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Research on Design Strategy and Contemporary Expression of New Chinese Style in Modern Villa Space

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SUMMARY: *As a combination of traditional Chinese style and modern design concepts, the new Chinese style is more concerned and loved by a wide range of people. This paper refers to the four methods of new Chinese style in villa space design, proposes the spatial decomposition method in virtual reality, and decomposes the subspace by this method, excludes a large amount of unreasonable data, and speeds up the calculation speed. On the basis of the immunogenetic algorithm, the immunity operator is added to ensure that the average affinity of individuals entering the next generation of the population is higher than that of the previous generation, and the immunogenetic algorithm is applied to optimize the solution processing of the data. In order to ensure the 3D visual comfort, after obtaining the parameters affecting the 3D perception, the scene brightness changes were realized by adjusting the camera exposure. ANOVA analysis of the satisfaction of the color scheme effect, the user's satisfaction score for the color of the villa space designed by applying virtual reality technology is 4.87, and F=6.248, p=0.005 in the ANOVA, showing a significant difference. Referring to the spatial syntax index, among the specific indexes of the new Chinese villa space, the most obvious and prominent one is the landscape learning index, with an index score of 4.625, and the mean value of the spatial experience satisfaction of the villa space is 4.019, which indicates that the users have a better experience during the process of using the villa space.*

KEYWORDS: *Spatial decomposition method; Immunogenetic algorithm; Virtual reality; Spatial color; New Chinese villa*

1 Introduction

With the economic development and social progress, people's living standards continue to improve, the consumption level and the concept of consumption has changed dramatically, and the understanding and requirements of living space has also changed dramatically with the transformation of the consumption level and the concept of consumption [1]. From the past cottage, silo, flat apartments and other purely to meet the most basic residential requirements, to now need to meet the different levels of people on the living space of life, learning, leisure and other functions of the material and spiritual needs of the villa, these to a certain extent fully reflects China's comprehensive strength of the great improvement, as well as the national pursuit of the pursuit of a better life and aspirations [2-4]. In particular, the rapid rise and development of villa architecture in mainland China since the reform and opening up, especially in the last decade or so, has satisfied the living needs of some of the more economically affluent people [5]. Compared with ordinary residential space, the architectural scale of villa space is

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large, and the spatial composition is more diverse, which to a certain extent greatly meets the material and spiritual needs of people's life, study, leisure and other aspects, and also provides more space and opportunities for the diversified development of interior design, and better display of the designer's wisdom and creativity, thus effectively improving the overall level and quality of China's interior design [6, 7].

On October 22, 2004, sponsored by the China Architectural Association Interior Design Branch of the 2005 China Residential Interior Design Trend Conference, with Chinese characteristics of the modern Chinese style is listed among them, and this style is called “new Chinese style” [8]. New Chinese style can best reflect the spirit of “in and new”, and from the architect Mr. Liang Sicheng that also get a response, which once divided the building into four major categories: “in and ancient, west and ancient, west and new, in and new”, it can be seen that the new Chinese style really has this kind of essential characteristics [9-11]. New Chinese style along with the gradual enhancement of national strength, national consciousness continues to recover, people from the commercialization of means of imitation and copy gradually explore the local culture of the Chinese design sector [12]. This decorative style has distinctive modern characteristics, and is different from the pure Chinese style, which will be the full integration of traditional Chinese culture and modern design techniques, reflecting the modern and fashionable atmosphere. Chinese culture is reflected in the details, and has become a popular trend in the current interior design style [13, 14]. For example, from the recognition and preference of the new Chinese style by the latest international exhibitions and major luxury brands, to the head of state's visit to the dress code craze, as well as the reverence of famous interior designers, to the rise of Chinese original home, such as the growth of brands such as HC28, acfhome, and ZiZhongFang, it can be clearly seen that the potential of the development of the new Chinese architectural style in the present as well as in the future of the design industry.

With the progress of the times, the hierarchical meaning of the great traditional colors have been dissipated, the new Chinese style to show the aesthetic experience, as well as a unique color matching system, it is a distinctive feature of the personality and the significance of the times, the symbolism of the “Chinese style” expressed to the fullest [15]. Its interior color matching concept continues to mature when its application is also expanding, from the garden to the residential interior design can be seen in the new Chinese design, and villa interior design color matching is through the shape of the space as well as spatial uses, characteristics of the overall grasp [16-18]. As a large amount of work, more systematic interior color matching design, the new Chinese design is relatively more pure [19]. At the same time, the new Chinese style is a kind of re-creation of traditional Chinese culture, which is more adaptable to the needs of modern life. In terms of design, foreign design styles are opulent and have a strong visual impact, which can bring a fresh and avant-garde sense of fashion, leading to the gradual coldness of the traditional Chinese design style [20, 21]. There is a certain gap between traditional Chinese architectural style and modern technological aesthetics, and it is necessary to follow the pace of the times in order not to be eliminated [22, 23]. The traditional Chinese design cannot match with new building materials or keep up with the intelligent technology of the network era, which leads to the gradual decline of the traditional Chinese architectural style [24]. In order to adapt to the development trend of the architectural era and satisfy people's aesthetic needs, people from the period of revival of traditional Chinese culture, people will be Chinese elements and modern materials skillfully and softly, forming a new Chinese design style. However, when the new Chinese style began to prevail in the villa interior, it was found that there have been some related theoretical studies, but there is little theoretical information combining the design strategy and contemporary expression of the new Chinese style in the villa space. Therefore, through the research on the use of New Chinese Style in villa space, it is of great practical significance to construct a suitable design methodology for villa space, to

utilize new design language and expression forms, and to further interpret oriental aesthetics.

This paper refers to all aspects of tradition and modernity, nature and humanity, space and layout, color and soft furnishings in villa space design. The spatial decomposition method is applied to speed up the calculation of space and exclude a large number of unreasonable data. In the immune genetic algorithm, the immune operator is added to analyze the characteristics of the individuals with the highest affinity retained, extract the common characteristics and effective feature information of the optimal individual gene loci among them, establish the polyhedral mathematical model, and optimize the solution of the data. Starting from the perspective that image acquisition parameters affect three-dimensional perception, scene brightness changes are realized by adjusting camera exposure parameters. A questionnaire survey is conducted on the color scheme of the new Chinese style villa space as well as the spatial layout planning to derive the user's perception of the villa space experience of the human fusion of the new Chinese style.

2 New Chinese style in the present villa space design

2.1 Combination of tradition and modernity

New Chinese style combines tradition and modernity in many aspects of interior space design. In the combination of materials, the new Chinese style can be the traditional mahogany, silk, lacquer and other materials and modern glass, metal, stone and other materials to combine the use of traditional and modern fusion collision of space atmosphere. In the combination of decorative elements, the new Chinese style space design can be modern soft furnishings and hard furnishings modeling appearance to add some traditional Chinese cultural decorative elements, so that the villa space environment full of modern atmosphere reveals the Chinese cultural flavor.

2.2 Integration of nature and humanity

The new Chinese style focuses on the integration of nature and humanity, usually adding some natural elements in the interior space, focusing on the selection of natural materials in the process of decorative design, such as wood, stone, bamboo and other materials, but also consider the introduction of a large number of natural light and green plant accessories, to create a villa space warm, comfortable natural atmosphere, thereby enhancing the sense of spatial experience of the occupants. At the same time, the new Chinese style also focuses on adding appropriate traditional cultural and artistic elements in the space, such as wall decorations of landscape paintings and calligraphy, porcelain ornaments, as well as some combination of Chinese cultural flavor of modern furniture, these elements not only reflect a certain decorative value in the space, but also the respect for traditional Chinese culture and art and heritage. Natural elements and humanistic elements in the space are complementary and integrated, their collision sublimates the quality and value of modern villa space design, so that people can not only feel the comfortable atmosphere of the natural environment, but also be able to experience the charm of traditional Chinese culture and art.

2.3 Planning of space and layout

Any type of interior space design is inseparable from the reasonable space layout and planning, new Chinese style villa space design is more so. The use of new Chinese style in the villa space design, first of all, we should consider the symmetry and coordination of the overall spatial layout, through this form can reflect the side of the traditional Chinese architecture of the steady

momentum, but also to a certain extent to create a harmonious atmosphere of the villa space. Secondly, is to consider the rationality of the space flow line and the whole space layout of the permeability, layout planning space, delineate the relationship between the functional areas of the flow line, so that the line of flow, natural, convenient and efficient.

2.4 Color and soft furnishings matching

In the new Chinese style modern villa space design, the reasonable matching of color and soft furnishings is also one of the important factors that the design effect can be perfectly presented. In the choice of color, cold gray and warm gray color can affect the spatial atmosphere of the new Chinese style to a certain extent.

3 Application of virtual display technology in villa space design

3.1 Spatial Decomposition and Immunogenetic Algorithms

3.1.1 Spatial decomposition

Spatial decomposition is a method that assumes that there are two target models, and considers the space occupied by these models as consisting of a subspace of simple structures. If these two models occupy the same simple structure subspace together, it means that these two models collide, so as to further decompose the subspace and find out the exact collision trajectory. Otherwise no collision occurs. The spatial decomposition method speeds up the computation because a large amount of unreasonable data can be excluded due to the decomposition of the space occupied by the target model.

3.1.2 Immunogenetic Algorithm Based Collision Detection

(1) Immunization operator

Immunity genetic algorithm in the solution of each evolutionary process, have to carry out a series of genetic operations such as coding, selection, crossover, mutation, as well as the calculation of individual affinity. In the process of repeating this series of genetic operations, some individuals will inevitably be degraded, i.e., the affinity is lower than that of the parent. Therefore, an immunization operator can be added to the immunogenetic algorithm to eliminate the individuals with low affinity, so as to ensure that the average affinity of the individuals entering the next generation of the population is higher than that of the previous generation.

The immunization operator consists of three stages: immunization selection, vaccine extraction, and vaccination, and the immunization vaccine extraction process is shown in Figure 1. The idea of immune selection is that the affinity of the vaccinated individual is calculated, if the affinity of the offspring is lower than that of the parent, it indicates that the individual is degraded, and then it will be replaced by the corresponding individual of the parent. If the affinity of the offspring is higher than that of the parent, the offspring will replace the parent in the next iteration of the process. The idea of extracting a vaccine is to characterize the individuals with the highest affinity retained from the previous $n-1$ generations, and to extract the characteristics and effective feature information common to the genome loci of the optimal individuals among them as a vaccine K. Vaccination is the incorporation of the extracted vaccine K into the individual to form a new individual. The key to the immunization algorithm is how to extract and vaccinate, and its flow is shown in Figure 2.

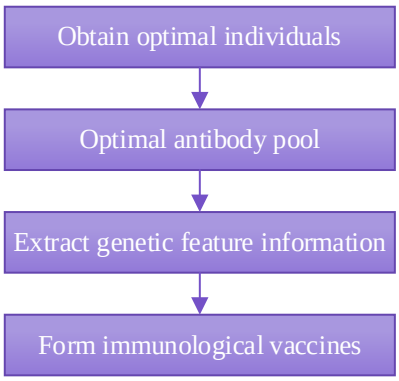

Figure 1: The extraction process of immune vaccines

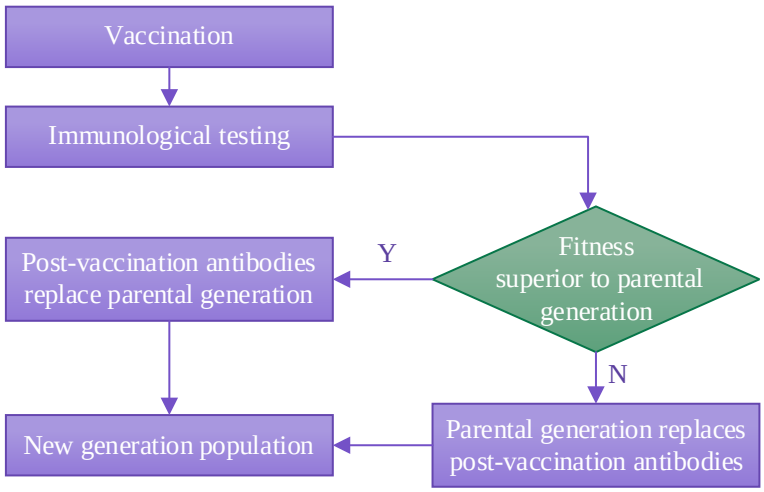

Figure 2: Immune selection process

(2) Mathematical modeling of polyhedra

A polyhedron containing a finite set of points $\{x_1,\cdots,x_n\}$ can be represented as:

$$\{x_1,\cdots,x_n\}=\left\{\sum_{i=1}^{m}\eta_i\chi_i \middle|\ \chi_i\in s,\eta_i\geq 0,i=1,\cdots,m;\sum_{i=1}^{m}\eta_i=1,m\in N_+\right\} \tag{1}$$

N_+ is the set of all positive integers.

Assuming that there are two polyhedral models A,B with the shortest distance between them $Mind_{A,B}$ and x, y are any points on the two polyhedral models of A,B, respectively, there are:

$$Mind_{A,B}=\left\|\sum_{i=1}^{m}\lambda_i x_i-\sum_{j=1}^{n}\sigma_j y_j\right\| \tag{2}$$

where $\sum_{i=1}^{m}\lambda_i=1$, $\sum_{j=1}^{n}\sigma_j=1$, $\lambda_i\geq 0$, $\sigma_j\geq 0\,(i,j=1,\cdots\cdots,n)$.

$\sum_{i=1}^{m}\lambda_i x_i$ is a point x on model A, $\sum_{j=1}^{n}\sigma_j y_j$ is a point y on model B, and λ_i and σ_j

satisfy the following conditions respectively:

$$st\sum_{i=1}^{m}\lambda_i=1,\lambda_i\geq 0,i=1,2\cdots,m \tag{3}$$

$$st\sum_{j=1}^{n}\sigma_j=1,\sigma_j\geq 0,j=1,2\cdots,n \tag{4}$$

This abstracts the problem of solving the shortest distance between models as a nonlinear problem with constraints, when $Mind_{A,B}$ is greater than zero, the models do not collide, and when $Mind_{A,B}$ is less than or equal to zero, the models collide. From the established mathematical model, it can be known that A,B two models have a finite number of coordinate points, therefore, the time complexity of finding the optimal solution becomes the key problem of the algorithm, and this paper proposes to use the immune-genetic algorithm to optimize the solution of the data.

(3) Immunogenetic algorithm solution

The steps of immune genetic algorithm are as follows

The point optimization problem on the polyhedron is the following minimization problem:

$$\begin{cases}\min f(x(1),x(2),\cdots\cdots,x(p))\\ a(j)\leq x(j)\leq b(j),j=1,2,\cdots\cdots,p\end{cases} \tag{5}$$

where $x(j)$ is the j th optimization variable, $[a(j),b(j)]$ is the interval over which $x(j)$ takes values, P is the number to be optimized, and f is the objective function.

1) Real number coding of antigen

Immunogenetic algorithms usually use binary coding, the advantage is that the search ability is strong but need to carry out a lot of calculations (encoding and decoding), and can not produce enough values, and based on the real number of coding can greatly reduce the amount of computation. Immunogenetic algorithm's operation object is antibody coding, each antibody corresponds to a solution of the problem, so the coding space of the antibody and the solution space is a one-to-one mapping relationship, it can be encoded as follows:

$$x(j)=a(j)+u_0(j)*(b(j)-a(j))\quad(j=1,\cdots\cdots,n) \tag{6}$$

After encoding, the j th optimization variable $x(j)$, which initially takes values in the interval $[a(j),b(j)]$, can be assigned to the real number $y(j)$ on the interval $[0,1]$, and we call $y(j)$ a gene. The set of genes corresponding to all the variables of the target problem together constitute the computational form of the problem solution $(y(1),y(2),\cdots,y(p))$, which we refer to as the individual. By encoding the real numbers in this way, the interval of values of the target problem variables is unified as $[0,1]$.

2) Initial antibody generation

With the nonlinear constraints satisfied, let the population size be n, and the number on the interval of generating n groups $[0,1]$ will be randomized, and there are m individuals in each group, i.e., $u_0(j,i)$. Take $u_0(j,i)$ as the value of the parent individual $y(j,i)$ of the initial population, substitute $y(j,i)$ into Eq. (2) to get the value of the optimization variable $x(j,i)$, and then go through Eq. (1) to get the corresponding value of the objective function

$f(i)$, and then arrange them in the order of from the largest to the smallest, then the next few individuals will be the dominant individuals. The smaller the population size, the smaller the search range correspondingly, but the computing time of each iteration is also smaller, and vice versa. Generally, the initial population size is 100-300.

3) Vaccine extraction

From the previous step to the superior individuals for gene extraction, each gene affinity evaluation, select the optimal set of genes, find the average of their genes $y(j)$, as the vaccine K.

4) Affinity calculation

The calculation of affinity degree plays a decisive role in evolutionary search, and choosing a suitable affinity degree function can avoid the algorithm from falling into a local optimal solution. In this paper, the affinity function is to transform the previous generation of individuals into individual $x_j(i)$ through equation (3) and substitute into $\min|f(x)|$ ($x \in D$, f is the objective function, x is the high-quality individual, and D is the feasible domain solution), which can be obtained as $f(i)$. The larger the value of $f(i)$, the smaller the affinity value of the individual, and vice versa. Finally, the affinity function value is defined as:

$$F(i)=\begin{cases}1/\ f^2(i) & f(i)\neq 0\\ M_{\max} & f(i)=0\left(i=1\cdots m\right)\end{cases} \tag{7}$$

5) Immunization selection

Arrange the individuals of the parent generation in the order of affinity value from small to large, and select the last N ones as the excellent individuals. Establish a function P_i that is inversely proportional to the affinity function value f_i and satisfy the relationship $P_i>0$ and $P_1+P_2+\cdots+P_n=1$.

From these excellent individuals, i individuals are selected according to the probability P_i, so that a total of $2M$ excellent individuals are selected to form a new population called $U_c(j,i)$.

6) Individual crossover and mutation

The individual parts of the two parents according to the crossover probability P_c with a certain pairing mechanism for linear combinations, so as to produce a new individual, the crossover probability is generally taken as 0.4 ~ 0.8. Let the clonal selection of a total of M pairs of successful pairing of individuals, notated as $U_{oc}(j,i)$, which any pair of individuals ($U_{oc}(j,i_1)$, $U_{oc}(j,i_2)$) satisfies the following linear condition:

$$U_c(j,i)=\begin{cases}u_{x1}*u_{oc}(j,i_1)+(1-u_{x1})u_{oc}(j,i_2) & u_x<0.5\\ u_{x2}*u_{oc}(j,i_1)+(1-u_{x2})u_{oc}(j,i_2) & u_x\geq 0.5\end{cases} \tag{8}$$

For the new population $U_c(j,i)$ obtained, the mutation operation is performed with probability P_m, too small P_m will lead to local convergence of the algorithm, too large destroys the population pattern and makes the algorithm a random search algorithm. P_m is generally set to 0.001~0.1, and the resulting mutation individual is $U_p(j,i)$, which operates as follows:

$$U_P(j,i)=\begin{cases}u(j) & u_x < P_m \\ u_c(j,i) & u_x \geq P_m\end{cases} \tag{9}$$

7) Immune Memory

In the process of evolution carried out by the population, the immune memory mechanism is used to record the excellent individuals produced in each iteration and eliminate those with poor affinity, so that the algorithm can be made to develop in the direction of the optimal solution.

8) Vaccination

Vaccination is the process of modifying the genes of certain individuals on the basis of prior knowledge, so that the new individuals obtained will have a greater chance of becoming excellent individuals.

3.2 Model Lighting Analysis

3.2.1 Stereo image acquisition

Stereo camera simulates the human eye perception process, in the motion shooting scene, the two cameras as a whole should always keep the distance unchanged and its direction of movement in space and rotation angle to maintain the same.

The entire model is determined by the parameters of the position of the left and right cameras at points in 3D space, the angle of spatial rotation, and the baseline distance between the cameras. Among the known parameters are the position of the left camera, the spatial rotation angle, and the stereo camera distance. The camera model is based on the left-handed coordinate system (X -axis pointing straight ahead, Y -axis pointing in the right direction, and Z -axis pointing directly above) and the Euler angles Roll, Pitch, and Yaw, and the left and right cameras keep the same spatial rotation angle, O_l is the origin of the coordinate system of the left camera, and O_r is the origin of the coordinate system corresponding to the right camera. Taking the spatial coordinate system where the two cameras are located as the unified coordinate system, the coordinate system of the left camera is the reference, and the origin of the right camera has new 3D coordinate information in the unified coordinate system. Let the coordinates of the origin of the left camera $O_l(X_l,Y_l,Z_l)$, the coordinates of the origin of the right camera $O_r(X_r,Y_r,Z_r)$, the baseline distance between the two cameras d_c, the spatial rotation angles α, β, γ, (α, β, γ) represent Roll, Pitch and Pitch respectively. represent the specific values of Roll, Pitch, and Yaw rotation angles, respectively), the coordinates of the left camera, the Euler angles, and the spatial baseline distances of the left and right cameras are known, and the relative offsets between the two cameras in the X, Y, and Z -axis directions are found to be, respectively:

$$\begin{bmatrix}x\\y\\z\end{bmatrix}=\begin{bmatrix}\tan(\gamma)\sqrt{\dfrac{d_c^2}{\tan(\gamma)^2+\tan(360^\circ-\alpha)^2+1}}\\ \sqrt{\dfrac{d_c^2}{\tan(\gamma)^2+\tan(360^\circ-\alpha)^2+1}}\\ \tan(360^\circ-\alpha)\sqrt{\dfrac{d_c^2}{\tan(\gamma)^2+\tan(360^\circ-\alpha)^2+1}}\end{bmatrix} \tag{10}$$

After determining the relative distance between the two cameras, the coordinates of the right camera can be obtained as:

$$\begin{bmatrix} X_r \\ Y_r \\ Z_r \end{bmatrix} = \begin{bmatrix} X_l \\ Y_l \\ Z_l \end{bmatrix} + \begin{bmatrix} x \\ y \\ z \end{bmatrix} \tag{11}$$

Again, based on the relative positions of the two cameras, it is known that the angle of rotation of the right camera is:

$$\begin{bmatrix} \alpha_r \\ \beta_r \\ \gamma_r \end{bmatrix} = \begin{bmatrix} \alpha_l \\ \beta_l \\ \gamma_l \end{bmatrix} \tag{12}$$

3.2.2 Design of scene brightness material parameters

An important parameter that affects the comfort and quality of 3D vision is scene brightness. The thesis realizes scene brightness changes by adjusting camera exposure from the perspective of image acquisition parameters affecting 3D perception. The experiment is designed with five levels from dark to bright, corresponding to five different camera exposure parameters.

In Unreal 4 engine, the exposure value of the camera is expressed using EV, which reflects the camera exposure and is mainly determined by the sensitivity ISO, the aperture coefficient f and the exposure time t together. The exposure equation is known to be defined as:

$$\frac{N^2}{t} = \frac{L \times S}{K} \tag{13}$$

where N is the aperture value $(f-)$, t is the shutter speed or exposure time, S is the ISO, K is the photometer calibration constant of 12.5, and L is the luminance. Formally the exposure value can be defined as:

$$EV_{ISO} = \log_2 \frac{L \times S}{K} = \log_2 \frac{N^2}{t} \tag{14}$$

In UE4 the sensitivity defaults to 100, so the combination of shutter and aperture is expressed as EV100. When the sensitivity is ISO100, the aperture factor is $f1$, and the exposure time is 1 second, the exposure is 0, i.e. EV100=0. In UE4 settings, the logarithmic mean of the scene luminance is usually used to determine the exposure of a scene, and given a luminance value in cd/m^2, the EV100 value for that luminance value is usually calculated according to this formula:

$$EV100 = \log_2 \left(lu\min ance / 1.2 \right) \tag{15}$$

where the camera lens transmittance in UE4 is 0.65 (65% of the light will shine on the sensor, the rest is lost), the lens saturates at a value of 0.78/lens transmittance at a sensitivity of 100, resulting in a parameter value of 1.2.

3.3 New Chinese villa space color color scheme

3.3.1 Spatial ordering scores

Research samples of new Chinese villa space important sorting research items, using the method of calculating the average composite score, detailed sorting calculation score data, as shown in Table 1, analyze the specific data in the table to get the following sorting: resting area (5.999)→washing area (4.95)→leisure area (4.711)→dining area (4.489)→office area (3.987)→storage area (3.69) → Other (1.666).

Table 1: Basic types of hotel selection by research samples

Sort/villa space	Leisure Area	Rest area	Dining area	Office Area"	The storage area is already available	Washroom area	Others
1(7)	152	458	40	38	29	88	34
2(6)	98	135	130	78	65	254	5
3(5)	130	54	160	120	100	128	5
4(4)	120	26	150	134	110	79	2
5(3)	111	25	105	135	134	60	4
6(2)	79	32	57	130	184	78	6
7(1)	6	30	2	1	3	8	348
Average comprehensive Total score	4.711	5.999	4.489	3.987	3.690	4.950	1.666

3.3.2 Spatial color tendencies

Set the age group as the independent variable X The color code of the inclined guest room space was set as the dependent variable Y, and the specific analysis data obtained are shown in Table 2. Among the valid questionnaire samples, the color effect codes of the inclined rooms for those under 18 years old are NO8(41), NO7(38), and NO2(35) in sequence. The preferred color effect numbers for those aged 18-25 are NO.7(185), NO.6(164), and NO.11(154) in sequence, and for those aged 26-35, they are NO.10(79), NO.2(78), and NO.1(54). The preferred color effect numbers for those aged 36 to 45 are NO.12(56), NO.9(40), and NO.7(40) in sequence, and for those aged 46 and above, they are NO.3(54), NO.10(40), and NO.1(30) in sequence. Among the valid questionnaire samples for the free textual expression survey on the ideal color environment of new Chinese-style villas, the following key words about the color of new Chinese-style villa Spaces were summarized: warm tones, cozy, elegant, and natural. Among them, 78% of the respondents indicated that they had a color environment that matched their ideal choice among the above-mentioned preferred color options.

Table 2: Basic types of hotel selection by research samples

Y/X	Under18	Proportion	18-25	Proportion	26-35	Proportion	36-45	Proportion	46 years old and above	Proportion	Total
NO1.	12	0.052	121	0.519	54	0.232	16	0.069	30	0.129	233
NO2.	35	0.116	135	0.447	78	0.258	32	0.106	22	0.073	302
NO3.	28	0.101	120	0.432	42	0.151	34	0.122	54	0.194	278
NO4.	8	0.048	98	0.590	23	0.139	18	0.108	19	0.114	166
NO5.	15	0.088	96	0.561	35	0.205	17	0.099	8	0.047	171
NO6.	30	0.121	164	0.664	14	0.057	29	0.117	10	0.040	247
NO7.	38	0.129	185	0.629	19	0.065	40	0.136	12	0.041	294
NO8.	41	0.177	134	0.578	24	0.103	15	0.065	18	0.078	232

NO9.	5	0.023	124	0.564	35	0.159	40	0.182	16	0.073	220
NO10.	16	0.060	95	0.358	79	0.298	35	0.132	40	0.151	265
NO11.	8	0.037	154	0.713	38	0.176	12	0.056	4	0.019	216
NO12.	10	0.047	83	0.393	44	0.209	56	0.265	18	0.085	211

3.3.3 Satisfaction with color application in villa space

Select the application design of the three color schemes of the new Chinese-style villa space, the effect of the design to carry out customer satisfaction evaluation survey, the results obtained using the statistical method of analysis of variance, to verify the scientific nature of the application design, the survey collected a total of 123 questionnaires, Table 3 for the villa space color effect favorite tendency statistics, 43.9% of the respondents preferred the virtual reality-based villa space design, and the color scheme has a high degree of public acceptance compared to the other two schemes.

Table 3: Statistics of favorite tendency of hotel room color renderings

Color effect of villa space	Number of people"	Proportion
Case 1	34	27.64%
Case 2(Based on virtual reality)	54	43.9%
Case 3	35	28.46%
Survey the valid number of people	123	100%

Table 4 for the color scheme effect satisfaction variance, through the calculation and analysis of the color scheme satisfaction statistics can be derived, the survey respondents on the villa color scheme a satisfaction score of 4.41, the survey respondents on the villa color scheme two satisfaction score of 4.87. The survey respondents on the villa color scheme three satisfaction score of 4.36, from the size of the value can be seen, there is a slight difference in the three, but does it Reach the level of statistical difference, the use of ANOVA to study the color scheme for the effect of the difference in satisfaction scores.

Different color scheme samples for effect satisfaction scores show significance ($p<0.05$), meaning that different color scheme samples for effect satisfaction scores have differences. Specifically, the three color schemes for effect satisfaction scores show a 0.01 level of significance ($F=6.248$, $p=0.005$), the three schemes have more obvious differences in the group mean score comparison results are: scheme 2 > scheme 1, scheme 2 > scheme 3. Through the analysis of the above findings, the new Chinese villa is proposed to adopt the villa color design of Scheme II as its final villa decoration scheme.

Table 4: Color scheme effect satisfaction variance

/	Scheme (average value + standard deviation)			F	P
	Scheme 1(34)	Scheme 2(54)	Scheme 3(35)		
Score	4.41±0.56	4.78±0.52	4.36±0.52	6.248	0.005**

*P<0.05, **P<0.01.

4 Planning of villa space and layout based on spatial syntax

4.1 Space syntax indicator reference

(1) Selectivity $(Nrom)$:

$$NC_i = \frac{Choice(i)}{D_i} \tag{16}$$

(2) Connectivity value (C):

$$C_i = k_i \tag{17}$$

where k denotes the number of nodes connected to the ith node.

(3) Integration degree value (RRA):

$$\begin{aligned} I_i &= \frac{1}{RRA_i} \\ RRA_i &= \frac{Rk_i}{D_n} \\ Rk_i &= \frac{2(MD_i - 1)}{n-2} \\ Dn &= \frac{n\left[f\log_2\left(\frac{n}{D_i}\right) - 1\right] + 1}{(n-1)(n-2)} \end{aligned} \tag{18}$$

where f is a function of $\frac{1}{D_i}$.

(4) The total depth value (D):

$$D_i = \sum_{j=1}^{k} d_{ij} \tag{19}$$

where d_{ij} denotes the shortest distance traveled from node i to node j.

(5) Average depth value (MD):

$$MD_i = \frac{\sum_{j=1}^{k} d_{ij}}{n-1} \tag{20}$$

where n is the number of all nodes in the connection graph.

4.2 Spatial syntactic analysis

Table 5 shows the analysis of space syntactic structure, villa 1 is designed by using virtual reality technology, in terms of visual layer, the maximum value of connectivity of villa 1 is higher than the maximum value of connectivity of villa 2 by 220.94, and the difference of its minimum value is 3.83, and the difference of the average value is 14.11. It shows that the permeability of the space of villa 1 is strong and weak, and focuses on the rhythmic change. Its average depth value is also greater than that of villa 2, only the integration degree is smaller than that of villa 2, with a difference of 1.92. This is due to the virtual reality technology applied in this paper, the villa's space is complex but connected to each other, and the use of rockery, trees, bridges, corridors, doorways, windows and other landscaping elements, which gives the angle of view of the multi-optionality and richness.

Table 5: Spatial syntax analysis

Type attribute	Villa 1			Villa 2		
	Minimum value	Average value	Maximum value	Minimum value	Average value	Maximum value
Connection degree	6.15	245.59	1023.48	2.32	231.48	802.54
Degree of integration	0.65	1.06	1.64	1.12	2.98	4.85
Average depth	7.36	11.52	17.48	3.15	4.95	9.48

4.3 Satisfaction with the virtual villa space experience

Figure 3 shows the scores of the indicators of the new Chinese villa space, the most obvious and prominent of the indicators is the landscape learning indicator, the indicator score of 4.625 points, the overall villa space of the spatial experience of the satisfaction mean value of 4.019, through the user's experience scores can be known that the villa design of the villa is more rational, indicating that the user feels that there is a better experience in the use of the process.

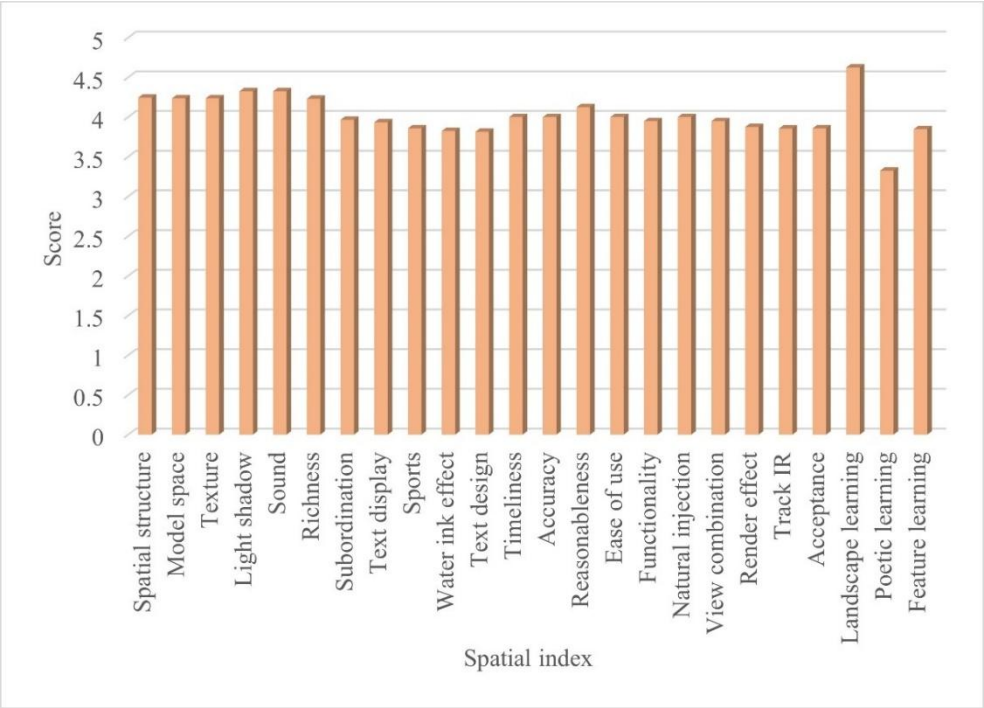

Figure 3: The new Chinese villa space index scores

5 Conclusion

This paper proposes four methods of new Chinese style villa space design, which are the combination of tradition and modernity, the fusion of nature and humanity, the space and layout planning, and the matching of color and soft furnishings. The spatial decomposition method in virtual reality is used to decompose the villa space, and at the same time, the immunogenetic algorithm is used to optimize the decomposition of the data. The influencing factors of scene brightness are obtained by means of stereoscopic image acquisition. The new Chinese style villa design scheme is applied in practice, and the empirical investigation method is used to investigate the color matching of the villa space, and in the spatial sorting, the users' score evaluation of the resting area, washing area, and relaxation area is higher, which is 5.999, 4.95, and 4.711, respectively, and in the satisfaction of color application, 43.9% of the respondents preferred the design of the villa space based on the virtual reality, which is a more popular solution to the villa space color is more acceptable to the public than the other two. According to the reference index of spatial syntax, decomposing the spatial structure of the villa, the maximum value of connectivity of villa 1 designed by virtual reality technology is 220.94 higher than the maximum value of connectivity of villa 2, and the value of depth is greater than that of villa 2. It is evident that modern villa integrating the new Chinese style gives the multi-selectivity and richness of the angle of sight.

About the Author

Jin Lu was born in Tianjin, China, in 1979. He obtained a Master’s degree from Dalian Polytechnic University in China. I am currently working in the College of Arts and Design, Daqing Normal University. My main research direction is interior and exterior environmental art design.

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