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Innovative Practice of Visual Art Elements in Housing Architectural Design for Aesthetic Enhancement of Living Environment

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Abstract The people's living space environment has changed dramatically under the rapid advancement of urbanization, and at the same time, the living habits have also changed, the most obvious of which is the increasingly strong pursuit of aesthetics. This study relies on Google SketchUp software to realize the practice of housing architectural space design based on visual art elements and environmental aesthetics theory. Combining the simulation synthesis evaluation method and Likert scale method, we propose an evaluation method of subjective perception of aesthetics, and use the eye movement index as the evaluation index of visual perception of aesthetics in the living environment, to explore the community residents' perception of the aesthetics of the living environment based on the design of visual art elements. The results of the design practice show that the community residents have a higher perception of the aesthetics of the housing living environment designed with visual art elements, with an average subjective perception score of 4.16 points. In addition, eye tracking showed that residents had a higher average gaze time and eye hopping speed, etc. in the images of the designed housing environment, indicating a superior perception of visual aesthetics. This study realizes the improvement of the aesthetic perception of the living environment in an innovative way by integrating visual art and environmental aesthetics, which provides certain research support and theoretical value for the beautification of the living environment in the process of housing building renovation.

Index Terms simulation integrated evaluation method, eye movement index, visual art elements, housing architecture, environmental aesthetics

I. Introduction

Aesthetics is a theoretical study about aesthetic experience and beauty, which has important value in architectural design. First of all, architectural design should focus on humanization, through reasonable layout, appropriate space planning and comfortable environment settings, to create a good experience of use and living environment, to meet people's needs for beauty [1]-[4]. Secondly, the architectural design should pay attention to the integration of the natural environment, through the reasonable vegetation design, landscape planning and lighting design, etc., and the coordination of the surrounding natural environment, resulting in a harmonious visual effect [5]-[7].

Visual art is a form of art that creates a sense of beauty through light and shadow, line, color and other elements, and its application in architectural design is to create a space with emotional and artistic value [8], [9]. In visual art, light and shadow is one of the most magical elements. Through the design techniques such as translucent windows, skylights or perforated panels, the change of light and shadow inside and outside the building will naturally create a sense of hierarchy in the space. The change of light and projection can change the shape and atmosphere of the space, and bring people a unique experience and feeling [10]-[13]. The smoothness of lines and the softness of curves can bring people a sense of comfort, while straight lines and angles bring a sense of stability and strength. The combination and structure of these lines can form the skeleton of the building and give the building personality and characteristics [14]-[16]. Of course, color is also an element that cannot be ignored in architectural design. Different colors can induce different emotions and feelings. Soft colors can bring people a warm and comfortable feeling, while bright colors can stimulate people's vitality and cheerful emotions [17]-[20]. In architectural design, the use of color should be determined according to the function and style of the building in order to achieve a harmonious effect [21], [22].

This paper realizes the improvement of the spatial aesthetics of the housing environment by remodeling the design of the housing architectural environment in an innovative way that integrates visual art elements and environmental aesthetic design. This paper utilizes Google SketchUp software to construct a simulation model of

housing architectural space. It combines the theory, guidance, and design significance of the aesthetic enhancement of the residential environment, and considers the way visual art elements are expressed in architecture. On this basis, visual art and environmental aesthetics design concepts are combined to design and transform the living environment in the simulated architectural model, and the immersive presentation of the living environment space is realized with the help of HTC VIVE Pro virtual simulation equipment. Subsequently, the subjective perception evaluation method of Likert scale method and fuzzy comprehensive evaluation method and visual perception evaluation method are proposed to explore the aesthetic value expressed by the living environment. This study takes a community as an example for design, and by analyzing the residents' perception of the aesthetics of the living space before and after the renovation in this community, it reveals the significance of the integration of visual art elements in enhancing the aesthetics of the living environment.

II. Visual arts-based design paths for residential environments

II. A. Analysis of the practical significance of the aesthetic enhancement of the living environment

II. A. 1) Theoretical implications

The theoretical significance of the aesthetics of the habitat environment [23] lies in the establishment of the environmental aesthetic view of the harmonious development of man and nature. Habitat environment aesthetics provides a new perspective and way of thinking for the development of urban landscape design. Exploring the laws of beauty in the field of material form and spiritual life in the city from the perspective of habitat aesthetics not only promotes the comprehensive experience of observing “aesthetic subject - aesthetic object - aesthetic practice”, but also makes the metaphysical theories of aesthetics and the construction of human settlement environment organically combine with the practice of human settlement environment. The theory of metaphysical aesthetics and the practice of human settlement environment construction are organically combined together. The theory of environmental aesthetics has been inherited and developed in the practice of exploring the aesthetics of the human environment. Using the theory of aesthetics of the human environment as a guide to analyze and summarize the problems of urban landscape, and constructing a research system of environmental aesthetics in line with the development of contemporary cities, it fills in the gaps in urban theory.

II. A. 2) Guiding significance

The exploration of the aesthetics of human settlements helps to realize the ideal relationship between people and the environment. A beautiful environment is an important reason why a city can give people an emotional sense of identity, a sense of belonging and a sense of spiritual support. At the same time, the cultural qualities reflected in the environment will always affect people's interest in life and spiritual outlook. The living environment is not only the space of people's material life, but also often become people's aesthetic object. The beauty of the living environment is not only an example of people's aesthetic value orientation, aesthetic interest, aesthetic ideal and even the development of aesthetic creativity, but also unavoidably becomes an aesthetic object that affects people's aesthetic understanding and enjoyment. Exploring the theory of aesthetics of human habitat, revealing the negative effects of the lack of aesthetic significance, and triggering people's reflection and awakening, can help guide people to establish a scientific aesthetic outlook, construct a good standard of aesthetic judgment of the living environment and design a beautiful living environment, and promote the healthy, ecological and sustainable development of the living environment.

II. A. 3) Design implications

Habitat aesthetics is a “practical aesthetics”. As a kind of aesthetics with guiding significance and aesthetics of life, it should serve our living environment. Based on the application of habitat aesthetics, landscape design provides a medium for it to go into practice, so that the theory of habitat aesthetics can be verified. Habitat aesthetics provides a new way of thinking and perspective for the development of urban landscape. Landscape design under the perspective of habitat aesthetics has a positive theoretical significance for contemporary urban construction and development.

II. B. Design of housing built environment under visual arts

Visual art [24] is a form of representational language. Fine art, plastic art, space art is often called visual art, is a kind of sculpture, painting, arts and crafts, architectural art and other space in the unfolding of the art of expression, tabula rasa, appealing to the visual form of artistic expression. As a linguistic medium for conveying information, visual art has its own grammatical structure and rules of use, just like language and words. As long as the language expressed by visual art is clearly recognized and felt to a certain extent, one can understand and comprehend the information and meaning conveyed by visual art through one's own eyes. “Visual art is a kind of image language

using different symbols", as a basic form of language, different forms of visual art works have different connotations of cultural spirit.

Based on this, this paper integrates visual design elements into housing architectural environment design to realize the innovative practice of residential environment aesthetics. After selecting the housing architectural environment prototype, the environmental space model is constructed using Google SketchUp software [25], where the visual art elements will be integrated into the design of the housing environment, and Enscape rendering plug-in is used to render and adjust the constructed housing architectural space environment model. The housing architectural environments designed to incorporate visual art elements were then presented with the aid of the HTC VIVE Pro virtual simulation device. Under the visual arts, the aesthetic evaluation of housing built environment was analyzed from three aspects: housing environment (housing appearance, water environment, light environment, color environment, greening environment, exercise and leisure environment, leisure and communication environment), landscape environment (coordination degree of landscape elements, richness of plant landscape, change of greenway vision, and degree of urban integration and coordination) and spiritual and cultural environment (sense of pleasure, sense of cultural identity of the times, creativity of public art, and cohesion of human resources).

III. Methods for evaluating the aesthetics of the residential built environment

III. A. Subjective perception evaluation methods

Currently there are more methods to carry out aesthetic evaluation of the living environment, which can usually be carried out through questionnaires, satisfaction, statistical software and GIS and other indicators. Among these evaluation methods, the habitat environment evaluation is more frequently used with the local livelihood information statistics and forecasting techniques and the industry's unified professional indicators as the standard. There is also the examination of the quality of the habitat based on environmental problems, observation and improvement and adjustment of exposed problems, as well as the provision of follow-up designs based on problems and needs, and the final addition or revision of design specification guidelines.P The OE method was originally applied to the evaluation of buildings designed to be constructed, defined as the systematic assessment of a building after it has been built and used for a certain period of time. The POE focuses primarily on the needs of the occupants, the effectiveness of the building's design, and the performance of that building once it is completed. These aspects of concern can provide a design basis and reference for future designs when using the POE method for different objects, it is necessary to consider the application of specific classifications and the feasibility of the method in a comprehensive manner. The main evaluation model used in this study is the POE method, and in the implementation of the method using fuzzy comprehensive analysis (objective evaluation) combined with the Likert scale method (subjective evaluation), taking the average of the two evaluation results to jointly realize the aesthetic evaluation of the housing architectural living environment based on the design of visual art elements in this study.

III. A. 1) Likert Scale Methods

One of the commonly used scales in POE evaluation [26] is the Likert scale, which is a reusable standardized measurement tool, the principle of which is to use the logical strength structure between the measured variable indicators and experience to measure, with a better effect of the attitude evaluation measurement form, through which the scale can be more scientifically and rationally derived from the measurement of high reliability and validity, with easy design, wide range of use of the Advantages. Likert scale is composed of a set of statements describing the evaluation of the environment, which can contain both positive and negative descriptions, and the assignment of values in accordance with the positive and negative directions, for example, the scale answers to the attitudes according to the strength of the structure is divided into five kinds of order. That is, very good, good, fair, poor, and very poor, while these 5 kinds of responses are assigned according to 1-5 or 5-1 respectively, and the significance of the assigned amount is to quantify the qualitative descriptive evaluation, in addition, sometimes, in order to quantitatively describe more accurately, the responses can also be subdivided into 7 or 9 kinds of levels. In this study, a 5-level structure of strengths and weaknesses was used.

III. A. 2) Fuzzy integrated evaluation methods

Fuzzy comprehensive evaluation method [27] is a comprehensive evaluation method suitable for solving non-deterministic problems, this method has strong logic and intuition, with fuzzy mathematics as the principle, a variety of qualitative judgments are converted into quantitative judgments, and finally the overall judgment is derived, and finally the overall judgment results made are clear and lucid, and have strong systematic. The general steps of this method are as follows.

(1) Evaluate the target factor thesis domain v

Assume that there is p thesis domain v, $v=\{v_1,v_2,v_3\cdots,v_P\}$ and each fuzzy subset corresponds to a rank.

(2) Establishment of fuzzy relationship matrix R

Statistics of each fuzzy subset of each factor quantitative value, each evaluated thing will be quantized on each factor $u_i = (i = 1, 2, \ldots\ldots, p)$, to determine the fuzzy subset affiliation degree to a higher level $(R \mid u_i)$, the relationship matrix construction formula:

$$R = \begin{bmatrix} R \mid & u_1 \\ R \mid & u_2 \\ \cdots & \cdots \\ R \mid & u_p \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{p1} & r_{p2} & \cdots & r_{pm} \end{bmatrix} \tag{1}$$

i_{jr} denotes the j th column element of the i rd row in matrix R, which represents the degree of affiliation of the evaluated thing on factor u_i to the v_i -rank fuzzy subset.

(3) Determination of weight vector of evaluation factors

Next, the weight vector of evaluation factors is determined: $A = (a_1, a_2, \ldots\ldots, a_p)$. In this paper, hierarchical analysis is used to determine the order of relative importance among evaluation indicators. From there, the weight factors are determined and normalized before synthesis. Namely:

$$\sum_{i=1}^{p} a_i = 1, a_i \geq 0, i = 1, 2, \cdots\cdots, n \tag{2}$$

(4) Result vector synthesis

Synthesize A with R of each evaluated thing to get the fuzzy comprehensive evaluation result vector of each evaluated thing B. i.e:

$$A \circ B = (a_1, a_2, \ldots\ldots, a_p) \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{p1} & r_{p2} & \cdots & r_{pm} \end{bmatrix} = (b_1, b_2, \ldots\ldots, b_m) = B \tag{3}$$

b_1 is obtained from the j th column operation of A and R, which indicates the degree of affiliation of the evaluated thing to the v_j -rank fuzzy subset from the overall view.

(5) Analyzing the fuzzy comprehensive evaluation result vector

There are two types of "$\circ$" symbols in $(B = A \circ R)$ in the above test: one is the operation of taking small and large, and the other is the operation of product and sum, which is more reliable and precise.

III. B. Visual perception evaluation analysis methods

The visual perception evaluation was analyzed mainly in terms of eye movement characteristics, and the eye movement indexes of the residents in the subject neighborhoods were collected and analyzed by using the Tobii Pro X3-120 on-screen eye-tracking device [28].

IV. Analysis of the effect of aesthetic enhancement of the living environment

IV. A. Case Selection and Environmental Design for Visual Arts

IV. A. 1) Overview of cases

Tianjin F residential building residential area is located in the commercial street adjacent to the east side adjacent to the completed 800 acres of water park, Yangliuqing Golf Course, northwest of Tianjin China Bicycle, green and pollution-free high-tech park. On the west side are hotel apartments and commercial, service and entertainment facilities developed by Vanke. In the future, the nearby town will be developed and constructed around the town government, and all kinds of supporting facilities will be more complete, which will also improve the environmental quality of the community and play a positive role in promoting. The residential building project was designed by Vanke, and the total area of the residential community is 45,216 m², of which the housing floor area and landscape area are 21,562 m² and 23,654 m² respectively, each accounting for 47.69% and 52.31%. The ratio of hundred square meters of trees in the landscape area is 6:4, of which the proportion of large trees over 25cm is 25.69%. The coverage rate of ground cover in the community is 25.41%, of which the coverage rate of flowers and ribbon shrubs is 7.52% and 17.89% respectively, mainly adopting five-fold landscape planting, and the ground cover style combines with flower mirrors and ribbons, which makes the functional areas no longer isolated from each other, and achieves the free access to the whole open space to create the situational atmosphere of a scene in one step.

IV. A. 2) Residential Environment Design Program

(1) Spatial Scale and Dimensions

The housing construction project has the following four claims and concerns about the pre-planning before proceeding with the design of the living environment based on visual arts elements.

(A) Regarding the volume ratio of the environmental space, a public space is set up in the middle of the high-rise and townhouses in the community environment, and a good-neighborly space integrating visual arts elements is created.

(B) Regarding the separation of pedestrian and vehicular traffic. The whole area is separated from people and vehicles in consideration of the design planning and business model requirements, the ground needs to be arranged parking spaces, parking spaces and driveways should be arranged along the fence as much as possible, to grasp the scale of the relationship to a greater extent.

(C) Regarding the ground structures civil substations, box-type substations, gas regulator stations, air shafts, and human defense exits, the aesthetic planning and design is rationalized under the premise of meeting the minimum number of specifications, avoiding axes and placing the edges of the site.

(D) With regard to supporting facilities, pipe wells supporting pipelines should be embedded according to the visual art elements and aesthetic design program based on the pipelines should avoid water features, tree pools, landscape walls, and paving such as manhole covers.

(2) Functional structure

At the beginning of the design of the living environment of this architectural project, the spatial design needs of modern residents are taken into account, and the design is based on the kinetic line to meet the residents' homecoming line, daily life, recreation and leisure, or excursion line. The functional modularization of the living space is based on the entrance space, which is divided into a garden entrance, a vibrant landscaped main street, a neighborly space, a private space, and a sharing space. In order to provide a variable and rich in visual art elements of the living environment layout, to meet the needs of different people. At the same time, the whole living environment space function structure is clarified, and the space form has more sense of belonging, making it affinity. It is conducive to the independence of each space and interconnection, so that the whole layout of the living environment has integrity and aesthetics.

IV. B. Selection and Characterization of Subject Residents

In the analysis of the aesthetics of the living environment, the residents of this community as the subjects are universal to carry out the evaluation of the aesthetics of the living environment based on the design of the visual art elements, so the households in the F neighborhood were selected as the survey and test subjects in this study. In conventional psychological experiments, more than 30 subjects are called large-sample experiments. Because of the need to consider the subsequent eye-tracking experiment, this study randomly recruited volunteers to participate in the experiment under the condition of “normal vision, naked-eye visual acuity or corrected visual acuity of 1.0 or above,” and 85 community residents were recruited as subjects. Excluding invalid data, a total of 83 valid data were collected in this study. The results of the statistical analysis of the basic situation of the subjects are shown in Table 1. There were 36 male and 47 female subjects, each accounting for 43.37% and 56.63% respectively, and the academic qualifications of the subject residents were mainly based on bachelor's degree (45.78%) and master's degree (22.89%), and there were 5 subjects engaged in the professional category of art (Chinese painting, oil painting, design, etc.), and the other occupations of the subject community residents included enterprise employees, teachers, freelancers, etc.

Table 1: The basic situation of the community residents

Project	Group	Number of subjects	Percentage
Gender	Male	36	43.37%
	Female	47	56.63%
Age	<20	2	2.41%
	21-30	15	18.07%
	31-40	24	28.92%
	41-50	16	19.28%
	51-60	11	13.25%
	>61	15	18.07%
Education	Below specialized	6	7.23%
	Specialty	11	13.25%

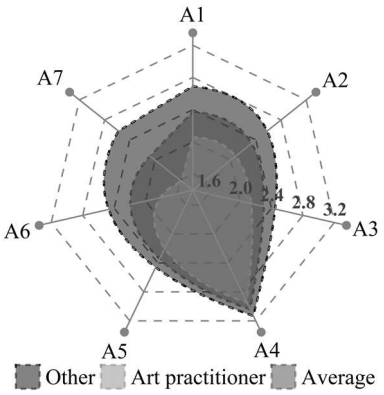
	Undergraduate	38	45.78%
	Master	19	22.89%
	Doctor and above	9	10.84%
Occupation	Art class	5	6.02%
	Enterprise unit	45	54.22%
	Teacher	4	4.82%
	Freelancing	12	14.46%
	Other	17	20.48%

IV. C. Analysis of the aesthetic perception of the living environment

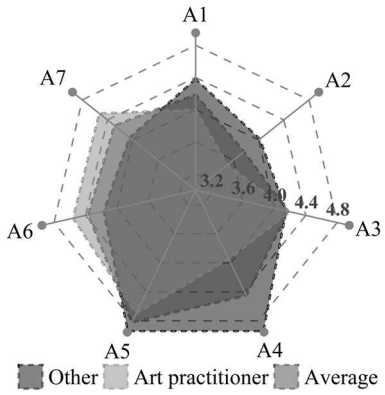
IV. C. 1) Analysis of multidimensional subjective perception results

The results of the analysis of community residents' multidimensional subjective perception of the aesthetics of the living environment obtained by the combination of the Likert scale method and the fuzzy comprehensive evaluation method are shown in Fig. 1, with (a) and (b) representing the results of the perceptions of the dimensions of the housing environment before and after the design of the housing architecture, and (c), (d), and (e), and (f) representing the results of the analysis of the multidimensional subjective perceptions of the landscape environment and the spiritual environment, respectively. In the figure, A1-A8 represent housing appearance aesthetics, water environment, light environment, color environment, green environment, exercise and leisure environment, and rest and communication environment, respectively. B1-B5 represent landscape element aesthetics, landscape element coordination, plant landscape richness, greenway vision change, and urban integration and coordination, respectively. C1-C4 represent mood pleasure, era cultural identity, public art creativity, and human resources Articulation. In the original residential environment design of this residential community, the average scores of community residents' subjective perceptions of the housing environment, landscape environment and spiritual environment were 2.55, 2.56 and 0.88 points. And due to the fact that art engaged workers have higher requirements for the aesthetics of the living environment, the subjective perception scores of residents of this type of occupation on the aesthetics of each environment are lower than those of residents of other occupations. This also indicates that the original community had fewer design elements for environmental aesthetics, and the perception of residential architecture was relatively poor.

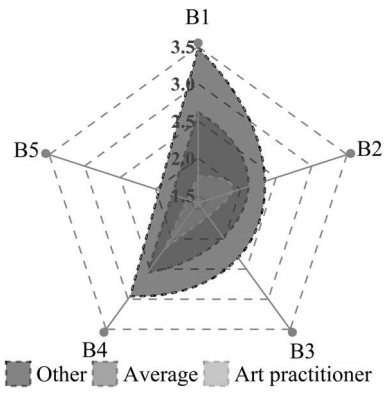
The community environment designed by the integration of visual art elements received high aesthetic subjective perception evaluation scores in the housing environment, landscape environment and spiritual environment, with average scores of 4.30, 4.16 and 4.03 respectively. The overall scores are much higher than the aesthetic perception scores of the original community environment, which belongs to the art-oriented residential environment with perfect basic recreational facilities, high aesthetic value of landscape, and good psychological and cultural experience. Moreover, the scores of all the perception indicators of non-art practitioners are above 4.0, and only the scores of moodiness and creativity of public art are 3.82 and 3.69 respectively. This indicates that community residents have a high level of perception of the aesthetics of the living environment designed based on visual art elements.



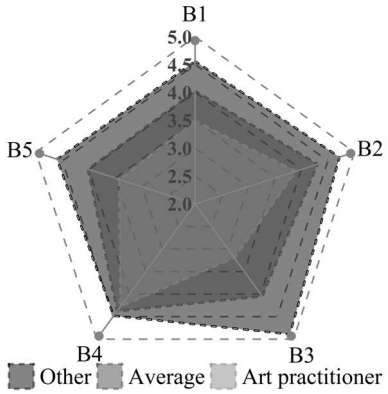
(a) Housing environment (Before)



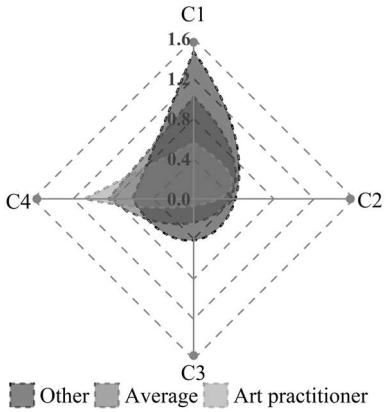
(b) Housing environment (After)



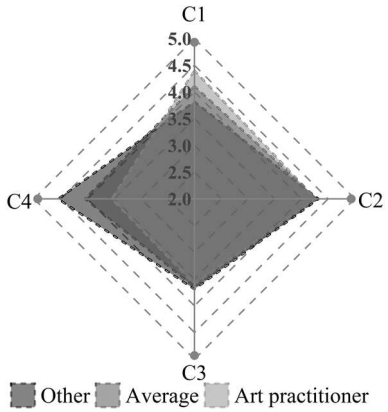
(c) Landscape environment (Before)



(d) Landscape environment (After)



(e) Mental environment (Before)



(f) Mental environment (After)

Figure 1: Subjective multidimensional perception analysis results

IV. C. 2) Comparative analysis of visual perception

(1) Selection of eye movement indicators

Referring to the classification of eye movement indexes in related studies and taking into account the characteristics of the landscape of the living environment, six indexes were finally selected as the indexes of the eye movement test, i.e., the average gaze duration (FDA), the first time gaze duration (FFD), the average speed of eye-beat (SVA), the average amplitude of eye-beat (SAA), the frequency of gaze (FF), and the frequency of eye-beats (SF). The gaze duration was divided by the number of gaze points to obtain the value of the mean gaze duration index, which characterizes the length of time subjects spent on each gaze for the sample landscape. The first gaze time is mainly the duration of the first gaze point that falls on the area of interest. This index characterizes how fast or slow the subjects' first gaze was for the sample landscape. Mean eye-beat velocity is the average of the peak value of each beat during an eye-beat. This indicator characterizes the extent of the subjects' acquisition of information about the sample landscape and reflects the degree of distinctiveness of the sample landscape's features. The average eye-beat amplitude index reflects the scope of the subject's acquisition of the sample landscape information, and the larger the index, the easier it is for the subject's gaze point to reach the target area. The frequency of gaze mainly refers to the ratio of the number of times of gaze to the time of gaze, which is an indicator reflecting the degree of interest and attention to the gaze area. The eye-beat frequency mainly refers to the number of eye-beats per unit of time, which characterizes the visual search behavior of the subjects for the sample landscape.

(2) Analysis results of eye movement indicators

In order to effectively analyze the impact of designing housing architecture based on visual art elements on the aesthetics of the living environment, this paper separately analyzed the eye movement behavior of community residents in the simulated image test of the living environment before and after the transformation. The results of

the analysis of the eye movement indexes of the community residents in the image test of the original housing building environment design are shown in Table 2, and the results of the analysis of the eye movement indexes in the image test of the housing building designed based on visual art elements after remodeling are shown in Table 3. In terms of average gaze time, the average gaze times of housing space, leisure facilities, landscape space and other spaces in the images of housing architectural design without integration of visual art elements are 186.93ms, 159.64ms, 160.18ms and 165.02ms, respectively, with the average gaze times being less than 200ms, which indicates that the various parts of the space of the living environment do not have a greater attraction to the community residents. There exists a large attraction. In the images of residential environment design based on visual art elements, the average gaze time of community residents in the housing space, open space facilities, landscape space and other spaces ranges from 207.6ms to 293.64ms, with a significant increase in the average gaze time, which indicates that the integration of visual art elements enhances the aesthetics and attractiveness of the residential environment.

Table 2: Analysis results of eye movement index (Before aesthetic design)

Eye-movement indicators		FDA (ms)	FFD (ms)	SVA (°/s)	SAA (°)	FF (every/s)	SF (every/s)
Housing space	Mean	186.96	144.23	96.71	1.57	1.24	0.94
	SD	15.76	21.5	1.38	0.24	0.15	0.11
Recreation facility	Mean	159.64	128.07	85.12	1.81	1.4	0.87
	SD	18.47	34.69	1.88	0.5	0.12	0.08
Plant landscape	Mean	160.18	168.42	98.48	1.91	1.37	0.91
	SD	21.02	27.88	1.88	0.36	0.1	0.08
Other landscape	Mean	165.02	167.26	84.19	1.59	1.02	1.04
	SD	20.19	26.69	1.23	0.55	0.14	0.15
Average	Mean	167.95	152.00	91.13	1.72	1.26	0.94
	SD	21.5	31.87	1.93	0.56	0.1	0.08

Table 3: Analysis results of eye movement index (After aesthetic design)

Eye-movement indicators		FDA (ms)	FFD (ms)	SVA (°/s)	SAA (°)	FF (count/s)	SF (count/s)
Housing space	Mean	240.3	187.4	100.6	2.38	1.95	0.62
	SD	23.05	30.93	1.58	0.59	0.16	0.09
Recreation facility	Mean	207.6	170.76	113.7	2.58	1.63	0.6
	SD	18.82	26.65	1.84	0.33	0.15	0.09
Plant landscape	Mean	252.09	188.72	118.7	2.21	2.38	0.76
	SD	18.79	32.06	0.81	0.24	0.13	0.14
Other landscape	Mean	293.64	160.54	119	2.28	2.23	0.77
	SD	23.58	29.3	1.72	0.42	0.16	0.14
Average	Mean	248.41	176.86	113	2.36	2.05	0.69
	SD	16.99	28.95	0.89	0.32	0.12	0.08

Subsequently, a variance chi-square test (F-test) was performed on the eye-tracking data, and the results of the variance chi-square test showed that there was no significant difference between the variances of the groups at the a=0.05 level, i.e., the variances were chi-square, which fulfilled the conditions for further multiple comparisons. In this study, the least significant difference method (LSD) was applied to further do the multiple comparison analysis, and some of the eye-tracking data obtained from the testing of the community living environment images before and after the design based on visual art elements were subjected to one-way ANOVA, and the results obtained from the one-way ANOVA are shown in Figure 2. In the eye movement index test of the community living environment design images before and after remodeling, there were significant differences ($P<0.05$) in the eye movement indexes of the average gaze time ($P=0.021$), first gaze time ($P=0.036$), and average eye hopping speed ($P=0.038$) of the subject community residents. This indicates that the integration of visual art elements makes the richness and artistry of elements in housing architectural design increase, promotes the improvement of community residents' visual perception, and reflects its positive driving effect on the aesthetics of the living environment.

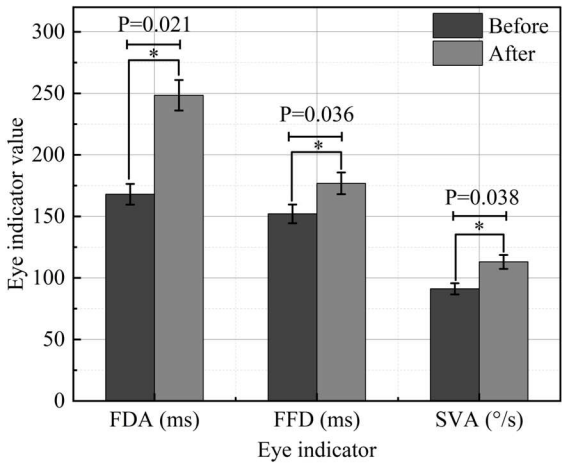


Figure 2: Visual perception comparison analysis results

V. Conclusion

In this paper, the design of housing architectural space reshaping based on visual art elements is realized by Google SketchUp software and HTC VIVE Pro virtual simulation equipment, and the shaping effect of the aesthetics of the living environment is evaluated according to the subjective perception and visual perception values of community residents. Community residents showed high aesthetic perception of the community environment designed based on visual art elements, and the subjective perception scores under different spaces (housing environment, landscape environment, and spiritual environment) were 4.30, 4.16, and 4.03, respectively, which were much higher than the aesthetic perception scores of the original living environment. In terms of visual perception evaluation, the average gaze time of community residents in each part of the housing space, open space facilities, landscape space, and other spaces ranged from 207.6ms to 293.64ms, with the average gaze time higher than 200ms, suggesting that the integration of the visual art elements enhances the aesthetics and attractiveness of the living environment. From the perspective of environmental aesthetics and visual arts, this study realizes the combination of ecological, architectural, and visual arts elements with aesthetic arts in housing architecture design to achieve a high degree of coordination and realize the wholeness, ecology, and aesthetics of the living environment.

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