourism in China. Literature [15] provides an overview of the supply chain issues and retrofit forms that exist at this stage of the cruise industry, and points out the opportunities that exist, exploring opportunities for innovation and development of interior design in the cruise industry based on the goal of net-zero pollution. Literature [16] emphasizes the ability of color to balance physical and psychological comfort and examines color palettes on cruise ships, noting that yacht owners can choose interior design colors based on preference and that there is a tradition of color schemes for interior courtyards. Literature [17] proposed a lightweight design method for two-way heads of cruise ship mezzanine bulkheads based on the theory of terrain optimization under the consideration of the weight objective and the strength and buckling constraints of the mezzanine bulkhead wall head morphology design, and verified the practicability of the design method through empirical analysis, which provides a new direction for the research of alternative design fire-resistant bulkheads. Literature [18] focuses on the effect of applying multiple TRIZ innovation methods in the design process, construction and management of cruise ships, aiming to provide theoretical support for the design and construction of large luxury cruise ships and guide people to solve problems creatively.

Based on the field theory, the article establishes the power field, perception field and spirit field of cruise ship interior design, and integrates the diverse design of traditional culture into the perception field and spirit field to provide new ideas for the innovative expression of traditional culture in cruise ship interior design.

Visual symbols such as decorative styles, furniture and artworks in cruise ships show the artistic aesthetic quality of a country, and the interior design integrating traditional culture determines the final visual expression and artistic image of a cruise ship. Based on the field theory, this paper analyzes the changes of power field, perception field and spiritual field in cruise ship interior design, constructs a model of cruise ship interior design, and combs out the specific expression of traditional culture in cruise ship interior design. The relevant cultural facilities of cruise ship interior design are rasterized by the raster method, and the intelligent layout optimization model of cruise ship interior design is constructed by combining the energy discount factor. The GA and SA algorithms are combined to construct the GSA optimization algorithm to solve the layout optimization model. From the rationality, safety, culture, coordination and aesthetics of the traditional cultural expression design in cruise ship interior design, the comfort evaluation index system of cruise ship interior design was established. The coefficient of variation method was used to solve the weights of the indexes, and the comprehensive evaluation model was combined to carry out a comprehensive evaluation of the comfort of cruise ship interior design. The GSA algorithm is applied to the simulation solution of the cruise ship interior design layout optimization model to analyze the comfort evaluation of cruise ship interior design integrating traditional culture, which provides reference for proposing the traditional culture expression strategy of cruise ship interior design.

II. Design of traditional cultural expressions in cruise ship interior design

With the rapid development of technological progress and consumer culture, the interior design of cruise ships has given birth to new changes and expressions, and the modernity of design innovation is becoming more and more important. In fact, relying on the diversity of traditional cultural expression combined with pop culture, modern style, futurism and other elements to promote the diversification of cruise ship interior design, can provide support for cruise ships to better convey the national identity and comprehensive strength.

II. A. Steps in constructing the interior design of a cruise ship

II. A. 1) Applicability of field theory

The field is a spatial network containing objective relations, and to think from the perspective of the field is to analyze problems and understand social reality from the perspective of relations, using the thinking of the network. In relation to Bourdieu's theory of social practice, “field” can be interpreted as “a place where actors in different positions struggle under the guidance of their own habits, relying on the capital they possess” [19]. In this place, actors with different power take different means of struggle according to their position in the field, and play for different goals of struggle, at the same time, these actors are also shaping and changing the field.

From this point of view, the diversity of traditional culture design in cruise ship interior design, while introducing the existing environment, will definitely cause the actors in different positions in the original field to struggle to protect their own interests. The concept of field provides us with help in understanding and analyzing the actual activities of actors in daily life, and the field is both influenced by the actions of social individuals, while each action of social individuals is also influenced by the field in which they are located. The field theory contains power field, induction field and mental field, and there are obvious differences in the influence on cruise interior design in different field environments.

II. A. 2) Cruise ship interior design steps

At present, the mainstream cruise ship design enterprises for large cruise ship interior space design steps are generally divided into market positioning, preliminary design, concept design, program optimization. The process of cruise ship interior space design from the perspective of field theory is shown in Figure 1, which mainly includes background architecture, functional architecture, interaction architecture, and meaning architecture, and the power field, induction field, and spiritual field are mapped one by one with the latter three steps [20].

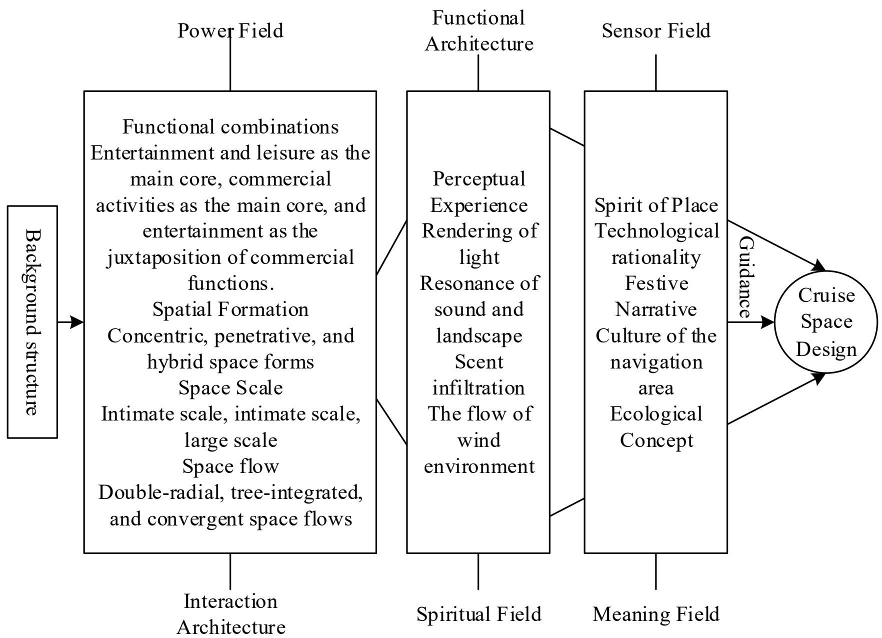


Figure 1: The design of the interior space of the cruise ship

Starting from the perspective of power field, it is helpful for atrium space planning and design, which involves function combination, space form, space scale and space flow, and is closely related to the functional architecture. From the perspective of induction field, it helps visitors to design their perceptual experience, including the rendering of light, the resonance of soundscape, the infiltration of smell, and the flow of wind environment, which is closely related to the interaction architecture. Starting from the perspective of the mental field helps to create the “spirit of place” in the atrium space, including the design of “manifestation” of traditional culture, the design of “empathy” of festival narratives, the design of “communion” of the cultural lineage of the navigation area, and the design of “integration” of the traditional culture of the navigation area. The design is closely related to the structure of meaning, including the design of traditional culture, the design of festival narrative, the design of “communion”, the design of ecological concept, and the design of “symbol”.

The scientific understanding of design ontology can effectively guide the practice of cruise ship interior space design, so that the cruise ship interior space becomes a composite space with the functions of art display, commercial consumption, leisure and entertainment, etc., which can satisfy the tourists' multi-dimensional perceptual experience needs and create a unique “spirit of place”.

II. B. Expression of traditional culture in cruise ship interior design

II. B. 1) Transformation of traditional culture into modernity

After thousands of years of precipitation and baptism, traditional Chinese culture has gradually accumulated and formed the philosophical ideas of the unity of heaven and man, harmony and perfection, and reverence for nature. The return and reconstruction of Chinese traditional culture is the historical necessity of contemporary society, and is also the necessary process of re-examining, excavating, inheriting and innovating Chinese traditional culture. Chinese traditional culture has a profound historical heritage, unique cultural elements and diversified cultural expressions, and its unique cultural values and thinking mode have received attention from the world.

In the design of cruise ship interior space, the conversion of thinking is a crucial step. Conversion of design thinking is not only a technical issue, but also a cultural and thinking mode issue. Designers need to change their perspective to the traditional Chinese culture, understand the connotation and extension of traditional Chinese culture, understand the Chinese aesthetic concepts and cultural emotions, scrutinize and excavate the aesthetic value contained therein, and create cruise ship painting design works with artistic value and cultural connotation. Cultural elements in cruise ship interior design are mainly expressed through colors, patterns, shapes, materials and so on. When applying cultural elements to cruise ship interior design, it is necessary to optimize and adjust the interior space, shape, volume, theme and other factors of the cruise ship in order to achieve the best fit and visual effect.

II. B. 2) Traditional cultural elements application expression

Relying on traditional cultural elements and specific steps of cruise ship interior design under field theory, traditional culture is symbolically transformed, relying on symbolic systems to express traditional cultural elements. Isomorphism mobilizes the location, volume, function, construction, material and other factors of the cruise ship interior space in order to establish the cruise ship interior space design experience. The specific logic of traditional cultural elements applied to cruise ship interior space design is shown in Figure 2. The basic mapping of traditional culture is carried out through vocabulary text, and then externalized into “surface structure” through the conversion of rules, and finally gained readability through words or other logical forms.

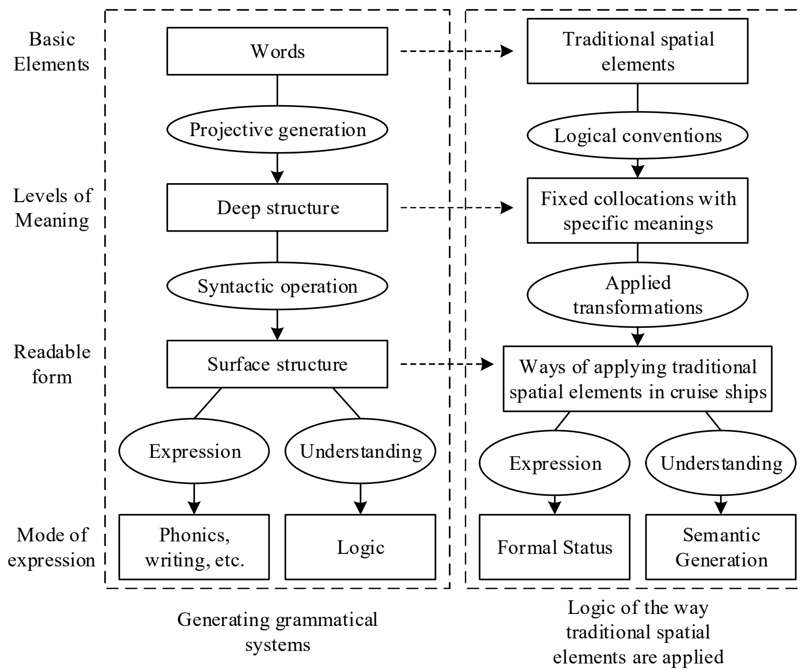


Figure 2: The application of traditional cultural elements

In the long process of historical and cultural evolution, traditional cultural elements have also been endowed with relatively stable meanings and collocation rules, and have been generally accepted. In the face of consumption and experience needs in the cruise ship interior design environment, traditional cultural elements can be transformed like words in a language, depending on the specific situation in terms of location, form, function, experience, materials and other perspectives, and together with its own semantics, it constitutes a new space. Relying on the diversified expression of traditional cultural elements, the innovative mode of cruise ship interior design is realized.

III. Evaluation of intelligent layout and comfort of cruise ship interior design

Traditional cultural symbols are not only a form of artistic expression, but also a national cultural symbol and inheritance of traditional culture. Incorporating traditional Chinese cultural symbols into the interior design of cruise ships symbolizes the rapid development of traditional Chinese culture and the revival of the nation. Cruise ships travel around the world, allowing people all over the world to experience Chinese cultural quality cabin space, which will be conducive to the spread of Chinese culture and expand its global influence. This chapter mainly introduces the cruise ship interior intelligent layout design method under the combinatorial optimization algorithm, and combines the fuzzy comprehensive evaluation to construct an evaluation model for the comfort of diverse cruise ship interior design integrating traditional culture, aiming to further explore the path of the in-depth integration of cruise ship interior design and traditional culture.

III. A. Intelligent layout optimization for cruise ship interior design

III. A. 1) Mathematical model construction for interior design

In order to realize the diversified design of traditional culture in the interior design of cruise ships, this paper relies on the grid method for the grid processing of facilities in the interior space of cruise cabins, and selects the grid size of 10cm*10cm according to the basic modulus in the design specification of cruise ships. The diversified design of traditional culture in the interior design of cruise cabins is essentially for the layout of indoor infrastructures in order to get the placement position and direction of facilities containing traditional culture, so as to get the optimal layout scheme. Facilities in the indoor placement position and direction, so as to get the optimal layout program. Therefore, the horizontal and vertical coordinates of the grid occupied by each traditional cultural facility in the coordinate system of the cruise cabin are the problem variables. Figure 3 shows the schematic layout of the facilities in the cruise cabin. Define the coordinates of the lower left corner of the grid where facility i is placed as (x_i, y_i), and its length and width are l_i, h_i respectively.

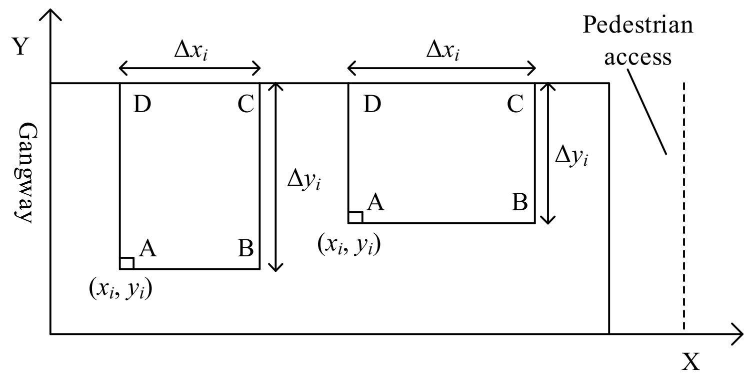


Figure 3: The cabin of the passenger cabin is arranged

As can be seen from the figure, when the facilities are placed vertically, $\Delta y_i = l_i$, $\Delta x_i = h_i$, and horizontally, $\Delta x_i = l_i$, $\Delta y_i = h_i$. Here, l_i, h_i, Δx_i and Δy_i are the ratio of the actual length to the modulus. The coordinates of the grid at the four vertices when the furniture facility i is placed are:

$$\begin{cases} A_i = (x_i, y_i) \\ B_i = (x_i + \Delta x_i - 1, y_i) \\ C_i = (x_i + \Delta x_i - 1, y_i + \Delta y_i - 1) \\ D_i = (x_i, y_i + \Delta y_i - 1) \end{cases} \tag{1}$$

In the layout plan, there may be a situation that the direction of facility placement does not meet the requirements, so it is necessary to correct its energy value, and here we introduce the discount factor β_i to perform the energy discounting operation. When the direction of facility placement does not meet the requirements, it is $\beta_i = 0.5$, and when it meets the requirements, it is $\beta_i = 1$. Thus, the energy value gap between the reasonable layout scheme and the unreasonable layout scheme is enlarged, and the solution speed is accelerated.

In order to make the layout of facilities in the cabin evolve towards the ideal scheme, the total energy value of all facilities is used to establish an objective function to judge the scheme. Based on the specific analysis above, the following objective function is established:

$$\max F = \sum_{i=1}^{p} w_i \cdot \beta_i \cdot f_i \tag{2}$$

where, w_i is the weighting coefficient of each facility in the passenger cabin, β_i is the discount coefficient, f_i represents the energy value of facility i under this layout scheme, and p is the number of facilities to be arranged.

Considering that different facilities occupy different areas, i.e., the number of rasters covered is different, it would be more reasonable to calculate the average of the energy values of all rasters occupied by the facilities and take it as the energy value of the facilities. Therefore the energy value of facility i can be expressed as:

$$f_i = \frac{\sum_{\substack{x^g - x_i \\ y^g - y_i}}^{\substack{x^g - x_i + \Delta x_i - 1 \\ y^g - y_i + \Delta y_i - 1}} e_i^{\left(x^g \cdot y^g\right)}}{\Delta x_i \cdot \Delta y_i} \tag{3}$$

where $e_i^{\left(x^g, y^g\right)}$ denotes the energy value of the raster $\left(x^g, y^g\right)$ occupied by facility i.

Therefore, after taking the average of the grid energy values as the energy values of the facility, the final objective function is:

$$\max F = \sum_{i=1}^{p} w_i \cdot \beta_i \cdot \frac{\sum_{\substack{x^g - x_i \\ y^g - y_i}}^{\substack{x^g - x_i + \Delta x_i - 1 \\ y^g - y_i + \Delta y_i - 1}} e_i^{\left(x^g \cdot y^g\right)}}{\Delta x_i \cdot \Delta y_i} \tag{4}$$

The constraints are analyzed in relation to the actual situation of the cabin interior layout:

(1) Overlapping constraints between facilities. In order not to affect the use of the occupants, any two facilities in the cabin should not overlap in the x-axis direction and the y-axis direction. The constraint can be expressed as:

$$\begin{cases} \left| x_j + \dfrac{\Delta x_j}{2} - x_i - \dfrac{\Delta x_i}{2} \right| \geq \dfrac{\left(\Delta x_i + \Delta x_j\right)}{2} \\ \left| y_j + \dfrac{\Delta y_j}{2} - y_i - \dfrac{\Delta y_i}{2} \right| \geq \dfrac{\left(\Delta y_i + \Delta y_j\right)}{2} \end{cases} \tag{5}$$

(2) Cabin boundary constraints. Any furniture and facilities in the cabin cannot exceed the cabin wall, and the constraint can be expressed as follows:

$$\begin{cases} 1 \leq x_i \leq 61 - \Delta x_i \\ 1 \leq y_i \leq 28 - \Delta y_i \end{cases} \tag{6}$$

The constraints are synthesized to construct the objective evaluation function of this paper:

$$\max F = \sum_{i=1}^{p} w_i \cdot \beta_i \cdot \frac{\sum_{\substack{x^g = x_i \\ y^g - y_i}}^{\substack{x^g - x_i + \Delta x_i - 1 \\ y^g - y_i + \Delta y_i - 1}} e_i^{\left(x^g y^g\right)}}{\Delta x_i \cdot \Delta y_i}$$

$$\begin{cases} \left| x_j + \dfrac{\Delta x_j}{2} - x_i - \dfrac{\Delta x_i}{2} \right| \geq \dfrac{\left(\Delta x_i + \Delta x_j\right)}{2} \\ \left| y_j + \dfrac{\Delta y_j}{2} - y_i - \dfrac{\Delta y_i}{2} \right| \geq \dfrac{\left(\Delta y_i + \Delta y_j\right)}{2} \\ 1 \leq x_i \leq 61 - \Delta x_i \\ 1 \leq y_i \leq 28 - \Delta y_i \end{cases} \tag{7}$$

III. A. 2) GSA optimization algorithm solution model

For the cruise ship indoor layout optimization model designed in this paper, this paper proposes a combined optimization algorithm, GSA optimization algorithm, which integrates genetic algorithm and simulated annealing algorithm. Genetic algorithm (GA) is a method of searching for the optimal solution by simulating the natural evolutionary process, which generates a group of individuals better suited to the environment through random selection, crossover, and mutation operations, so that the group evolves to better and better regions in the search space [21]. However, the GA algorithm is not perfect and suffers from poor local search capability and tendency to fall into local convergence. Simulated annealing algorithm (SA) is a probability-based algorithm, which derives its idea from the principle of solid annealing [22].The SA algorithm starts from a certain higher initial temperature, accompanied by a continuous decline in the temperature parameter, accepts a new solution that is worse than the current solution with a certain probability, and solves the problem through repeated iterations until the final solution is obtained, which has a strong global optimization search capability. Compared with other optimization algorithms, the SA algorithm is easier to implement, and in the annealing process, the gradual decrease of temperature allows the search space to be shifted from global to local, which makes it possible for the SA algorithm to jump out of the locally optimal solution and find the globally optimal solution, which is a unique advantage that other optimization algorithms can not be compared.

Aiming at the shortcomings of GA algorithm, this paper fuses SA algorithm and GA algorithm, designs GSA algorithm, and uses this algorithm to solve the layout model of cruise ship interior design, and its detailed steps are as follows:

Step1 Initialize the population. Generate an initial population of size δ for cruise ship interior design layout optimization.

Step2 Coding method. In this paper, we adopt the real number coding method, a population individual corresponds to a cruise ship cabin interior design layout optimization scheme, and the fitness value corresponding to the i nd scheme in β iterations can be expressed as:

$$Z_{\alpha}^{\beta}=\left(z_{\alpha_1}^{\beta},z_{\alpha_2}^{\beta},\cdots,z_{\alpha_{n_a}}^{\beta}\right) \tag{8}$$

Also, in order to avoid duplicate fitness values, it needs to satisfy the constraints. Namely:

$$z_{\alpha_i}^{\beta}=\left\{z_i^a,z_i^{a+1},z_i^{a+2},\cdots,z_i^l\right\} \tag{9}$$

$$\sum_{z=a}^{l} y_i^k = z_i^r \tag{10}$$

Step3 Adaptation function, in this paper, we choose the following formula as the adaptation function of GA algorithm. Namely:

$$\sum_{z=z_i^a}^{z_i^l} y_i^z = z_i^r, z=\left\{1,2,\cdots,n_a\right\} \tag{11}$$

Step4 Selection of operators. In this paper, in the selection phase of the genetic algorithm, the roulette method is used to select the data. The probability that an individual in the population is selected is first calculated by the formula, and the data with higher fitness is more likely to be selected by the roulette method, i.e., the probability that the data is selected by this selection method is proportional to the size of the fitness of the data. Then:

$$P_i = f_i \Big/ \sum_{j=1}^{N'} f_j \tag{12}$$

where P_i is the probability that the i nd individual is selected, f_i is the fitness value of the i th individual, and N' is the population size. This method can ensure that individuals with higher fitness are selected and inherited more, which is conducive to the convergence and search ability of the optimization algorithm.

Step5 Crossover operator. The crossover operator increases the richness of the population and expands the scope of finding the optimal solution by simulating the process of biological evolution in nature, so that the global search ability of the genetic algorithm can be enhanced. In order to make the genetic algorithm can better explore the new solution space, this paper adopts the single-point crossover method and sets the crossover probability to 0.95.

Step6 Variation operator. The role of mutation operator in genetic algorithm is to generate a part of new mutated individuals, which is used to improve the diversity of the population. In order to prevent the mutation process from destroying the data near the optimal solution, a small mutation probability should be set, and in this paper, the mutation probability is set to 0.001.

Step7 Simulated annealing operator. After the data obtained by the genetic algorithm is perturbed by a small amount to get a new solution, the Metropolis function is used to determine whether to accept the new solution, and the formula is as follows:

$$\Delta f = f_{new} - f \tag{13}$$

where f denotes the fitness function value of the solution when no perturbation is added, and f_{new} denotes the fitness function value of the new solution obtained after the perturbation is added to the current solution. If $\Delta f<0$, then the new solution is accepted, otherwise it is judged whether this solution should be accepted or not according to the probability of $\exp\left(-\Delta f/kT\right)$, where k denotes the temperature decrease rate, which is set to 0.9 in this paper.The simulated annealing operation is repeated continuously until the algorithm reaches the equilibrium state.

In the GSA optimization algorithm, with the increase in the number of iterations, the cruise ship cabin interior design layout scheme gradually “evolved” to the optimal solution. At this time, the calculated values of the model are constantly approaching the actual observed values, so that the value of the fitness function gradually converges to the optimal solution.

III. B. Comfort evaluation model for cruise ship interior design

III. B. 1) Comfort evaluation index system

After the integration of traditional culture and infrastructure to carry out the cruise ship interior design program, in order to verify the effectiveness of the method of cruise ship interior design, this paper from the perspective of sensory comfort, the establishment of the cruise ship interior design comfort evaluation index system based on rationality, safety, culture, coordination and aesthetics of the five dimensions. Its specific content is shown in Table 1, which mainly emphasizes the differences in the layout of facilities and the diversity of traditional culture expressed in cruise ship interior design.

Table 1: The design comfort evaluation index of the liner interior design

Dimension	Content	Code
Reasonable	Active surface product	O1
	Space utilization	O2
	Safe flow distance	O3
Safety	Material environmental protection	O4
	Disaster defense	O5
Culture	Traditional cultural harmony	O6
	Traditional culture is bright	O7
	Traditional cultural appreciation	O8
	Traditional culture degree	O9
Aesthetics	Sense of room order	O10
	Interior space	O11
	Interior space integrity	O12
Coordination	Household coordination	O13
	Good space environment	O14
	Temperature illumination	O15

III. B. 2) Coefficient of variation method for determining weights

In the selection of evaluation methods for the comfort of cruise ship interior design, the most important thing is to choose a reasonable weight calculation method. The calculation method of weights can be roughly categorized into subjective assignment method and objective assignment method. Because the subjective assignment method itself often carries a certain degree of subjectivity, if in the absence of sufficient experience often can not get the accurate weight calculation value, which will have a great impact on the subsequent evaluation results and interference. Therefore, in this paper, the coefficient of variation method is used in the evaluation and calculation of weights, and the weights of the evaluation indicators are objectively calculated and determined according to the evaluation data.

The coefficient of variation method is a method of calculating the degree of change of the indicators in the statistical method, according to this calculation method, the indicators with large differences in change have larger weights, and the indicators with smaller differences in change have smaller weights. Thus, the degree of importance of the indicators is determined according to their statistical characteristics of change, and this method allows the calculator to find out the weights of the indicators more objectively and accurately. The specific steps are as follows:

(1) Firstly, the target vector and the indicator vector of each year are constructed into a matrix. Namely:

$$A = \left(A_1, A_2, \ldots\ldots A_m\right) \tag{14}$$

(2) Calculate the standard deviation of the i st comprehensive evaluation indicator. i.e:

$$D = \sqrt{\frac{\sum\left(X_i - \bar{X}\right)}{n-1}} \tag{15}$$

(3) Calculate the coefficient of variation of the i st comprehensive evaluation indicator. I.e:

$$V_i = \frac{\sigma_i}{\bar{Z}_i}\left(i = 1, 2 \cdots n\right) \tag{16}$$

(4) The coefficient of variation of each evaluation indicator is processed to calculate the weight of each indicator. Namely:

$$W_i = \frac{V_i}{\sum_{i=1}^{n} V_i} \left(i = 1, 2 \cdots n \right) \tag{17}$$

where V_i is the coefficient of variation of the i nd indicator, σ_i is the standard deviation of the i th indicator, $\bar{X}_i$ is the mean of the i th indicator, and W_i is the weight of the i th indicator.

III. B. 3) Fuzzy integrated evaluation model

Fuzzy comprehensive evaluation method is an evaluation method based on fuzzy mathematics, which uses certain rules to quantify some factors that are difficult to quantify and have unclear boundaries through the principle of fuzzy relationship synthesis, so as to make a comprehensive evaluation. The method is actually based on the theory of fuzzy mathematics to qualitative to quantitative, so as to make a general evaluation of things. Its specific steps are as follows:

(1) Determine the set of indicators. The guideline level indicator is represented by B, i.e. $B = \{B_1, B_2, \ldots\ldots, B_i\}$. The indicator level is represented by B_{ij}.

(2) Evaluation level set

According to the relevant research, each indicator is described as corresponding evaluation, and it is divided into different grades to be judged, and it is confirmed that it is expressed by V, that is, $V = \{V_1, V_2, \ldots\ldots, V_n\}$.

(3) Establishment of affiliation matrix

According to the evaluation index system, obtain the index set, combine it with the established rubric set, and use the mathematical arrangement method to obtain the corresponding judgment matrix R, that is:

$$R_{ij} = \left(r_{ij} \right) = \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1} & r_{m} & \cdots & r_{mn} \end{pmatrix} \tag{18}$$

(4) First-level fuzzy comprehensive evaluation matrix

The affiliation of the evaluation object to the evaluation set V, the evaluation results are normalized to get the matrix R, multiply the matrix R with the amount of B, you can get the results of the fuzzy comprehensive evaluation of the corresponding evaluation object. Establish the matrix R_i as:

$$R_i = \begin{pmatrix} r_{i11} & r_{i12} & \cdots & r_{i_1} \\ r_{i21} & r_{i22} & \cdots & r_{i2p} \\ \vdots & \vdots & \ddots & \vdots \\ r_{in1} & r_{in2} & \cdots & r_{inp} \end{pmatrix} \tag{19}$$

i is the indicator serial number, n is the corresponding number of indicators in the indicator set, p is the corresponding number of evaluations in the rubric set Comprehensive evaluation set calculation C_i is:

$$\begin{cases} C_i = B_i * R_i = \left(C_{i1}, C_{i2}, \ldots., C_{ip} \right) \\ c_{ip} = \sum_{j=1}^{n} b_{ij} \times r_{ijp} \end{cases} \tag{20}$$

The above equation c_{ip} is the degree of affiliation of the i nd indicator to the set of rubrics P.

The first level fuzzy judgment matrix R is established as:

$$R = \left(C_1, C_2, C_3, \cdots, C_i \right) \tag{21}$$

(5) The second level fuzzy comprehensive judgment matrix is:

$$C = B * R = \left(C_1, C_2, C_3, \cdots, C_p \right) \tag{22}$$

(6) Determination of evaluation level

After a series of calculations the final result is an evaluation vector, the vector itself can not intuitively reflect the evaluation grade, for this reason will use the maximum degree of affiliation as the final judgment criteria.

Assuming a final result of C and a comment set of $V = \{V_1, V_2, \ldots\ldots, V_n\}$, when $C_i = \{C_n\} \max$, the evaluation result is the evaluation result with the largest number of evaluation results.

IV. Validation and comprehensive evaluation of the intelligent layout of cruise ship interiors

In the era of rapid economic development, cruise ship visitors have changed to purely cruise ship that is the tourist destination of the identity of tourists, tourists on the cruise ship culture, entertainment, comfort experience quality will be more important. From passengers to tourists, from function to experience, the cruise ship in the era of experience economy is undergoing great design needs and changes, relying on traditional culture to diversify the design of cruise ship interior space can help to meet the cultural needs of cruise visitors, but also can provide a new path for innovation of traditional cultural traditions.

IV. A. Simulation of cruise ship interior design layout optimization

IV. A. 1) Deviation of algorithmic solution results

In order to test the performance of this paper's combined optimization algorithm integrating GA and SA in solving the cruise ship interior design layout model, the GSA algorithm is compared with the GA algorithm, the SA algorithm, the PSO algorithm and the ABC algorithm. The parameters of the five algorithms are designed the same, in order to ensure the fairness of the comparison results, all the algorithms are developed by MALATB software, with the same running environment and the same maximum running time as the termination criterion of the algorithms.

Based on the cruise ship interior design layout model given in the previous section, 30 different interior design schemes were generated, and each algorithm was run independently for 10 times, and the results were evaluated by the relative percentage deviation (RPD), the lower the RPD, the better the average effect of the algorithm compared with the other four algorithms in solving the cruise ship interior design layout scheme. Figure 4 shows the comparison results of the relative percent deviation of different algorithms.

The average relative percent deviation (ARPD) is obtained for the RPD, which reflects the comprehensive performance of the algorithms in solving the 30 cases.The ARPDs of the GA, PSO, SA, ABC, and GSA solving results are 8.93%, 10.06%, 5.07%, 11.09%, and 1.85%, respectively. Taken together, GSA solves the 30 cruise ship interior design layout scenarios with an average relative percent deviation of 1.85%, followed by SA with 5.07%, which is much better than the remaining three algorithms. As can be seen from the line graph, the results of the GSA algorithm solving each cruise ship interior design layout scheme are optimal relative to the other four algorithms. Moreover, as the size of the layout scheme increases, the trend of the curve varies between 0.81% and 2.47%, indicating the stability of the GSA algorithm in solving the cruise ship interior design layout scheme.

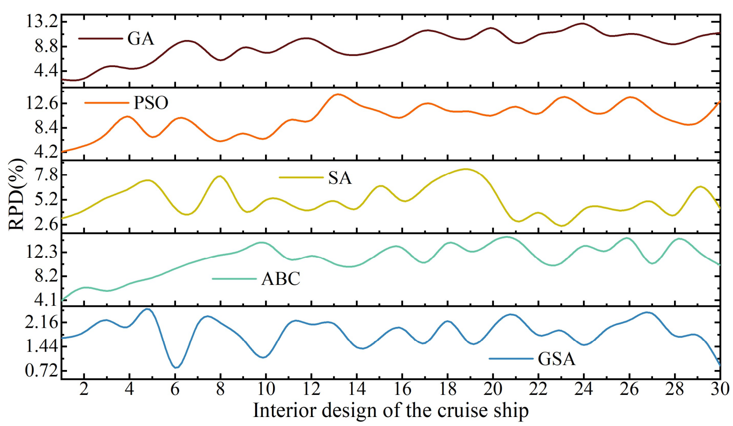
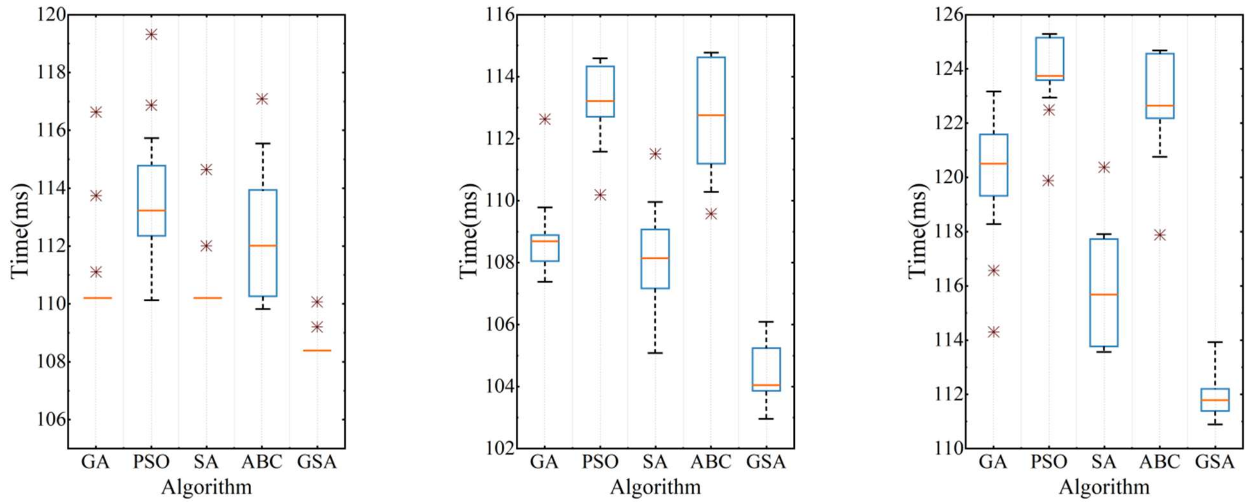


Figure 4: The RPD comparison results of different algorithms

For further comparative analysis, cruise indoor design schemes 5, 10 and 20 are taken to represent the three scale schemes, respectively, and the box line plots of each algorithm under different scheme sizes are plotted as shown in Fig. 5, where the horizontal and vertical coordinates are the algorithms and the time required to solve the schemes, respectively.The average of the results of the GSA in the three scale schemes is smaller than that of the rest of the four algorithms, which indicates that the proposed GSA algorithm converges better than the comparison algorithms. SA, GA and SA have the highest stability in solving small-scale schemes. As the size of the scheme increases, the degree of data concentration of the remaining four algorithms changes significantly, while GSA changes little, indicating that GSA has good stability.



(a) Solution 1 (b) Solution 10 (c) Solution 20

Figure 5: A box diagram of the size of the different schemes

IV. A. 2) Convergence test of the algorithm

In the combinatorial optimization algorithm, the purpose of the convergence test is to test the user satisfaction and usefulness of the cruise ship interior layout in the optimization of the cruise ship interior design layout results. Since the characteristics of the design and art industry make a quantitative description of convergence difficult, 20 testers were selected to use the model in this experiment, and the maximum number of iterations was set to 100 to investigate the testers' satisfaction with the individuals.

Given that the purpose of the cruise ship interior design layout optimization model is to ultimately produce user-satisfied solutions, as long as a number of high-quality solutions are eventually evolved, the model can be considered to have achieved its design purpose. In each iteration, testers select the individual in the group that best matches their preferences and score it on a scale from 0 to 100, and then calculate the average score given by the 20 testers in each iteration. The higher the scores for both metrics, the better the algorithm's ability to converge. When the score of the final solution reaches 80 or more, the model is considered to have generated a layout solution that the user is ultimately satisfied with. Figure 6 shows the trend of satisfaction level changing with the algorithm.

From the figure, it can be seen that when the number of iterations is in the range of [0,10], there is no significant difference in the mean value of satisfaction among the five algorithms. When the number of iterations exceeds 20, the GSA algorithm shows stronger convergence ability than the other four algorithms, and it is easier to jump out of the GSA algorithm after it falls into the local optimum, and it will end up with higher satisfaction, and the mean value of its satisfaction score can be up to 92.21 points. At the same time, the upper limit of the score is significantly improved at a high number of iterations after adding the simulated annealing algorithm, which accelerates the convergence speed of the algorithm, facilitates the evolution of the algorithm before the user falls into fatigue in low iterations, and helps the user to obtain a more optimal layout scheme for the interior design of the cruise ship.

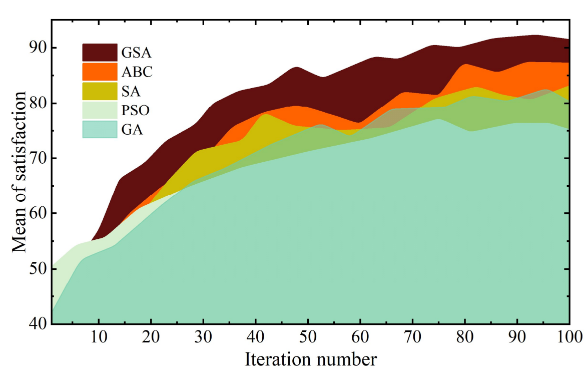


Figure 6: Convergence test results

IV. A. 3) Cruise ship interior design layout

Based on the combinatorial optimization algorithm designed in this paper, the effectiveness of the algorithm is simulated and verified by taking the interior design layout of the accessible cabin of a cruise ship as an example. The layout optimization problem of FAC-SSA (double bed configuration) for barrier-free cabin is simplified into a two-dimensional layout optimization problem. Taking FAC-SSA (Sea View Room, Double Bed Configuration) as an example, five furniture modules are laid out inside a rectangular cabin, which are double bed module, bathroom module, sofa module, writing desk module and closet module. In order to make the ergonomic performance of each furniture module of the accessible cabin FAC-SSA effective, its plan dimensions are obtained by synthesizing the static dimensions of each furniture and the required gesture space.

The chromosomes are encoded by means of tuple arrays, and the fitness function is the same as the one chosen in the previous section. Roulette selection was used for the selection operator, two-point crossover for the crossover operator, and basic bitwise mutation for the mutation operator. For the simulation calculation, the population size is set to 1000, the number of iterations is 500, and the crossover probability and the mutation probability are set as before. The simulation process is realized by MATLAB autonomous programming, and after optimization calculation, the optimal layout scheme of the accessible cabin is obtained as shown in Fig. 7.

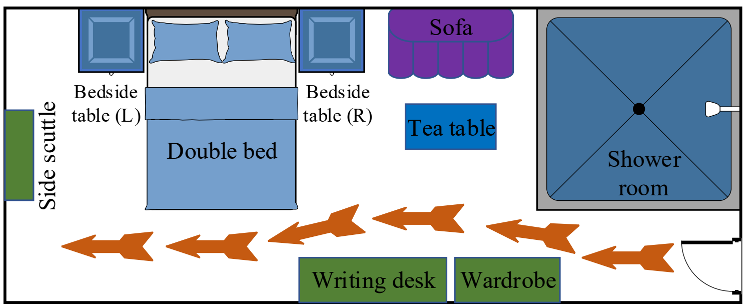


Figure 7: Optimal layout scheme for accessibility cabin

Because the barrier-free cabin has high requirements for indoor accessibility, after the optimal layout of the barrier-free cabin is obtained by the layout optimization simulation calculation, the rigid indexes such as the width of the entrance doorway of the cabin, the width of the barrier-free passageway, and the circular turning space of the layout should also be calibrated, and the specific calibration process is shown in Fig. 8. Among them:

① check the entrance door width of the accessible cabin, the minimum limit value is 820mm, and the actual value is 920mm in the layout program, which meets the checking requirements.

② and ③ check the circular turning space inside the accessible cabin and bathroom respectively, and the minimum limit value of their diameters are 1500mm and 1540mm respectively, and both circular turning spaces meet the checking requirements in this layout scheme, but the circular turning space inside the cabin (②) seems to be slightly compact.

④ and ⑤ Check the width of the net floor space between the double bed and the writing desk in the accessible cabin, and the minimum values are 700mm and 750mm, while the actual values of the net floor space width in this layout are 750mm and 820mm, which meet the checking requirements.

⑥ The width of the barrier-free passageway between the double bed and the porthole side of the accessible cabin is verified, and the minimum limit is 900mm, while the actual value is 1020mm in this layout plan, which meets the verification requirements.

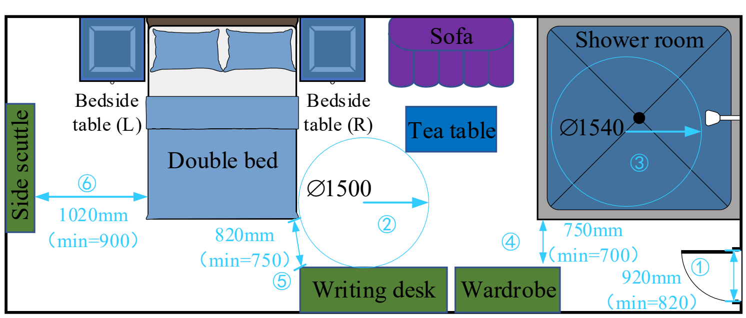


Figure 8: The process of the optimal layout of the cabin

Through the above calibration analysis, it can be seen that the optimal layout plan obtained by layout optimization basically meets the calibration requirements of barrier-free cabin and has better man-machine effect.

IV. B. Comfort evaluation of cruise ship interior design

IV. B. 1) Comfort indicator weights

The questionnaire is designed based on the comfort evaluation index system of cruise ship interior design and is quantified using a five-point measure, and the collected data are weighted using the coefficient of variation method to solve the weights. Before calculating the weight of each evaluation index factor, the mean and standard deviation of each evaluation index factor need to be counted. The comfort evaluation index weights of cruise ship interior design obtained by the coefficient of variation method are shown in Table 2.

As can be seen from the table, among the comfort evaluation dimensions of cruise ship interior design, the weight value of culture reaches 0.2648, the weight of aesthetics is ranked second (0.2034), and the evaluation weight of safety is the lowest at 0.1592, which indicates that the integration of traditional culture into cruise ship interior design can effectively promote the development of its diversity, and it will also contribute to the promotion of cruise ship interior design to be more aesthetically pleasing, and the spatial integrity of the expression of the cruise ship interior design to be clearer. Clearer. Among the secondary indicators, the weights of sense of traditional culture (O6), sense of order in interior space (O10) and sense of traditional culture viewing (O8) are in the top three, with the values of 0.0781, 0.0762 and 0.0745, respectively, which can enhance the international image of the cruise ship through the integration of traditional culture and contribute to the spread of Chinese traditional culture in a wider range.

Table 2: Comfort evaluation index weight

Dimension	Index	Means	STD.	Variation coefficient	Weight
Reasonable (0.1951)	O1	4.023	2.172	0.558	0.0642
	O2	4.115	1.334	0.542	0.0638
	O3	3.769	1.717	0.572	0.0671
Safety (0.1592)	O4	2.876	1.685	0.483	0.0614
	O5	3.051	1.338	0.595	0.0678
Culture (0.2648)	O6	4.537	1.404	0.679	0.0781
	O7	4.306	1.641	0.631	0.0713
	O8	4.198	1.583	0.648	0.0745
	O9	4.274	1.539	0.615	0.0709
Aesthetics (0.2034)	O10	4.315	1.406	0.663	0.0762
	O11	3.998	1.922	0.561	0.0653
	O12	4.051	1.625	0.506	0.0619
Coordination (0.1775)	O13	3.794	1.687	0.551	0.0641
	O14	3.885	1.756	0.537	0.0626
	O15	4.103	1.898	0.458	0.0508

IV. B. 2) Comprehensive evaluation of comfort

Based on the specific steps of fuzzy comprehensive evaluation, determine the set of evaluation factors for the comfort of cruise ship interior design. Set five evaluation levels of excellent, good, average, poor, and poor, and set the values of the evaluation levels as 10, 9, 8, 7, and 6. Carry out the single-factor evaluation of each single evaluation factor in accordance with the principle of bottom-up, and determine the affiliation of the factor to the evaluation target on the rubric level. Then construct the single-factor fuzzy evaluation matrix of the evaluation indexes according to the single-factor evaluation set, and calculate the fuzzy comprehensive evaluation vector of the index layer. Combining the weights of each evaluation index, the single-factor fuzzy evaluation vector is obtained as:

$$C = B * R = [0.2551, 0.1592, 0.2048, 0.1434, 0.0875]$$
$$* \begin{bmatrix} 0.4828 & 0.2843 & 0.2042 & 0.0879 & 0.0247 \\ 0.3927 & 0.3315 & 0.1874 & 0.1051 & 0.0428 \\ 0.2857 & 0.2779 & 0.1827 & 0.1114 & 0.1051 \\ 0.3018 & 0.2547 & 0.2042 & 0.1238 & 0.1267 \\ 0.2979 & 0.2786 & 0.1239 & 0.1062 & 0.0815 \end{bmatrix} \tag{23}$$
$$= [0.3135, 0.2431, 0.1595, 0.0890, 0.0599]$$

Combined with the evaluation rating values, the formula was used to calculate a comprehensive evaluation score for the comfort of the cruise ship's interior design:

$$S = C \circ V = [0.3135, 0.2431, 0.1595, 0.0890, 0.0599] \circ \begin{bmatrix} 10 \\ 9 \\ 8 \\ 7 \\ 6 \end{bmatrix} \tag{24}$$
$$\approx 7.581$$

It can be seen that the comfort evaluation result of cruise ship interior design is 7.581 points, which is between 7 and 8 points of the rubric set, and the fuzzy grade is general. The method of combining the coefficient of variation method and the fuzzy comprehensive evaluation method mainly means that the cruise ship interior design evaluation index system is firstly calculated by the index weights, and then the fuzzy comprehensive evaluation method is utilized in a hierarchical manner to finally arrive at the total evaluation results. This method not only considers the subjective factors in cruise ship interior design, but also takes the objective factors into account. Therefore, the relevance and accuracy of the evaluation process are also reflected. The evaluation scheme designed in this paper can provide meaningful references for the adjustment and optimization of traditional cultural diversity design in cruise ship interior design.

IV. C. Traditional Cultural Expressions in Cruise Interior Design

IV. C. 1) Cruise ship interior Chinese design

China's market inshore cruise ship can choose a representative of the Chinese characteristics of the attractions as the theme of the interior of the hull, such as the Forbidden City, the Summer Palace and other famous attractions for the refining and analysis of the color, so as to carry out the cruise ship interior color Chinese style design. The interior can be a large area of gold, yellow color, while red to decorate, the whole interior to yellow as the main plus red and green as the auxiliary color. At the same time in the glass of the windows and doors with black lines to divide the large white, roughly outlined the style of the traditional window lattice, low brightness yellow as the main color of the ground, so that the space is calm and steady at the same time, but also let the ground has the sense of gravity.

The theme design can also be derived from the Chinese Taoist culture as a starting point. The unique viewpoint of Taoism has an important position in the residence, literature and hermit culture, this concept plays an important role in maintaining social stability at that time, at the same time, the style led by this idea is inherited to modern times, which is mainly manifested in the pure and simple color space, the rusticity of the furniture, which is the unique style of the Chinese residence in the traditional Chinese culture.

IV. C. 2) Characteristic use of decorative materials

Aluminum honeycomb panels are the best choice for cruise ship interior design. Honeycomb has a very clear geometric form, the single lattice plane presents hexagonal, the combination of plane hive room bottom anastomosis and overlap, increase the bearing force, hexagonal hive to ensure the plane organization of the compact, easy to combine, more economical and solid. Aluminum honeycomb sandwich structure composites are lightweight, high strength, high stiffness, and are mostly used as structural components with large structural dimensions and high strength requirements. Cruise ships commonly used aluminum honeycomb panels to do panel processing materials, its completely non-toxic green quality, less unnecessary environmental protection procedures, its fire prevention, corrosion resistance, environmental protection, easy to dismantle and assemble the characteristics of the cruise ship interior design has become an excellent design materials.

Use the natural properties of materials to regulate the indoor air environment. When integrating traditional culture in the cruise ship interior design, we should advocate the de-artificialization of decorative materials, mainly made of high-quality teak and ash wood, with a large number of teak floors on the ground, sliced plywood of ash, rosewood and teak on the walls for surface treatment, part of the furniture is made of natural marble, and the outdoor recreational platforms are made of rattan with combined assets to retain their original natural tones. In order to better express the traditional culture of the unity of man and nature, and to realize the green design of the cruise indoor.

V. Conclusion

The article combines the genetic algorithm with simulated annealing algorithm for solving the intelligent layout optimization model of cruise ship interior design, and analyzes the comfort of traditional cultural design in cruise ship interior design with fuzzy comprehensive evaluation. With the increase of the size of the cruise ship interior design layout scheme, the change trend of the GSA algorithm is between 0.81% and 2.47%, which indicates that the GSA algorithm has high stability in solving the cruise ship interior design layout scheme. Taking the barrier-free cruise cabin design as an example, the width of the entrance doorway obtained by the GSA algorithm can reach 920mm, which is 100mm higher than the minimum restriction, and the width of the barrier-free passageway on the side of the porthole is 1020mm, which is 120mm different from the minimum restriction. The overall layout plan meets the needs of the barrier-free cabin of the cruise ship, and it provides a reference for the optimization of the layout of the interior design of the cruise ship. In the comfort evaluation of cruise ship interior design layout design, the relative weight value of culture can reach 0.2648, and the fuzzy comprehensive evaluation score of traditional culture and interior design is 7.581 points, with a grade between average and good.

The layout optimization of cruise ship interior design based on combinatorial optimization algorithm has strong application feasibility, and combined with the fuzzy comprehensive evaluation, it can clarify the diversified design expression forms of traditional culture in cruise ship interior design. Relying on the application of color, shape and green materials of traditional culture, it provides a carrier to further enhance the cultural and aesthetic qualities of cruise ship interior design, and helps the omni-channel dissemination of traditional culture.

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References

[1] Wang, J. , Yin, J. , Khan, R. U. , Wang, S. , & Zheng, T. . (2021). A study of inbound logistics mode based on jit production in cruise ship construction. Sustainability, 13(3), 1588.

[2] Lin, L. Y. , Tsai, C. C. , & Lee, J. Y. . (2022). A study on the trends of the global cruise tourism industry, sustainable development, and the impacts of the covid-19 pandemic. Sustainability, 14.

[3] yananyu. (2021). Cha11enges for cruise sustainab1e deve1opment and its 1ega1 response the case of china. Sustainability, 13.

[4] Teng, Y. M. , Wu, K. S. , & Wang, M. . (2020). Using the analytic hierarchy process (ahp) and delphi analysis to evaluate key factors in the development of the taiwan cruise tourism industry. Journal of Coastal Research, 36, 828 - 833.

[5] Knnl, K. , Kangas, K. , Seppl, K. , Mkel, M. , & Lehtonen, T. . (2020). Considering sustainability in cruise vessel design and construction based on existing sustainability certification systems. Journal of cleaner production.

[6] Sun, R. , Chu, Y. , & Ye, X. . (2024). China's cruise tourism policy evolution and effectiveness analysis. Marine policy, 159(Jan.), 1.1-1.11.

[7] Zhang, H. , Wang, Q. , Chen, J. , Rangel-Buitrago, N. , & Shu, Y. . (2022). Cruise tourism in the context of covid-19: dilemmas and solutions. Ocean & coastal management, 228, 106321.

[8] Jian, H. , & Yuantao, J. . (2021). System dynamic simulation of online customers for cruise travel: based on the customer life cycle perspective. Wireless Communications and Mobile Computing.

[9] Stieghorst, T. . (2017). Floating architecture : cruise lines are increasingly emphasizing interior design, recruiting designers from outside the industry to bring innovation, flare and excitement to ship environs. Travel Weekly.

[10] Sun, X. , Xu, M. , Lau, Y. Y. , & Gauri, D. K. . (2019). Cruisers' satisfaction with shore experience: an empirical study on a china-japan itinerary. Ocean & coastal management, 181(Nov.), 104867.1-104867.10.

[11] Ma, W. , Ji, F. , Liang, C. , Sun, Q. , & Wu, J. . (2024). A deep learning and large group consensus based cruise satisfaction evaluation model with online reviews. Information Sciences, 676.

[12] Hart, E. , & Sim, K. . (2018). On constructing ensembles for combinatorial optimisation. Evolutionary Computation, 26(1), 67-87.

[13] Liu, Y. , Dong, E. , Li, S. , & Jie, X. . (2020). Cruise tourism for sustainability: an exploration of value chain in shenzhen shekou port. Sustainability, 12.

[14] Sun, R. , Ye, X. , Li, Q. , & Scott, N. . (2024). Assessing the eco-efficiency of cruise tourism at the national level: determinants, challenges, and opportunities for sustainable development. Ecological Indicators, 160.

[15] Moore, R. . (2022). Cruise interiors: a new era of innovation. Passenger ship technology.

[16] Mayson, H. . (2017). Current color solution features in interiors on modern ships. Theory and Practice of Design(12).

[17] Zhang, F. , Yang, D. , & Qiu, W. . (2022). Design and experimental study of lightweight fireproof bidirectional bead bulkheads in a cruise ship. Marine structures(May), 83.

[18] Zhang, Y. , Jiang, Y. , & Huang, Y. . (2024). Preliminary Application Research on TRIZ Method in the Design and Construction of Luxury Cruise Ship. International Conference on SmartRail, Traffic and Transportation Engineering. Springer, Singapore.

[19] R Cartas Fuentevilla,K Peralta Martinez,D A Zarate Herrada & J L A Calvario Acocal. (2024). Strong/weak duality symmetries for Jacobi–Gordon field theory through elliptic functions. Journal of Physics A: Mathematical and Theoretical(38),385201-385201.

[20] Nan Wang. (2023). Theme design and style features of interior decoration of cruise atrium. Journal of Civil Engineering and Urban Planning(10).

[21] Ying Chen,Chuang Guan,Juncai Li,Fanwei Meng,Chao Zhang,Xin Wang & Tianbiao Yu. (2024). Analysis and Prediction of Morphology and Properties of Laser-Directed Energy Deposition CoCrFeNi High-Entropy Alloy Using Response Surface Methodology and Non-dominated Sorting Genetic Algorithm II. Journal of Materials Engineering and Performance(prepublish),1-13.

[22] Ahmad Abouyee Mehrizi,Reza Ghanbari,Sedigheh Sadeghi & Khatere Ghorbani Moghadam. (2024). Solving continuous quadratic programming for the discrete balanced graph partitioning problem using simulated annealing algorithm hybridized local search and multi-start algorithms. Applied Soft Computing112109-112109.