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Exploring the Relationship Between Architectural Space Perception and User Experience in the Construction Industry Using Digital Art

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Abstract. With the development of electronic information technology, architects use computers to conduct simulation research on the physical environment of buildings, such as space perception, user experience, etc. The obtained physical environment parameters gradually play a decisive role in architectural design. These simulations guide the design direction with accurate data results, and the most important digital art in architectural design still has room for improvement. In order to explore the correlation mechanism between architectural space perception and user experience, this paper explores the relationship between space environment and users' physiology and psychology under the influence of differences by comparing the difference between people's subjective perception of space environment in virtual and real scenes. The research set up a comparative experimental method of virtual environment evaluation and real environment evaluation, and formed a set of research methods based on digital art to explore the changes of three indicators: people's subjective evaluation of architectural space, physiological and psychological responses of human perception to architectural space environment Condition. The research results can be used for subjective feedback in the architectural space design stage, and then accurately optimize the architectural space environment design.

Keywords: Digital Art; User Experience; Architectural Space Perception; Correlation Mechanism; Experience in the Construction Industry
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1 INTRODUCTION

The design of architectural space [8],[12],[18] is the first step in constructing a spatial environment. How to generate different spaces through design and thus have a specific impact on users is the answer that architects have always wanted to seek. In the process of use, the user's experience in it is the only criterion for evaluating the space environment [5],[16]. Based on the user's evaluation of the space environment, the architect obtained feedback, summarized the feedback, and obtained the advantages and disadvantages of the corresponding architectural space design [13],[25],[7], so as to optimize the design and allow users to get a better space experience. The most critical part of this process is to obtain users' evaluation of the space environment, that is, the post-use evaluation of the built environment - POE (Post Occupancy Evaluation). Theoretical research on POE began in Scotland in the 1960s.

Originally developed by scholars in the field of environmental behavior from the architectural environment design, it refers to the systematic and rigorous evaluation process after the building is built and used for a period of time.However, in actual use, this evaluation method relies more on the subjective feedback of users. Although this method can reveal the difference between the expected design and the actual experience [2], it cannot accurately point out the design features [20],[14] that cause the difference. The collected data cannot exclude the interference factors of the user's physiology, psychology [6],[19], time, etc., and truly and objectively reflect the subjective satisfaction of the human body [3],[1]. Therefore, the data is obviously general and lacks the accuracy of guiding the design.. Second, the method is for evaluation feedback on the built environment. The evaluation object itself must have been built. Once the project is completed, it will be much more difficult and expensive to make any structural changes. At the same time, as an evaluation model that highlights user needs, there is currently no formal way to incorporate POE evaluation results into maintenance planning or management.

Although POE, as a relatively mature evaluation method of architectural space environment, has demonstrated its value in countless buildings around the world in the past 50 years, in the process of application of this method, due to the fact that the application object is the "built environment" Due to limited conditions, there are still the following defects that cannot be ignored: 1. The feedback time period is long and the material investment is large; 2. The evaluation feedback is highly subjective; 3. The feedback feature object is not accurate; 4. Existing research results and actual construction out of touch. These problems have raised the threshold of the entire evaluation process to a certain extent, making it impossible to apply to every building design and construction, and can only be used as guiding opinions to make some guiding suggestions for other buildings in the design stage. However, a mature quantitative evaluation system for the space environment in the design stage has not yet been formed. If this system can be established, it can greatly shorten the feedback cycle, save a lot of resource consumption, obtain more accurate quantitative indicators, and obtain a certain characteristic. Feedback results to avoid the above problems.

With the development of digital art technology [10],[9],[17], computer models can be used in the architectural environment, and the space can be presented with a high degree of fidelity through virtual reality [24],[21] head-mounted displays in the design stage. With the help of computer, virtual reality software constructs the form of virtual scene, which can use multi-dimensional interactive means to effectively improve the efficiency of information transmission of architectural schemes. In the process of communication, it can provide an immersive experience and realize the first-person all-round space perception, which is especially conducive to communication with non-specialists and timely feedback to make corresponding modifications and optimizations. Digital art technology can quickly complete the construction and simulation of a large number of space and environmental elements, provide immersive display, and shorten the design cycle.

The main contributions of this paper are as follows:

1. This paper connects people's subjective experience of architectural space information with human physiological signals through digital art technology, and conducts quantitative analysis, so as to explore new ideas for objective evaluation of architectural space environment.

2. Through the combination of digital art and EEG technology, this paper can conduct quantitative analysis and rapid feedback on the evaluation of architectural design, which has high

application value for actual architectural engineering, architectural scene reproduction, architectural space research, etc.

2 RELATED WORKS

2.1 Digital Art

The emergence of digital art is inseparable from the development of computer technology, so early digital art (Digital Art) is also called "computer art". However, with the rapid development of digital technology, especially after the 1990s, the development of digital media technology, artificial intelligence technology, blockchain technology and other emerging digital technologies, digital art has also broken through "computer art" and "multimedia art" [23]. The concept of "art" is limited, and it moves towards a broader category. Since digital art is based on digital technology and its developed digital media, the concept of digital art has gradually been determined.In a broad sense, as long as the art practice activities using digital technology can be called digital art, it includes both the digitization of traditional art and the "digital native art" developed by digital technology. In a narrow sense, digital art needs to meet four conditions:

First, the art of bit form. Digital art as an emerging art form based on the development of digital technology, the main difference between traditional art is the digitization of the art language. All artistic languages of digital art must appear in the form of binary numbers "0" and "1". Therefore, digital art from the creation, production, dissemination and acceptance of the whole process is bound to be bitized form.

Second, independent aesthetic value. Digital art as a kind of, first of all, should follow the general law of art, is a kind of aesthetic ideology, which is the key to distinguish digital art from other digital technology-based behavior. Under the premise of adhering to the aesthetics-oriented, digital art should also be distinguished from the aesthetic value of traditional art, which is determined by its technical attributes. The bitization art language of digital art makes it have its own independent creation law and aesthetic characteristics.

Third, the dynamic art process. Digital technology and its medium of communication, the Internet, together created a virtual "cyberspace", the openness and interactivity of the Internet, also directly affects the process of digital art creation. As Negroponte said, "Digitalization allows us to convey the process of art formation, not just the final product." Digital technology will bring the distance between the creator and the appreciator closer, and make it more convenient for the interactive behavior between the two. Therefore, digital artworks are no longer "frozen visual symbols "1 , but a time-lapse interactive process and a co-temporal interactive scene.

Fourth, the organic and unified system. Bitization of digital art completely lost the "original" and "copy" of the difference, which makes digital art from the beginning of the creation of the conditions for large-scale processing and production, naturally and inevitably into the socialization of mass production, as the consumer era of art. It has become a product of mass production in the age of consumption. Based on this, digital art, as an object of commodity production, can no longer complete the whole art practice by a single artist, and requires a socialized collective to form an organic and unified system of creation, production, dissemination and acceptance as an inseparable process [11]. To sum up, on the basis of previous research, this paper tries to define digital art as "an art system with independent aesthetic value, which is composed of creation, production, dissemination and acceptance by artists or art organizations based on digital technology such as computer technology and Internet technology, and "bit" as art language. art system with independent aesthetic value".

2.2 Architectural Space

Space consists of four basic elements: points, lines, surfaces and bodies. The first three cannot be directly perceived in the three-dimensional world, but the concept of "body", which is formed by them together, is the basic element that forms the perceptible three-dimensional space. The entity replaces and encloses the space, occupies the space, and at the same time forms a fixed volume in the space. Architecture is the use of the space occupied by the entity and its formed volume space to produce a limited division of three-dimensional space, so as to be perceived by human beings. Commonly, architectural space refers to the volumetric space enclosed by entities, which are shaped in different ways through different forms of enclosure. The space of a building usually does not exist as a single entity, but is a combination of many spaces, which are linked according to their function, similarity or movement trajectory, and together constitute a building. The building constitutes the space perceived by human beings with certain connection, the building space perceived by human beings contains the independent space and combined space in the building, and also contains the connection and communication between the spaces, but the perception ability of human beings is limited, and they perceive the space directly through their vision, hearing, and touching senses, and the space that human beings pay attention to at a point in time is usually a simple independent space.

Space is created by enclosing entities, and the information of space, in addition to its basic length, width, and height, also contains information about the entities that form the space, as well as information about the entities housed within the space, as shown in Table 1. Together, this information constitutes the information about the architectural space as perceived by humans. However, the information contained in architectural space is very rich, and the nature of the elements of space, such as form, proportion, scale, texture, light and sound, is ultimately determined by the properties of the enclosing parts of the space, and the human perception of these elements is often a response to the combined effect produced by the various properties encountered.

ID	*Characteristics*
1	*form*
2	*color*
3	*texture*
4	*pattern*
5	*sound*
6	*proportion*
7	*scale*
8	*limit*
9	*degree of enclosure*
10	*Light*
11	*vision*

Table 1: Spatial Characteristics.

Human perception of the spatial environment is a complex process [4], the human body through the visual, auditory, tactile, olfactory, gustatory and other perceptual capabilities, to receive all kinds of spatial information in the external space, analyzed by the brain, combined, and ultimately in the human brain to form the concept of the space as a whole. Spatial information is of various kinds and quantity. Take visual information as an example, the information related to architectural space includes shape, size, distance, color, light intensity, etc. The human visual perception system is the most important part of the human brain. Human visual perception system is the most complex and sophisticated image processing system in human cognition. Vision is an effective symbolic description for constructing images of the outside world, and these descriptions are composed of many different but fixed expressions. Each expression represents some aspect of the external scene. In the process of human cognition of the environment, human subjective consciousness does not perceive and process all the information of the environment, but simplifies the perception of the space, then extracts the elements of the information, that is, the parameters of the spatial information, and then forms a connection between these parameters, so as to form the concept of the information of the whole space. Architectural spatial information is perceived by the human body in the form of elements, so by changing the parameters that constitute the architectural spatial information, the human body's perception of space can be directly affected. That is to say, the parameter informationization of architectural spatial information, and the quantitative analysis of the association between the parameters and human perception.

Parametric informatization of architectural spatial information according to a logical hierarchical classification [22], and generalization and classification of multiple parameters are the basis for carrying out research on architectural spatial information. In this paper, based on the influence of each element of architectural space Based on the influence of the elements constituting the architectural space on the physical environment of the space, this paper classifies the abstract spatial information into four types of material flows: shape, quality, quantity and structure, which correspond to four metrics - geometric scale, interface nature, internal accommodation and external association. The physical environment that constitutes the space is also categorized and analyzed to obtain Table 2.

ID	*Parameters*
1	*Bottom shape*
2	*Bottom size*
3	*Space height*
4	*Structural Column Size*
5	*Number of floors*
6	*Thermal performance of building materials*
7	*Window position and window-to-wall ratio*
8	*Instant window opening rate*
9	*Shading measures*
10	*Internal Greening Rate*

11	*Landscape moisture content*
12	*Internal crowd density*
13	*Relationship with surrounding space*

Table 2: Building Spatial Information Parameters**.**

These parameters are intended to establish a reasonable analytical pathway for the study of the relationship between the physical environment of architectural space and human beings. Based on the physical environment of architecture, i.e., the three physical properties that can be influenced by architectural space, namely, acoustics, optics, and thermodynamics, the physical environment of architecture is divided into categories, which are more comprehensive in nature, and at the same time pay more attention to the functionality of architectural space. Architectural physics as a complete discipline has been formed for nearly 100 years, through the complete integration of architectural acoustics, architectural optics and architectural thermal engineering to achieve the purpose of studying physical function and architectural art from the architectural point of view. By drawing on the research methods of physics, building physics continuously promotes the optimization of the physical environment of buildings through measurement, simulation and reproduction. Each index that this discipline focuses on in the research process is an element of the architectural spatial environment, that is, a parameter that constitutes the architectural spatial information. On the basis of the grading and classification methods of building physical sciences, grading and classifying the architectural environment that can be perceived visually, and realizing the parameterization of architectural spatial environment is the necessary process of research on the perception of architectural spatial environment.

3 METHODOLOGY

The proposed method is based on digital art (DA) and electroencephalographic signal acquisition (EEG) technology, through the digital art technology to build a virtual experimental environment, can quickly complete the construction of a variety of architectural spatial information experimental scenarios that can be controlled, supplemented by the physical environment of the laboratory regulation, can be more accurately simulate the environmental feeling of the real scene. Subjects wear EEG equipment to enter the test building space and complete the subjective/objective test. The subject records the relevant experimental data and analyzes the corresponding relationship of the data. The overall structure of the method is given in Figure 1.

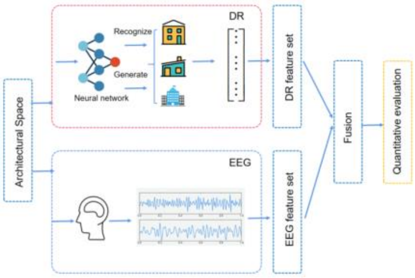

Figure 1: Schematic of the Overall Structure of the Proposed Model.

3.1 Neural Networks for Recognizing Architectural Spaces

In this paper, we use VGG16 network (as shown in Figure 2) to recognize the spatial content of buildings, VGG16 is a classical convolutional neural network. The basic working principle of convolutional neural network is to utilize convolution kernel to perform convolution operation. For example, there is an image and a convolution kernel. We slip the convolution kernel onto the image and use the weighted sum of the inputs covered by the convolution kernel as the output via a nonlinear transformation function. Each convolution kernel has its own set of weight values that do not change during the convolution operation. In this way, the input image can be convolved with a plurality of convolutional kernels in the convolutional neural network to produce convolutional kernel mappings. These convolutional kernel mappings are then convolved with more convolutional kernels to generate more feature mappings. Lower-level convolutions correspond to lower-level features, such as lines or spots. As you move to higher levels of convolution, the features become more and more complex. Convolutional neural networks can extract image features, which are the basis for recognizing the spatial content of buildings. When performing a recognition task, we are not training a neural network. Instead, the loss function needs to be optimized by changing the pixel values of the random noise image. Simply put, when training a neural network, the weights and biases of the network model are updated, but in recognizing the spatial content of a building, the weights and biases need to remain constant.

1. Content loss and style loss

The loss function is important in order to keep the weights and biases constant. Given a target image x, a content image c and a style image s, the equation of the image content loss function for architecturalspace recognition based on a two-channel VGG convolutional neural network is expressed as follows:

$$L_{content}^{l}(c,x)=\sum_{i,j}\left(F_{ij}^{l}(x)-F_{ij}^{l}(c)\right)^{2} \tag{1}$$

The image content loss is a function that defines the squared distance between the input image x and the content image c. Let cnn be a trained deep convolutional neural network. Suppose x is an arbitrary image, then $cnn(x)$ is the neural network provided to image x. Let $F_{ij}^{l}(x)\in cnn(x)$ and $F_{ij}^{l}(c)\in cnn(x)$ describe respectively the input image x and the content image c in l intermediate feature representation of the layer network.

Similarly, the equation for computing the loss function can be expressed as follows:

$$L_{style}^{l}(s,x)=\sum_{ij}\left(G\left(F_{ij}^{l}(x)'\right)-G\left(F_{ij}^{l}(c)'\right)\right)^{2} \tag{2}$$

where G denotes the Gran matrix of the content image and the target image. The equation for calculating the total loss function of style migration for the two-channel VGG convolutional neural network is as follows:

$$L_{total}^{l}(c,s,x)=aL_{content}^{l}(x,c)+bL_{style}^{l}(x,s) \tag{3}$$

where a is the balanced weight coefficient of the image content loss function, and b is the equilibrium weight coefficient of theloss function weight coefficients.

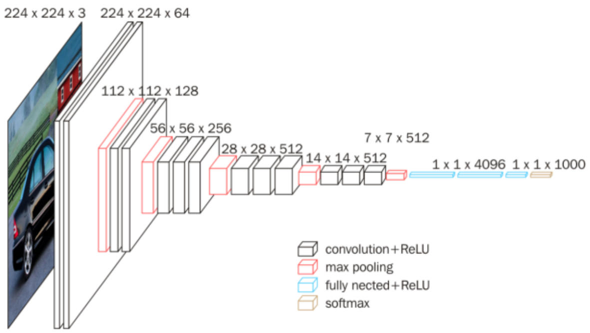

Figure 2: Schematic Diagram of Vgg16 Network Structure.

2. VGG-16 network for feature extraction

ConvNet Configuration					
A	A-LRN	B	C	D	E
11 weight layers	11 weight layers	13 weight layers	16 weight layers	16 weight layers	19 weight layers
input (224 × 224 RGB image)					
conv3-64	conv3-64 **LRN**	conv3-64 **conv3-64**	conv3-64 conv3-64	conv3-64 conv3-64	conv3-64 conv3-64
maxpool					
conv3-128	conv3-128	conv3-128 **conv3-128**	conv3-128 conv3-128	conv3-128 conv3-128	conv3-128 conv3-128
maxpool					
conv3-256 conv3-256	conv3-256 conv3-256	conv3-256 conv3-256	conv3-256 conv3-256 **conv1-256**	conv3-256 conv3-256 **conv3-256**	conv3-256 conv3-256 conv3-256 **conv3-256**
maxpool					
conv3-512 conv3-512	conv3-512 conv3-512	conv3-512 conv3-512	conv3-512 conv3-512 **conv1-512**	conv3-512 conv3-512 **conv3-512**	conv3-512 conv3-512 conv3-512 **conv3-512**
maxpool					
conv3-512 conv3-512	conv3-512 conv3-512	conv3-512 conv3-512	conv3-512 conv3-512 **conv1-512**	conv3-512 conv3-512 **conv3-512**	conv3-512 conv3-512 conv3-512 **conv3-512**
maxpool					
FC-4096					
FC-4096					
FC-1000					
soft-max					

Figure 3: Schematic Diagram of Vgg16 Network Structure.

Before elaborating on the VGG-16 network (as shown in Figure 3), knowledge of convolutional neural networks is first required. A colour image is usually divided into three channels of RGB, representing the colours red, green and blue respectively. For a black and white image, each pixel location is assigned a pixel value between 0 and 255 to represent the intensity of that pixel, but for a colour image, each pixel location is given three pixel values to represent the red, green and blue luminance of that pixel, all of which are also between 0 and 255. The colours in a colour image can be represented by different combinations of the three RGB channel values or by blending them in different proportions. The convolution process is based on a small matrix, also called a convolution kernel, which is continuously moved through each layer of the pixel matrix in steps, multiplying the number of passes by the number in the corresponding position of the convolution kernel, and then summing them to create a new matrix. Starting with a random initial value, each value in the convolution kernel represents a parameter of the neuron being trained. When training the network, these parameter values will be continuously updated via backward propagation until the optimal parameter value is determined. After the convolution operation there will be fewer dimensions, which means that the resulting matrix will be smaller than the original matrix.

The VGG-16 network uses the principle that several small convolution kernels can replace a large convolution kernel, and calculates through continuous 3×3 convolution kernels, replacing the 11×11 and 7×7 in its previous work AlexNet. convolution kernel. For a given receptive field (the local size of the input image relative to the output), stacking small kernels outperforms larger ones. According to the calculation of the receptive field below, using three 3x3 convolution kernels can be equivalent to a 7x7 convolution kernel, and two 3x3 convolution kernels can be equivalent to a 5×5 convolution kernel. A point at a certain position on the feature map has the same receptive field on the input image, but it deepens the depth of the network compared to the previous network, thereby improving performance.

3.2 EEG Feature Extraction

The non-stationary and nonlinear characteristics of EEG signals determine that EEG signal processing can be done from the time-frequency domain and nonlinear perspectives. In this paper, wavelet transform is used to extract EEG features. Wavelet transform (WT) is a time-frequency domain analysis method, which was first proposed by French engineers in 1974. In 1986, mathematician Y.Meyer constructed the first real wavelet base, and it was compared with S.Mallat Established a unified method for constructing wavelet bases - multi-scale analysis, from which the theory of wavelet analysis was basically formed. Scholars also found that wavelet transform, compared with the widely used Fourier transform in the past, has wavelet base functions that are not unique, The advantages of variable window shape and joint time-frequency domain distribution.

Wavelet transform is converted from Fourier transform. For the function $\psi(t)$, its Fourier transform is $\Psi(t)$, if and only if $\Psi(t)$ is the allowable condition shown in the following formula, $\psi(t)$ can be regarded as the base wavelet.

Then the continuous wavelet basis function can be expressed as:

$$\psi_{a,b}(t) = \frac{1}{\sqrt{a}}\psi(\frac{t\text{-}b}{a}) \tag{5}$$

where a is the expansion factor, b is the displacement component, and t is the independent variable. The projection decomposition of the continuous and energy-limited signal $x(t)$ under the wavelet basis function is defined as the continuous wavelet transform (Continuous Wavelet Transform, CWT) of the signal $x(t)$, and the expression is:

$$WT_x(a,b)=\left\langle x(t),\psi_{a,b}(t)\right\rangle=\int x(t)\psi_{ab}^*(t)$$
$$=\frac{1}{\sqrt{a}}\int_{-\infty}^{+\infty}x(t)\psi^*(\frac{t-b}{a})dt \tag{6}$$

4 EXPERIMENT AND RESULTS

4.1 Experimental Settings

The main space of the laboratory is divided into two main parts, the first part is the subject experiment space, located in a dome space of .2.4m radius size, to reduce the influence of external factors in the experiment; the second part is the researcher recording space, located outside the dome space, to guide and record the experiment. The subjects' experimental space is relatively closed through the dome and curtains to reduce the interference of external factors, while the stability and controllability of the experimental environment is realized through the physical environment control system inside the dome. The researcher's recording space is equipped with experimental data recording equipment, which guides the normal conduct of experiments and at the same time records the experimental data in real time, making it easy to analyze the data and draw relevant conclusions later on.

The experimental data acquisition equipments mainly include EEG (electroencephalography) and VR (virtual reality). EMOTIV EPOC Flex Saline Sensor Kit is used as the EEG acquisition device, which contains 32 acquisition points and 2 reference acquisition points, and has a high frequency of data acquisition to ensure the accuracy of the data; at the same time, EMOTIV does not need to use gel or paste media, which greatly improves the efficiency of the experiment and shortens the experimental process; moreover, EMOTIV can record the experimental data and export the raw data through the relevant software. At the same time, EMOTIV can be used without the use of gel or paste media, which greatly improves the experimental efficiency and shortens the experimental process; moreover, EMOTIV can record the experimental data and export the original experimental data through the relevant software, which is convenient for the analysis of data in the later stage of experiment. The virtual reality device (VR) uses Oculus Rift S all-in-one VR headset. On the one hand, Oculus is easy to wear, simple to operate, moderate cost and high realism; on the other hand, Oculus is compatible with computers, and through Unity and other software, it can quickly and conveniently build and modify the virtual experimental space.

4.2 Software Environment

In this experiment, a convolutional neural network built using the TensorFlow framework was utilised. TensorFlow is an open source software library for machine learning and numerical computing. TensorFlow employs nodes to represent mathematical calculations, and graph edges to represent multidimensional data arrays in a data graph or tensors transferred between them. Its architecture is adaptable, enabling users to extend computing to one or more CPUs or GPUs on desktops, servers, or mobile devices via an API. The computer operating system is Windows 10 Professional Edition, and the experimental hardware equipment: CPU of Intel(R) Core(TM) i7-6700HQ, GPU of NVIDIA GeForce GTX 1080, the memory size is 8G, and the graphics library CUDA 9.0 launched by NVIDIA is used for the experiment. GPU accelerated computing.

4.3 Experimental Results and Analysis

	1	*2*	*3*	*4*	*5*
Virtua	*0.81*	*0.90*	*0.92*	*0.83*	*0.88*
Real	*0.79*	*0.85*	*0.86*	*0.79*	*0.77*

Table 3: User Experience Satisfaction in Virtual and Real Environments.

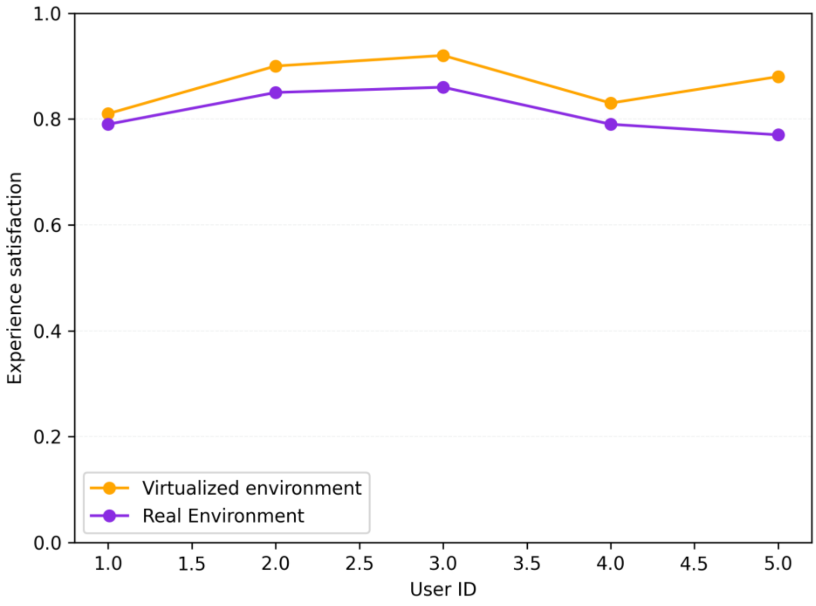

Figure 4: User Experience Satisfaction in Virtual and Real Environments.

From Table 3 and Figure 4, it can be seen that in both real and virtual scenarios, there is a good correlation between the subjects' subjectively expressed feelings about space, and it can be assumed that there is no significant difference between the subjects' subjective feelings in the virtual environment and the real environment.

	form	color	texture	pattern	sound	proportion	scale	limit	degree of enclosure	Light	vision
Male	*0.79*	*0.87*	*0.79*	*0.85*	*0.83*	*0.87*	*0.87*	*0.83*	*0.90*	*0.79*	*0.75*
Female	*0.88*	*0.91*	*0.82*	*0.81*	*0.91*	*0.91*	*0.91*	*0.87*	*0.89*	*0.75*	*0.78*

Table 4: Subjective Score - Gender Correlation Test.

	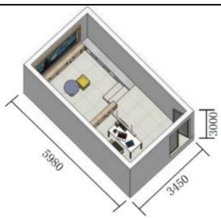	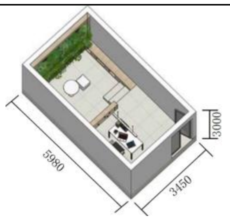	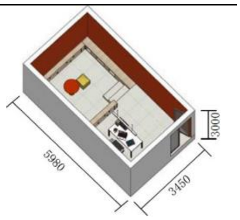
Male	*0.82*	*0.85*	*0.81*
Female	*0.81*	*0.90*	*0.83*

Table 5: Recognition Score - Gender Correlation Test.

It is clear from Tables 4 and 5 that the significance P is greater than 0.05, indicating that there is no significant difference between the two sets of data, i.e., there is no statistically significant difference in the subjective evaluation of the environment by the different genders.

5 CONCLUSIONS

Architects use computers to conduct simulation research on the physical environment of buildings, such as space perception, user experience, etc., due to the advancement of electronic information technology. Gradually, the obtained physical environment parameters play a crucial role in architectural design. Accurate data results from these simulations guide the design direction, and the most important digital art in architectural design has room for improvement. To investigate the correlation mechanism between architectural space perception and user experience, this paper investigates the relationship between space environment and users' physiology and psychology under the influence of differences by comparing the subjective perception of space environment in virtual and real scenes. The research established a comparative experimental method of virtual environment evaluation and real environment evaluation, as well as a set of digital art-based research methods to investigate changes in three indicators: people's subjective evaluation of architectural space, physiological and psychological responses of human perception to architectural space environment Condition. The research results can be utilized for subjective feedback during the architectural space design phase, and then the architectural space environment design can be optimized with precision.To validate the effectiveness of using digital art in architecture and construction, empirical research and case studies should be conducted to measure the impact on user experience, construction efficiency, and cost-effectiveness.

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