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Research Article

Interaction Design of Wellness Building Space by Deep Learning and VR Technology in the Context of Internet of Things

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This study explores the application of deep learning theory and virtual reality (VR) technology to the interactive behavior design of building space according to the interaction behavior of wellness building space in the context of the Internet of Things (IoT). Firstly, VR theory is made into an image-based 3-dimensional (3D) modeling process. Secondly, the interactive behavior information data is analyzed according to the theory of deep learning and edge computing. Finally, the particle swarm optimization (PSO) is used to analyze the predicted temperature with the wellness building space model, as well as to make a study based on the changes in the user's psychological indicators. The results show that the model predictions of deep learning-edge computing are most like the actual environmental settings. Both PSO and deep learning algorithms have varying degrees of influence on the final prediction results. The average temperature of the wellness building space established by deep learning and edge computing is 24.58 degrees, the average measured value of the actual environment is 24.49 degrees, and the predicted values of the two are similar. While users experienced the interactive design of the health building, their heart rate dropped from 73.17 to 68.79 and gradually became stable. There is no obvious change in the user's heart rate, which reflects the comfort of the wellness building space designed based on deep learning and VR interaction.

1. Introduction

A wide variety of building components are included in the architectural space, and the building components have only changed in terms of styles and materials during hundreds or decades of development [1]. If each building component is not in the same position, it is physically connected by the relationship between each other. If these large numbers of building components can be intelligently transformed through the Internet of Things (IoT), then the physical connections between them can be upgraded to communication and information connections, thus forming the overall space with intelligent properties. These structures make it a space of interconnected intelligent building components that can be controlled remotely, managed on-site, collected data feedback from sensors, stored status information in the cloud, and analyzed and managed big data [2–5]. This will lead to dramatic changes in buildings, making them more comfortable, energy-efficient, convenient, and safe. Meanwhile, it can reduce various energy consumption losses through intelligent adjustment to achieve a fantastic life experience and maximize the function of energy-saving and emission reduction [6, 7]. Virtual reality (VR) technology can reconstruct multidimensional cultural spaces and provide the possibility of immersion in the digital world and has increasingly become an important tool for cultural heritage research, protection, and dissemination. Regarding VR development in Europe, especially in the research of distributed parallel processing, auxiliary equipment design, and application, the intersection of VR application should focus on the overall comprehensive technology. The technology mainly includes VR reconstruction problems and architectural and scientific visualization computing [8–10].

Firstly, a three-dimensional model of the building must be constructed to simulate the building environment space. Viewing through the monitor can only be from one angle or one side [11]. Previously, the way of browsing animation is mainly adopted. For example, when a spline curve is established as a browsing path, a camera simulating a "human eye" is set up on this path to obtain a dynamic change in the architectural environment space. However, this animation has poor operability and human-computer interaction [12]. 3D Studio MAX is used to generate the design of the 3D architectural virtual space. This software system provides a camera plug-in. It consists of two cameras set horizontally. It is set at the appropriate position of the building scene and can obtain still pictures of buildings or browse animations simultaneously. Two pictures of the same target object are obtained [13–15]. However, the previous architectural design was based on the interaction between space and behavior. The three-dimensional spatial structure of the architectural space cannot be dynamically demonstrated, and there is a patterned architectural design behavior. Deep learning includes computational vision, natural language processing, and deep reinforcement learning. These address the problem of identification and decision-making concerning different types of data [16, 17]. At present, edge computing of operators is mainly in the pre-commercial stage of technical research, laboratory testing, and relatively simple scenarios [18]. Deep generative models are becoming the foundation of modern machine learning. Research on conditional generative adversarial networks (CGAN) shows the learning complex high-dimensional distributions on natural images [19]. While state-of-the-art models can generate high-fidelity, diverse natural images at high resolution, they rely on many annotated data [20].

Based on the IoT background, the deep learning theory and VR technology are applied to the interactive behavior design of building space according to the interaction behavior of wellness building space. Firstly, VR theory is made into an image-based 3D modeling process. Secondly, the interactive behavior information data is analyzed according to the theory of deep learning and edge computing. Finally, particle swarm optimization is used to predict temperature analysis with the wellness building space model, as well as make research based on changes in user psychological indicators. Technological development is taken as the premise; the comfort of health building is taken as the foundation. In the context of IoT, an interactive space for healthcare buildings based on VR and deep learning is designed. The design breaks through the traditional interactive design concept of healthcare buildings and has certain reference significance for the rational and scientific space design of healthcare buildings. The innovation lies in IoT and deep learning to supervise and control the equipment data of healthcare building space, which is different from the previous model of the design of healthcare building space. Additionally, VR technology is used for spatial interaction design to avoid the weak sense of interactive experience caused by relying on two-dimensional images for design and establish a dynamic interactive design of health building space.

Section 1 discusses the background of building space design for healthcare and the current status of building space and deep learning. Section 2 describes the production process, technical principles, and technical characteristics of the VR technology environment and explains the modeling process of VR technology on images. This part also discusses the workflow of deep learning and the principle of edge computing, which provides the technical and theoretical basis. Finally, the interactive design process of health building space based on VR and deep learning in IoT is designed. Section 3 mainly conducts temperature prediction and experience analysis of the designed health building space. Section 4 discusses based on the analysis results. Section 5 summarizes the research.

2. Method

2.1. Exploration of VR Technology Theory. Virtual reality (VR) is a new technology in the computer field developed as a comprehensive computer graphics, multimedia, sensor, human-computer interaction, network, stereoscopic display and simulation, and other technologies. At present, the research and application fields involved have included military, medicine, psychology, education, scientific research, commerce, film and television, entertainment, manufacturing, and engineering training. VR is a computer system that can create and experience virtual worlds (virtual worlds are a general term for all virtual environments). The VR system is established as multidimensional cyberspace that contains various kinds of information, and it is no longer purely digital cyberspace. Human perceptual cognition and rational cognition ability can be brought into full play in this multidimensional cyberspace [21]. Creating a VR system that allows participants to have an immersive sense of reality and a perfect interaction ability requires high-performance computer hardware and software, various advanced sensors, and a toolset that can generate virtual environments. The production process of the VR technology environment is shown in Figure 1.

In Figure 1, the VR technology environment applies the limitations of existing digital computers to process purely digital information. It builds cyberspace to accommodate various information sources such as images, sounds, and chemical smells. The information space can not only observe the results of information processing from the outside but also participate in the information processing environment through visual, auditory, olfactory, password, gesture, and other forms. Such an information processing environment is called a virtual environment. The virtual environment is generated by a computer and acts on the user through sight, hearing, touch, etc., to produce an immersive interactive visual simulation. VR uses "immersion," "interaction," and "imagination" to describe its characteristics, and the three are indispensable. The technical characteristics of VR are shown in Table 1.

In Table 1, immersive technologies have changed, to a certain extent, the way consumers, businesses, and the digital world interact. Users expect a greater shift from the 2-dimensional (2D) interface to the more immersive 3D world. They can capture richer, smoother pictures and experiences in 3D. Augmented reality (AR) is a field extended by the development of VR technology. It organically "superimposes" computer-generated virtual images or other information into real-world scenes with the help of computer vision and interactive technologies, including

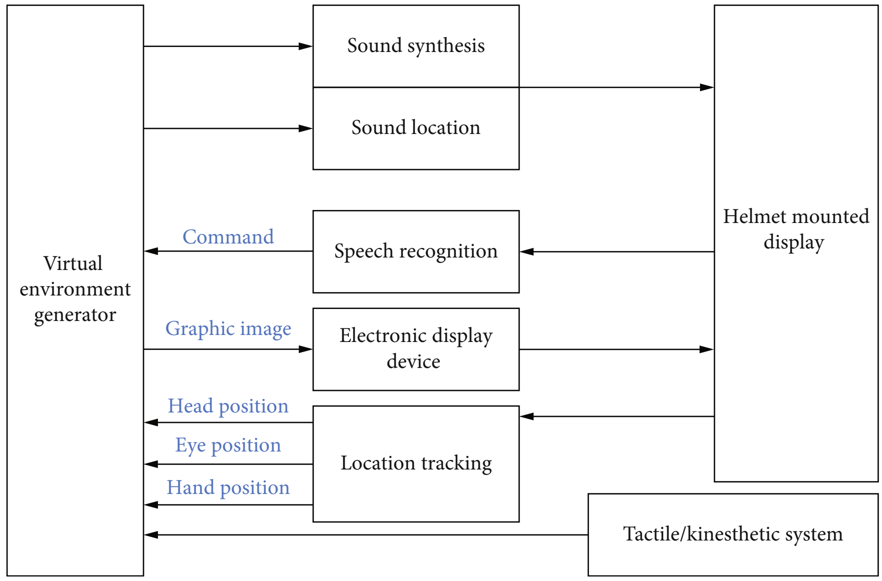

Figure 1: The generation process of the VR technology environment.

Table 1: Features of VR technology.

Feature	Equipment used
Immersion	Helmet display and data headset
Interaction	Computer keyboard, mouse, etc.
Imagination	Equipped with visual, auditory, tactile sensing, and reaction devices

visual, auditory, olfactory, and tactile information. AR achieves a sensory experience "beyond" reality. The foundation of AR technology lies in tracking and positioning, user interaction, virtual fusion, and system display technology. VR technology uses computer simulation to generate a virtual world of 3D space, providing users with simulations of visual, auditory, tactile, and other senses. It allows users to observe things in 3D space in a timely and unlimited manner as if they were in the real world. When the user moves the position, the computer can immediately perform complex calculations and transmit the precise 3D world image to produce a sense of presence. It can substitute human consciousness into a virtual world. When people look at the world around them, they get slightly different images due to the different positions of the two eyes. This difference allows people to perceive depth and makes things appear 3D. VR technology also uses this visual difference to arrange different pictures for the eyes so that the observer can feel the three-dimensionality of the picture. VR is a 360-degrees panoramic interaction. It not only has a strong sense of immersion and three-dimensionality but also allows users to interact with the virtual world [22]. The principle of VR core technology is shown in Figure 2.

In Figure 2, VR technology is a computer technology that can create and experience virtual worlds. It can use a computer to generate a simulation environment, a system simulation of multisource information fusion interactive three-dimensional dynamic scene and entity behavior. This technology can use professional equipment such as sensor helmets to allow users to enter the virtual space and perceive and operate various objects in the virtual world in real time to get a real immersive experience. The image-based modeling process of VR technology is shown in Figure 3.

Figure 3 expresses the scene in different forms, such as panoramic images and light fields, with photo data taken in different directions and positions. Secondly, the new view of image synthesis is used to compose a new virtual environment. The all-seeing function is used to perform a set of all environment mappings for a given scene [23]. The all-seeing function is defined as

$$u = \text{Plenoptic}\left(\theta, \phi, \lambda, V_x, V_y, V_z, t\right). \quad (1)$$

(V_x, V_y, V_z) represents the position of the viewpoint in space. ϕ represents the elevation angle for the field of view direction and range. θ is the azimuth angle. λ represents the wavelength perceived by the human eye. t stands for time. The brightness of each point on the image reflects the intensity of light at a certain point on the surface of an object in space. The position of the point on the image is related to the geometric position on the surface of the space object. The reference coordinate system of the camera model

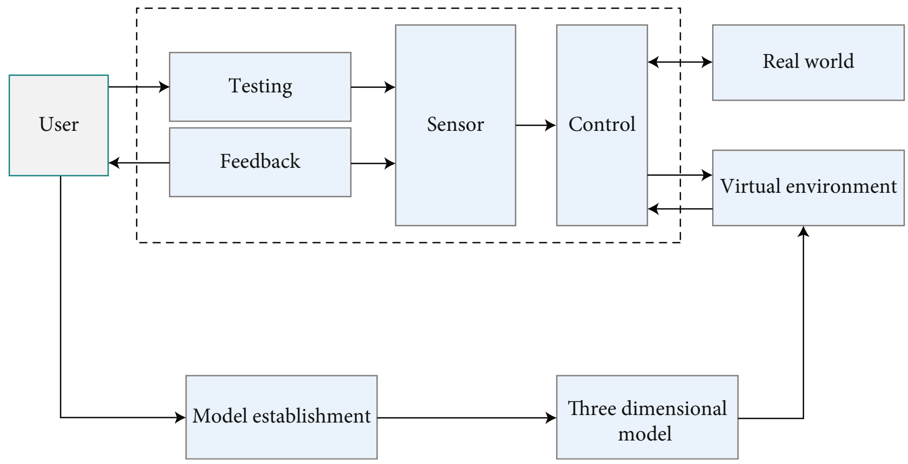

Figure 2: The principle of VR core technology.

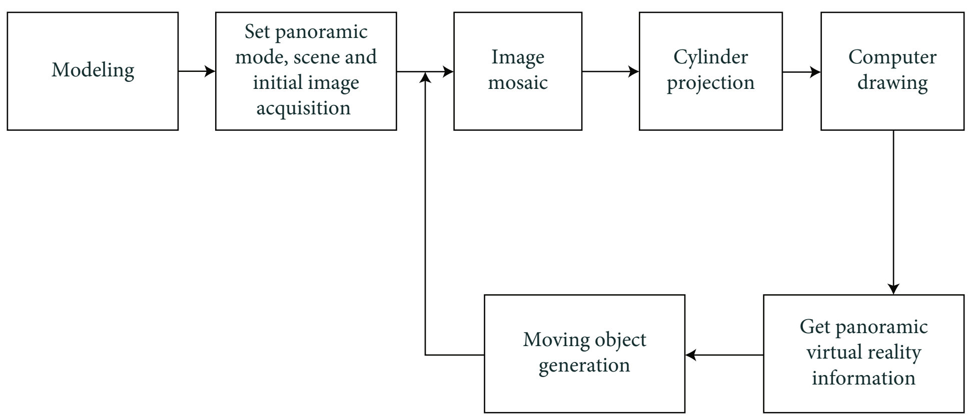

Figure 3: The modeling process of VR technology image-based.

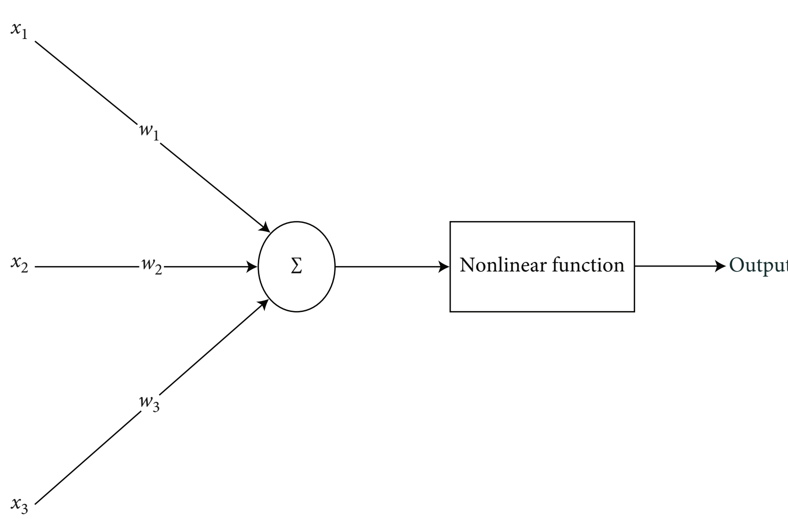

Figure 4: Deep learning neural network.

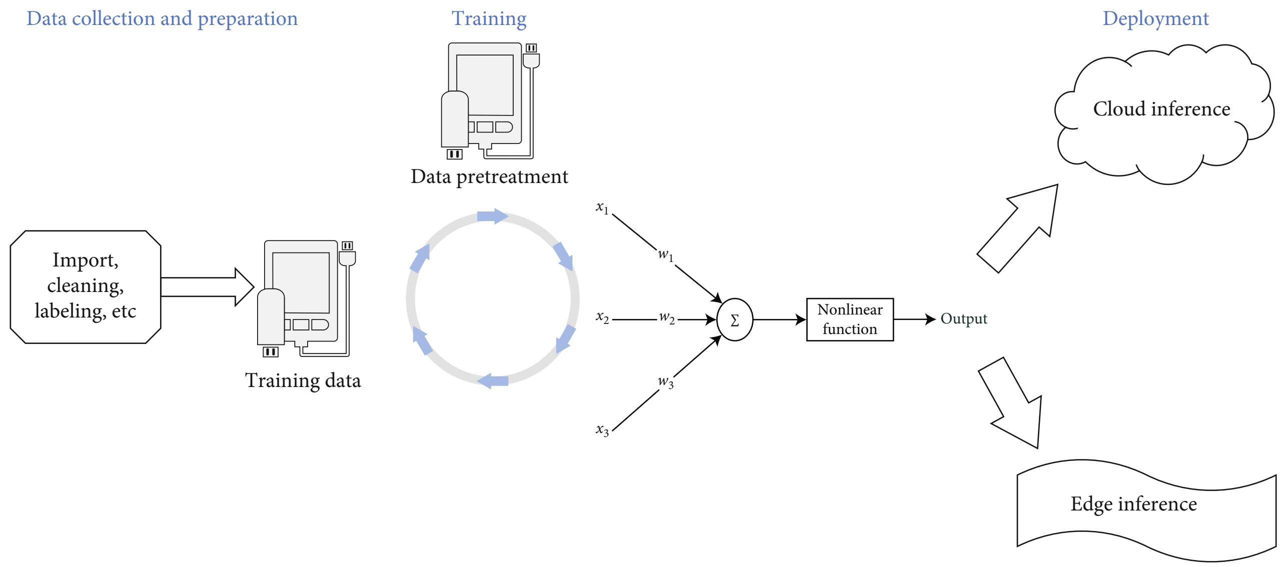

Figure 5: Workflow of deep learning.

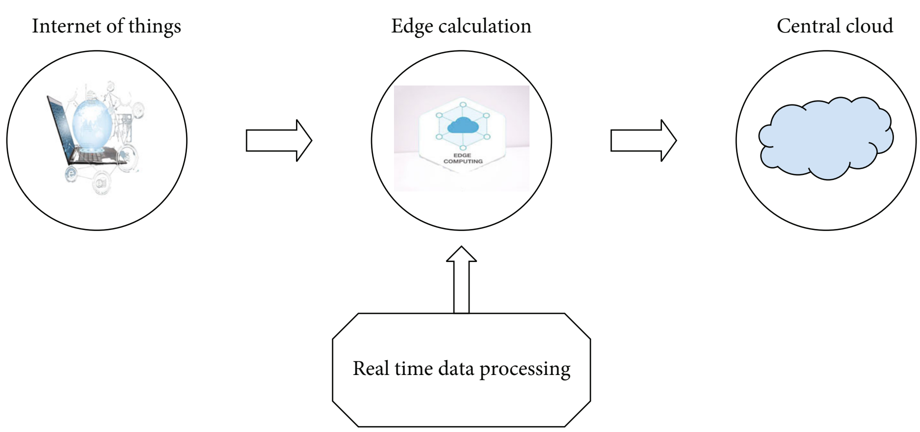

Figure 6: Principles of edge computing.

is used to solve for each coordinate, as shown in

$$\begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = M \begin{bmatrix} X_w \\ Y_w \\ Z_w \\ 1 \end{bmatrix}, \tag{2}$$

$$Z_c \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = M_1 M_2 X_w = M X_w. \tag{3}$$

(u, v) is expressed as the coordinates of the computer image in pixel units. (X_w, Y_w, Z_w) are the coordinates of the actual image in physical units. M is the camera calibration. The internal parameters of the camera are marked as M_1, and the external parameters are marked as M_2. The original image data is converted into stitched image data according to the requirements of panoramic vision consistency and maintaining the spatial constraints in the actual scene. The feature points are selected as Harris corners on the image, and the theoretical description is shown in

$$C = \begin{bmatrix} \left(\frac{\partial I}{\partial x}\right)^2 & \left(\frac{\partial I}{\partial x}\right)\left(\frac{\partial I}{\partial y}\right) \\ \left(\frac{\partial I}{\partial x}\right)\left(\frac{\partial I}{\partial y}\right) & \left(\frac{\partial I}{\partial y}\right)^2 \end{bmatrix}. \tag{4}$$

$I(x, y)$ represents the grayscale value. If the two eigenvalues of the matrix C at a point are large, a small movement of the point in any direction will cause a large change in the gray value. The function of corner detection is shown in

$$R = \det C - k(\text{trance}C)^2. \tag{5}$$

The k parameter is set to 0.04. The point in the local area corresponding to the maximum value of the corner function is the corner. Determine a threshold, and select the point whose R-value is greater than the threshold as the corner point.

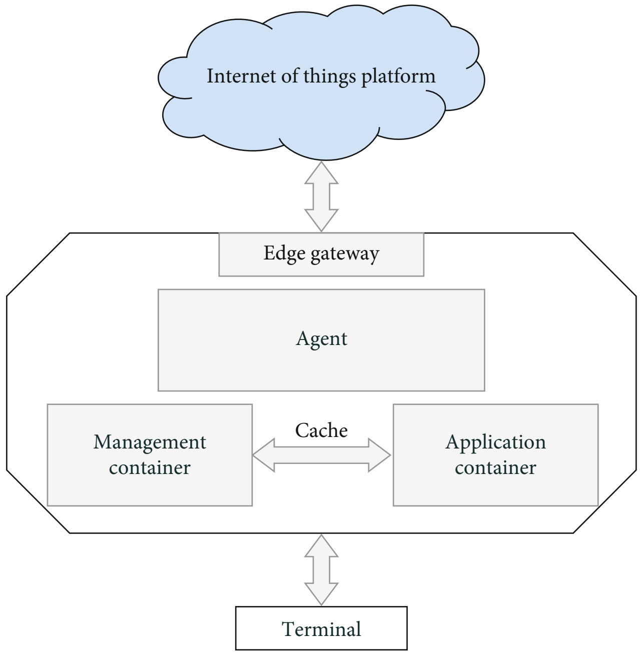

FIGURE 7: Data processing of edge computing in the context of IoT.

2.2. Principles of Deep Learning and Edge Computing. As an emerging technology in machine learning algorithms, deep learning is to build a neural network that simulates the human brain for analysis and learning. Its essence is to perform hierarchical feature representation on observation data and realize the further abstraction of low-level features into a high-level feature representation. This is all performed through neural networks [24]. The deep learning neural network is shown in Figure 4.

In Figure 4, deep learning uses neural network technology. The most basic unit of a neural network is a neuron. x_1, x_2, and x_3 are the input values of deep learning. w_1, w_2, and w_3 are weights. When the network adds a computing layer, it can not only solve the exclusive OR (XOR) problem but also have a perfect nonlinear classification effect. Theoretically, a two-layer neural network can approximate any continuous function infinitely. The deep learning workflow is shown in Figure 5.

In Figure 5, firstly, the definition is questioned, and the dataset is collected to ensure that the dataset is feature-rich enough to make predictions. Secondly, model prediction performance metrics are defined. Finally, the model evaluation method is determined, and the model is built for verification. Edge computing supports a hierarchy of end devices, edge computing nodes, and cloud data centers. It can provide computing resources and scale according to the number of clients, avoiding network bottlenecks in a central location. The principle of edge computing is shown in Figure 6.

In Figure 6, edge computing does not need to transmit data to the cloud when processing data. It is suitable for data analysis and intelligent processing and has the advantages of safety, speed, and easy management. Edge computing can better support real-time intelligent processing and execution of local data and meet the real-time requirements of IoT [25]. The image-based two-dimensional partial differential equations are shown in

$$\frac{\partial f(x,y)}{\partial x} = \lim_{\epsilon \longrightarrow 0} \frac{f(x+\epsilon, y) - f(x,y)}{\epsilon}, \quad (6)$$

$$\frac{\partial f(x,y)}{\partial y} = \lim_{\epsilon \longrightarrow 0} \frac{f(x, y+\epsilon) - f(x,y)}{\epsilon}. \quad (7)$$

In Equations (6) and (7), the gradient of the image is the partial derivative of the current pixel (x, y) concerning the x-axis and the y-axis. Therefore, the gradient can be understood as the speed at which the gray value of the pixel changes. After the image has been computed, nonmaximum suppression can help suppress all gradient values except local maxima to 0.

2.3. Establishment of a Spatial Interaction Design Model of the Healthy Building in the Context of the IoT. A deep neural network is a complex, nonlinear, and nonconvex function. This function is then used to fit the patterns in various types of input data so that patterns in these data can be identified. Ultimately, it can align the model's prediction with the ground-truth label. The data processing of edge computing in the context of IoT is shown in Figure 7.

Figure 7 applies a software development kit (SDK) by providing devices adapted to different access protocols. Edge nodes can uniformly manage and monitor different devices, making device access simple and fast. Nodes can process data reported by devices in real time, clear and filter data, and authenticate devices online. It supports offline nodes to store and encrypt local data and supports the deployment of custom applications to edge nodes in container mode. The cloud can manage, monitor, and operate images and container applications unified.

Wisdom combines technical means and IoT and technical means to connect all traceable intelligent device data to the Internet. User data is stored in a decentralized way of IoT, and the public key and private key cannot be tampered with to complete the verification and confirmation. Wellness is the application direction and scenario-based on big data artificial intelligence, applying IoT unmanned intelligent terminal equipment to build smart cities and communities. The design is simple, pays attention to the shape of the volume, and emphasizes the contrast between the virtual and the real. The design is simple, focusing on the shape of the volume, emphasizing the contrast between virtual and real. The main building complex of beige paint is appropriately matched with warm red brick walls and a bell tower in length and height. This highlights the modern fashion but does not lose elegant, warm temperament, in line with children and the elderly physical and psychological needs [26]. The wellness building space interaction is shown in Table 2.

In Table 2, the interaction design process of VR wellness building space in an IoT context based on deep learning and edge computing is shown in Figure 8.

In Figure 8, the interaction design of the wellness building space is designed by combining VR technology with deep learning [27]. According to the selected wellness building design scheme, it is operated through the client software

Table 2: Interaction behavior of wellness building space.

Various spaces	Interactive behavior
Living space	Family visits, indoor walks, window sill viewing, balcony activities, watching TV, and chatting
Bed living space	Sleep, nursing, and family visits
Traffic contact space	A simple walk, rest at corridor rest, visit friends, and stop for communication
Public event space	Recreational activities, leisure communication, rehabilitation and fitness, laundry and bathing, consultation, and prescription

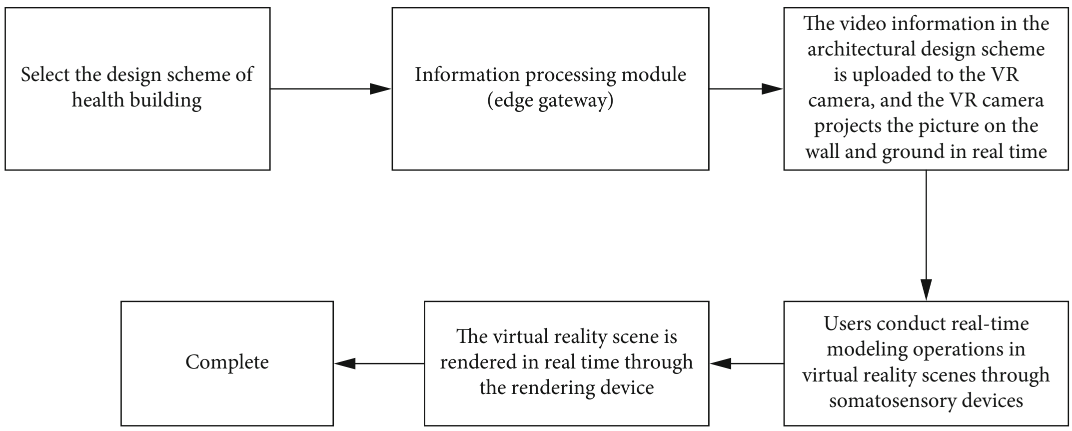

Figure 8: The interaction design process of wellness building space-based on VR and deep learning in the context of IoT.

installed on the smart mobile terminal (Android phone or iPad) device. The wellness building design scheme has different decoration materials, including wall color, floor selection, sofa style, and door and window style. The somatosensory device captures the posture of the human body and obtains the skeleton data and motion trajectory of the human body. The device uploads the data to the VR camera, calibrates, and obtains the coordinates of the user's head position or eye position in the VR scene. Finally, the coordinate parameters are corrected, and the interaction design of the Wellness building space is completed. Table 3 shows the qualified range of healthcare building environmental indicators and user physiological indicators.

3. Results and Discussion

3.1. Comparison of Temperature Prediction Results in Wellness Building Space under Different Models. According to VR technology and deep learning theory, the model parameter weight w_i in deep learning is 0.4~0.9. The value of edge computing ε is 0.0001. In the information processing data, 500 groups of data are selected as the sample set, and 25 groups are selected as the interactive behavior data set to predict wellness building space by different models—prediction of the interaction behavior of wellness building space-based on deep learning-edge computing and PSO. The number of model iterations is 200. Figure 9 shows the prediction results of the wellness building space interaction design under different models.

Table 3: Qualified range of healthcare building environmental indicators and user physiological indicators.

Index	Indicator normal range
Building temperature	24-25°C
Body temperature	36-37°C
Systolic blood pressure	140~90 (mmHg)
Diastolic blood pressure	90~60 (mmHg)
Heart rate	60~100 (min)

In Figure 9, the model prediction of deep learning-edge computing is most like the actual environment setting value. Both particle swarm optimization and deep learning algorithms have varying degrees of influence on the final prediction results. The average temperature of the wellness building space established by deep learning and edge computing is 24.58 degrees. The average value of the actual environmental measurement value is 24.49 degrees. The two predictions are similar. The prediction of the model is successful. The wellness building space of the PSO studied as a comparative study predicts an average temperature of 23.60 degrees, which is quite different. As the number of iterations increases, the average error rate of PSO increases from 10.56% to 13.45%. The average error rate for deep learning-edge computing is 6.40%.

3.2. Physiological Index Analysis of User Experience in Wellness Building Space. The advantage of the wellness building industry is that it can realize the remote supply of

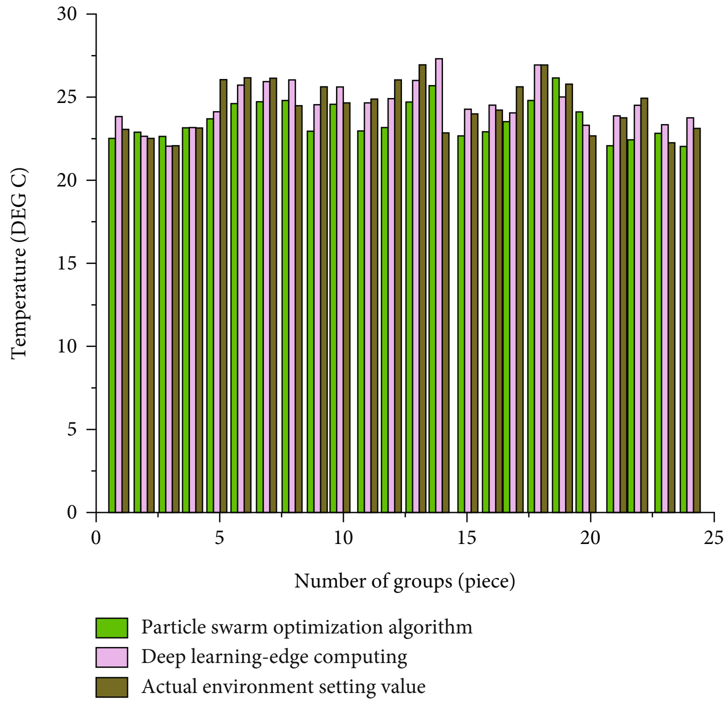

FIGURE 9: Prediction results of wellness building space interaction design under different models.

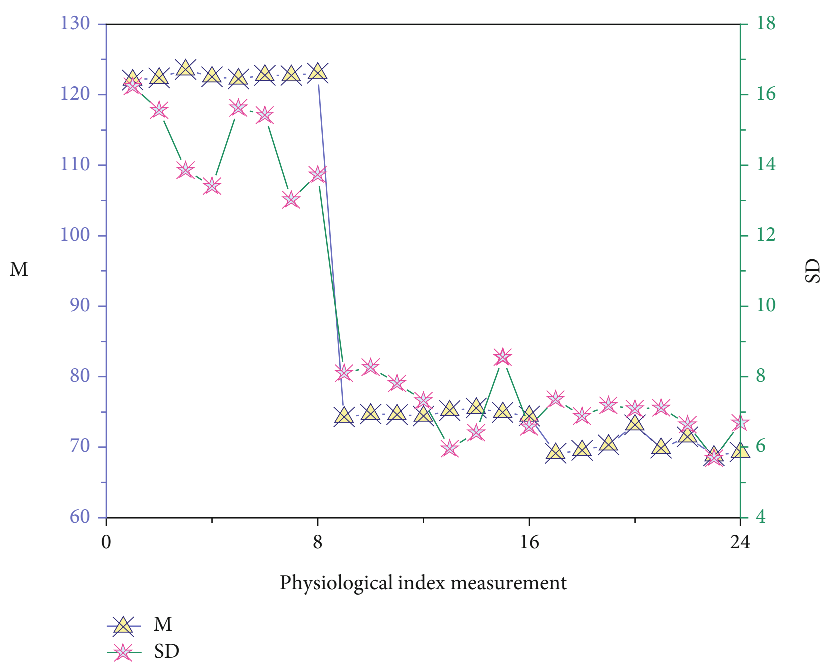

FIGURE 10: Analysis of physiological indicators of user experience in wellness building space.

resources. Unlike traditional industries, wellness is an industry that can easily achieve long-distance supply. The elderly and subhealthy people have become the main target groups of the wellness industry. However, according to incomplete estimates, the current annual supply of products for the wellness life of the elderly is between 500 billion and 700 billion yuan. Product demand continues to be strong, but effective supply is insufficient. The interaction design experience of wellness building space is studied and analyzed according to the user's physiological indicators. Physiological indicators are divided into three categories, 1-8 are systolic blood pressure measurement indicators, 9-16 are diastolic blood pressure physiological measurement indicators, and 17-24 are physiological measurement indicators. Figure 10 shows the analysis of user physiological indicators in the wellness building space-based on deep learning and VR technology.

In Figure 10, while the user experiences the wellness building interactive design, the mean systolic blood pressure is 122.65, and the standard deviation is 14.60. The diastolic blood pressure mean is 74.76, and the standard deviation is 7.37. The mean heart rate is 70.19, with a standard deviation of 6.83. And the mean of systolic blood pressure is much larger than the standard deviation of systolic blood pressure. While the user experiences the interaction design of the wellness building, the heart rate drops from 73.17 to 68.79 and gradually becomes stable. There is no significant change in the user's heart rate. These data reflect the comfort of the wellness building space-based on deep learning and VR interaction design.

4. Discussion

The healthcare building space is predicted by building temperature, and the user experience physiological indicators are analyzed. The model based on deep learning-edge computing predicted that the average temperature of the healthcare building space is 24.58°C. The average value of the actual environmental measurement value is 24.49°C, and the predicted value of the two is similar. These values correspond to the appropriate temperature values for building dwellings. The data reflects the effectiveness and feasibility of the design from the side. In addition, when users experience the health building space, the physiological indicators conform to the normal physiological index range. In the interactive design of healthcare building space based on VR emotion measurement, the rationality of the design of elderly care institutions is directly proportional to the results of the emotional index scale (physiological and psychological) of the elderly. This result is beneficial in promoting the expression of positive emotions in the elderly. This is consistent with the physiological indicators of user experience in the research of healthcare building space in this paper, which shows the rationality of the research results, and reflects the comfort of healthcare building space based on deep learning and VR interactive design.

5. Conclusion

The interaction design of wellness building space is studied based on VR technology and deep learning theory and edge computing. The results show that the average temperature of the health building space established by deep learning and edge computing is 24.58°C; the average measured value of the actual environment is 24.49°C. The two predicted values are similar, and the model prediction is successful. The average temperature of the health building space predicted by the particle swarm algorithm as a comparative study is 23.60°C, which is quite different. As the number of iterations increases, the average error rate of PSO increases from 10.56% to 13.45%. The average error rate for deep learning-edge computing is 6.40%. While users experience the interactive design of healthcare buildings, the mean value of systolic blood pressure is 122.65, and the standard deviation is 14.60. The diastolic blood pressure mean was 74.76, and the standard deviation was 7.37. The mean heart rate was 70.19, with a standard deviation of 6.83. The mean of systolic blood pressure is much larger than the standard deviation of systolic blood pressure. This study has certain reference significance for the virtual interaction design of healthcare building space in the context of IoT. However, according to the development of modern healthcare buildings, more and more intelligent equipment may have a certain impact on the design. It is hoped that this study can optimize the interactive design of the health building space with the advancement of technology. And there is no description of the services provided by the healthcare building. In the future, effective resources will be used for intelligent healthcare building service design.

Data Availability

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethical Approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Consent

Informed consent was obtained from all individual participants included in the study.

Conflicts of Interest

All authors declare that they have no conflict of interest.

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