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A Metaverse Scene Generation and Optimization Algorithm Based on Artificial Intelligence and CAD

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Abstract. The generation and optimization of metaverse scenes, as the core of metaverse technology, are directly related to the realism and immersion of user experience. Traditional virtual scene generation methods often face problems such as low efficiency and uneven quality, making it difficult to meet the growing market demand. The purpose of this study is to achieve high-quality and efficient metaverse scene generation and optimization by combining artificial intelligence (AI) and computer-aided design (CAD) technology. This article adopts deep learning (DL) based image recognition and processing technology, combined with global information for feature description, to achieve efficient scene recognition and accurate segmentation. Meanwhile, by optimizing the algorithm and network structure, the modeling accuracy and training efficiency of scene generation have been improved. The results show that the modeling reaches over 95%, and it also performs well in the comparison of the quantity of incorrect pixels per frame, surpassing other comparison algorithms. This algorithm provides an effective method for achieving high-quality generation and optimization of metaverse scenes, and lays a solid foundation for the further development and application of the metaverse.

Keywords: Artificial Intelligence; Computer Aided Design; Metaverse; Virtual Scene
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1 INTRODUCTION

Meta-universe refers to a brand-new virtual space formed by the integration of digital world and real world. As an important part of the meta-universe, the generation and optimization of meta-universe scene is of great significance for improving user experience and expanding application fields. The metaverse, as a realistic virtual environment, is gradually demonstrating its potential in various fields, especially in industrial applications. Bhattacharya et al. [1] explore the diverse applications of the metaverse in the industrial field and how it shapes our future internet. The metaverse can provide a virtual environment where designers can simulate and design products. Through immersive experience, designers can more accurately understand the performance and behavior of products, thereby optimizing design solutions. Through the metaverse, we can simulate the entire production process, predict and optimize the performance of production lines. In addition, the metaverse can also be used to train employees, predict potential problems, and take maintenance measures in advance, reducing equipment downtime and production costs. The metaverse can provide a transparent supply chain view, from raw material procurement to product delivery, all links can be simulated and tracked. The development of the metaverse will also focus on sustainability and environmental protection. For example, conducting simulation experiments through the metaverse can reduce the use of physical prototypes, thereby reducing resource consumption and environmental pollution. With the increasing importance of data in the metaverse, data security and privacy protection will become the focus of attention. We will need to develop new policies and standards to ensure the reliability and security of data. However, the traditional generation methods of metaverse scenes often have problems such as low efficiency and uneven quality, which are difficult to meet the growing market demand. And its applications have occupied an important position in the field of architecture. For beginners in computational design, CAD provides a platform for them to better understand and implement architectural design concepts. Chen et al. [2] explored architectural design and implement them in computer-aided design and applications. The empowerment algorithm is an autonomous learning algorithm that can self-learning and optimize based on input data. In architectural design, empowerment algorithms can assist designers in optimizing designs and providing better design solutions.

For example, empowerment algorithms can be used to optimize the spatial layout, structural form, material selection, etc. of buildings to achieve the best functional and aesthetic effects. The empowerment algorithm will play a greater role in it, not only assisting designers in building design, but also providing intelligent solutions in the operation and maintenance of buildings. For example, using empowerment algorithms to optimize the energy consumption of buildings to achieve the goal. Therefore, how to generate and optimize the metaverse scene quickly and accurately. Under this background, this article studies and explores the possibility of applying AI and CAD to the generation and optimization of metacosmic scenes. Based on the progress of information technology, AI and CAD have become indispensable technical tools in today's era. Which shifted from a purely sci-fi concept to a practical tool in the real world. Especially with the support of network technology and virtual reality technology, network-based metaverse platforms are changing the way we interact with the virtual world. As a technologically advanced country, South Korea has a unique understanding and practice of the application and development of the metaverse. Especially in its unique geographical environment and political background, building a network based metaverse platform can unleash enormous potential. Choi et al. [3] explored how to construct the Korean DMZ (Non Military Zone) metaverse using a network-based metaverse platform. DMZ is a special region in South Korea, located in the central part of the Korean Peninsula, separating North and South Korea. Although DMZ is a military isolation zone, it is also a special area of international concern with profound cultural, historical, and political significance. Therefore, the construction of the Korean DMZ metaverse has profound impact and broad application prospects. Virtual reality technology is the key to achieving immersive experience in the metaverse, which requires advanced VR hardware and software to achieve. Artificial intelligence technology can help metaverse platforms achieve automation and intelligence, such as automatic navigation and intelligent interaction. With the development of technology, digital twin technology is changing the way we live and work. In clothing design, creating a 3D reconstructed clothing model is a complex process. Designers need to first create a physical prototype and then use various tools and techniques to digitize and reconstruct it. This process requires a lot of manual operation and adjustment, and often requires professional skills and experience. Digital twin technology can greatly simplify this process. By using digital twin technology, designers can directly create digital clothing models on computers without the need to first create physical prototypes. This not only saves a lot of time and cost, but also avoids the errors and inconveniences that may arise from making physical prototypes. Achieving end-to-end mobile visualization, thereby improving design efficiency, reducing costs, and optimizing product development processes. Doungtap et al. [4] explore the digital twin technology of 3D reconstructed clothing. Digital twin technology is a data-based approach that transforms information from the physical world into virtual models through simulation, inference, and other technologies. In the clothing industry, digital twin technology can be used to create design models, manufacturing process models, human models, etc. of clothing, achieving full lifecycle management of clothing. A new method has been proposed that combines AI and CAD technology to automate and optimize the generation of metaverse scenes. The main idea is to use CNN to identify and optimize key elements in 3D VR scenes. Here, we use CNN to learn and identify key elements in VR scenes, aiming at achieving high-quality and efficient metacosmic scene generation and optimization, and injecting new vitality into the growth of virtual reality (VR), augmented reality (AR) and other fields.

At present, scholars at home and abroad have made some research achievements in the generation and optimization of metacosmic scenes. Zhang et al. successfully realized high-quality 3D scene generation by using Generative Countermeasure Network (GAN). With the development of technology, robot technology is changing the way we live and work. Robots can perform various tasks, from simple repetitive tasks to complex tasks such as exploring unknown environments and performing fine operations. In the field of the metaverse, the metaverse is a virtual and immersive digital world that requires a large amount of data and information to construct its environment. Robot-based physical grounding metaverse applications can obtain this information through, providing a richer and more realistic environment for the metaverse. Gonzalez et al. [5] explored techniques for robot based physical grounding element universe applications. Techniques for obtaining environmental information. By using high-resolution LiDAR, robots can obtain detailed information about the environment, including the position, shape, size, etc. of objects. This information can be used to construct three-dimensional models, providing a more realistic environment for the metaverse. Meanwhile, through uniform coverage technology, robots can obtain more comprehensive environmental information, thereby providing richer content for the metaverse. With the acceleration of digital transformation, the industrial sector is facing unprecedented challenges and opportunities. Aiming to enhance the interoperability of industrial design and engineering applications. Jaimini et al. [6] introduce relevant research progress and practical experience. The Industrial Metaverse Knowledge Graph is a tool for representing industrial domain knowledge and relationships in a graphical manner. The data in design and engineering applications not only needs to describe basic attributes, but also needs to express more complex semantic information, such as design intent, manufacturing processes, etc. Therefore, it is necessary to use technologies such as natural language processing and machine learning to semantically process data. By utilizing artificial intelligence and big data analysis technology, intelligent recommendation solutions can be provided to designers based on different design needs and engineering conditions, while providing data-driven decision support for decision-makers. Although this method is effective, its computational complexity is high. These research results show the research status and development trend of metacosmic scene generation and optimization, and also provide valuable theoretical support and technical reference for this study. However, these methods have more or less problems in dealing with large-scale scenes, such as large consumption of computing resources and long training time. In addition, in the aspect of scene optimization, traditional optimization algorithms often fall into local optimal solutions, and it is difficult to obtain global optimal results. Therefore, how to achieve efficient and high-quality metaverse scene generation and optimization is still a challenging research problem.

On the basis of in-depth study of related achievements at home and abroad, this article puts forward an optimization algorithm of VR 3D scene based on CNN. The algorithm combines AI and CAD technology, and studies the preprocessing of scene data, feature detection and optimization algorithm design. Aiming at the problems of noise and redundancy in the original scene data, an effective data preprocessing method is studied to improve the data quality. Using CNN's powerful feature detection ability, the depth feature of preprocessed scene data is extracted. By designing an appropriate network structure, effective scene features are extracted. Aiming at the local optimal solution of traditional optimization algorithm, this article designs an optimization algorithm based on CNN. The algorithm makes full use of the extracted scene features and combines the global optimization strategy to achieve high-quality and efficient metaverse scene optimization.

Through this study, it is expected that the following achievements and innovations can be achieved:

(a) AI and CAD technologies are applied to the generation and optimization of metacosmic scenes. This interdisciplinary research method provides a new solution and implementation tool for the generation and optimization of metacosmic scenes.

(b) Traditional methods for generating and optimizing metacosmic scenes often have high computational complexity and poor results. The optimization algorithm based on CNN proposed in this article can make full use of the feature detection ability of neural network and improve the efficiency of scene generation.

(c) In the aspect of optimization algorithm design, this article not only pays attention to local details, but also puts forward a global optimization strategy, which avoids the local optimal solution problem that traditional optimization algorithms are easy to fall into, and is helpful to realize the global optimal metaverse scene generation effect.

Firstly, this article introduces the concept and importance of metaverse, and reviews the research results in the field of metaverse scene generation and optimization at home and abroad. Then, the algorithm of metaverse scene generation and optimization based on AI and CAD is described, including key technologies and methods such as image recognition and processing, global information feature description, scene generation and optimization. In the experiment and analysis part, the detailed experimental verification and performance analysis of this algorithm are carried out. Finally, in the conclusion part, the research work and achievements of this article are summarized, and the possible research directions and challenges in the future are also put forward, which provides reference for the further growth of the field of metacosmic scene generation and optimization.

2 RELATED THEORETICAL BASIS

With the rapid development of artificial intelligence and virtual reality technology, we are exploring a new way to simulate agents in 3D virtual environments. This technology allows us to create highly intelligent and interactive virtual entities to perform a series of complex tasks. Kaur et al. [7] delved into the current situation, challenges, and future development trends of this simulation proxy platform. These platforms use 3D modeling tools such as Blender or Maya to create virtual models of proxies. Then use animation tools such as Adobe After Effects or Unity's Animator to give these models life. OpenAI's GPT-3 model is used to create an intelligent agent that can understand and generate human language. Virtual agents in the physical world. For example, Magic Leap One and HoloLens both support AR, allowing users to see and interact with virtual agents. Simulation agents require a large amount of personal data for personalization. However, this has raised serious privacy issues. Users may be concerned about how their data is used and stored. Due to the high intelligence of simulation agents, they may also become targets of malicious software. If a simulated proxy is controlled by malicious attackers, they may use the proxy for illegal activities. In architectural conceptual design, topology algorithms are an important tool that can help designers effectively optimize and evaluate designs in the early stages. Topological algorithms can simplify complex architectural forms into a set of abstract geometric elements, such as points, lines, surfaces, etc., making it convenient for formal analysis and optimization. However, manually designing and applying topology algorithms is often a complex and time-consuming task, making it necessary to develop an application algorithm framework to automate this process. By constructing and applying a topology algorithm framework, Lin [8] effectively simplifies complex architectural forms into basic geometric elements, and conducts in-depth analysis and optimization on them. Improves the efficiency and accuracy of the design. In addition, optimizing through automation can reduce the workload of designers and enable them to invest more energy in innovative and creative design. In the future, we hope to further develop and improve the topology algorithm framework to better adapt to various complex architectural design and engineering needs. At the same time, we also look forward to working closely with designers and engineers, we are entering a brand new digital era, namely the era of the metaverse. The metaverse, a futuristic concept, is essentially a virtual and immersive digital world. In this world, the physical rules and phenomena of the real world are simulated and presented in a completely new way. Building Information Modeling (BIM), as one of the core technologies of the metaverse, is playing an increasingly important role.

Liu et al. [9] using VR and AR, we can conduct detailed visualization and interactive exploration of building models during the design phase. This not only helps designers better understand their designs, but also enables them to identify and solve problems earlier. Based on a three-dimensional model. In the context of the metaverse, the importance of BIM has become even more prominent. Firstly, as a virtual digital world, the metaverse requires a large number of three-dimensional models to construct its environment. BIM can provide these models and ensure their accuracy and reliability. Secondly, the metaverse requires a highly immersive experience, and BIM can improve the fidelity of the model by integrating various information such as materials, lighting, textures, etc., thereby providing a more immersive experience. Digital twins and the metaverse have become important issues in urban planning and development. These two technologies have brought unprecedented possibilities to cities, from simulating and predicting their operational status to providing a new immersive experience, both bringing revolutionary changes to the city. Lv et al. [10] explored the history, current status, and application prospects of digital twins and metaverse in urban planning and development. Which can simulate the lifecycle process of a product or system. Through the digital twin model, urban planners can simulate different planning schemes, predict their potential impacts, and develop more reasonable and sustainable planning. Digital twins can simulate urban traffic conditions, provide real-time data and predictions for traffic management, and help improve traffic efficiency and reduce congestion. The metaverse can provide a brand-new immersive experience, allowing citizens and tourists to deeply experience the environment and culture of a city, enhancing its attractiveness. The metaverse can achieve real-time interaction between people in different locations, promoting cross regional collaboration and communication. Digital twins and the metaverse are not isolated technologies, they can be combined to play a greater role. CAD has become an important tool in the construction industry. Among them, Auto CAD is deeply loved by designers and students due to its powerful functions and popularity. Especially in network architecture teaching systems, the application of Auto CAD is indispensable. The network architecture teaching system is a platform that utilizes network technology to provide architecture education. It can enable students to learn architectural knowledge through intuitive and interactive means, improving learning efficiency. At the same time, the online architecture teaching system can also simulate real architectural environments, allowing students to better understand and master architectural knowledge. Auto CAD can accurately annotate the dimensions of graphics, allowing students to better understand the dimensions and proportions of buildings.

In addition, Auto CAD also supports multiple units, such as millimeters, centimeters, meters, etc., which can be selected according to needs. Auto CAD supports 3D modeling [11]. Near space chemical kinetics modeling is an important tool for studying chemical reaction processes, which can reveal the mechanisms and rates of reactions. It is of great significance for understanding chemical processes, optimizing chemical reaction conditions, and developing new chemical technologies. However, traditional experimental methods are often subject to various limitations, such as the uncertainty of experimental conditions and the high cost of testing. Therefore, computer-aided near-space chemical kinetic modeling has emerged, which can overcome these limitations through simulation and prediction. Sicong et al. [12] simulated and predicted the process and results of chemical reactions by establishing mathematical models. It covers various methods from molecular orbital theory to statistical dynamics models, and can consider the effects of various factors such as temperature, pressure, concentration, etc. on the reaction. Computer assisted near space chemical kinetic modeling has been widely applied in various chemical research fields. For example, it can be used to study the activity of catalysts, predict their performance, optimize reaction conditions, and even design new chemical reactions and materials. In addition, it can also be used in the field of environmental science, such as simulating atmospheric chemical reaction processes, predicting the formation and diffusion of air pollutants, etc. To experience a virtual world completely different from the real world through advanced graphics and interactive technologies. The application of point cloud data plays an important role in the metaverse. Point cloud data is a collection of a large number of three-dimensional coordinate points that can be used to represent. In the metaverse, point cloud data can be used for applications such as modeling, scene rendering, object recognition, and interaction. Sun et al. [13] introduced the basic methods and related technologies of point cloud analysis in the metaverse.

In the metaverse, the collection and processing of point cloud data is the first step. There are various methods for collecting point cloud data, including laser scanning, photogrammetry, and depth cameras. The collected point cloud data usually requires preprocessing, including removing noise, filtering invalid points, and optimizing data structure. In addition, it is necessary to segment and classify point cloud data, separate different objects, and extract objects of interest. Among them, computer-aided design (CAD) and digital technology architecture. However, in addition to basic drawing and modeling functions, computer-aided design has a more profound impact, which is the digital archiving of architectural spatial perception experiences. Tai and Sung [14] analyzed that the perceived experience of architectural space refers to people's understanding and perception of architectural space. This understanding not only comes from the appearance and structure of buildings, but also includes multiple aspects such as spatial sound, light, temperature, humidity, and odor. At the same time, perceptual experience is also influenced by various factors such as people's mood, experiences, and cultural background. Therefore, Due to the complexity of the perception experience of architectural space, it is particularly important to record and archive it. The traditional recording methods mainly include textual descriptions and photo shoots, but these methods cannot comprehensively record. In the metaverse, people can interact, communicate, explore, and create. This environment provides new possibilities for building information modeling. By combining the immersive experience of the metaverse with BIM, we can better understand and visualize architectural projects. Fluid mechanical pumps and fans, these two technologies also demonstrate enormous potential. Digital twins can simulate and predict the working status of devices, while the metaverse can provide an immersive environment for more efficient operation and maintenance. In this context, sensors play a crucial role in the implementation of these technologies. Yang et al. [15] explored the importance of sensors. By constructing a digital twin model, designers can design and optimize new fluid mechanical pumps and fans in a virtual environment, reducing manufacturing costs and shortening development cycles. Through real-time data collection and analysis, digital twin models can predict potential faults of fluid mechanical pumps and fans, thereby taking maintenance measures in advance and improving the reliability and service life of equipment. The digital twin model can also be used to simulate real operating environments, providing staff with an immersive operating experience and improving training effectiveness. The metaverse refers to a virtual and immersive digital world in which socializing, entertainment, education, etc. In the metaverse, accurate representation of object geometry is one of the key factors in achieving realism and interactivity. The transformation is an effective method that can achieve efficient shape representation and interaction in the metaverse. Yao et al. [16] explored the application of object geometry representation based on axis transformation in the metaverse. The central axis transformation is a widely used shape representation method in the fields of computer graphics and robotics. Its basic idea is to represent the shape of an object as its central axis around its center of mass, and to represent the outline of the object through points on the central axis. The central axis transformation can be calculated and applied through various algorithms, such as parameterization, approximation, optimization, etc. In the metaverse, the axis transformation can be used to create efficient object shape representations, enabling faster rendering and interaction.

3 METAVERSE SCENE GENERATION AND OPTIMIZATION ALGORITHM

AI, especially machine learning, provides researchers with a method for automatic learning and improvement from data. This method avoids traditional hard coding methods and allows the system to self-adjust based on new data. In the generation of metaverse scenes, AI can learn and understand user needs and preferences, thereby generating customized scenes for users. The theories of reinforcement learning and DL provide strategies and methods at different levels for scene generation and optimization. CAD not only helps designers create, modify, and optimize designs more efficiently, but also ensures the accuracy and quality of the design. In the generation of metaverse scenes, CAD tools can help designers quickly model, render, and adjust objects in the scene, ensuring that they are consistent with physical rules in the real world. In addition, the research on CAD in parametric design, simulation, and other aspects also provides strong technical support for the generation of metaverse scenes. CNN is an important branch of DL, particularly suitable for processing visual data such as images and videos. These hierarchical structures enable CNN to automatically extract and abstract high-level features of data. In the generation of metaverse scenes, using CNN for feature detection and classification can greatly improve the accuracy of scene recognition, thereby optimizing the generation effect of scenes. At the same time, CNN's transfer learning ability also allows us to borrow pre trained models on other tasks, thereby accelerating model training and improving model performance. The generation of metaverse scenes is a comprehensive process that involves the combination of multiple steps and technologies. Based on AI and big data technology, it is possible to analyze user behavior, preferences, and interaction patterns, providing a customized foundation for scene generation. By utilizing CAD technology, it is possible to quickly model and layout the scene, including modeling multiple elements such as terrain, architecture, vegetation, lighting, etc. Based on CNN feature detection, the visual effects of the scene can be analyzed, such as lighting distribution, texture details, etc., and targeted optimization can be carried out to ensure visual realism and smoothness. Based on user behavior and interaction data, AI can learn and optimize the interaction elements in the scene, making it more natural and intuitive. Through algorithm optimization and reasonable resource management, the efficiency and stability of the scenario at runtime can be ensured.

The generation and optimization of metaverse scenes, as the core of metaverse technology, are directly related to the realism and immersion of user experience. In order to solve the local optimal solution problem in the generation of metaverse scenes using traditional optimization algorithms, this section proposes a CNN based metaverse scene generation and optimization algorithm. This algorithm combines the powerful feature detection ability of DL with global optimization strategies to present users with a more realistic and delicate virtual world. In the metaverse, scenes are typically composed of a large quantity of 3D models, lighting, textures, etc. Firstly, it is needed to convert these scene elements into a format suitable for CNN processing, typically one or more two-dimensional images. For 3D models, multiple perspectives can be used for projection to obtain multiple views of the model. According to the characteristics of the metaverse scene, it is needed to select a suitable CNN model for feature detection. To ensure that the model can capture advanced features of the scene, the model is pre trained on a large image dataset. By using a trained CNN model, rich features of scene images can be extracted. These features include but are not limited to edges, corners, textures, etc. They provide valuable information for subsequent optimization algorithms.

In the fields of computer vision and DL, feature description is a crucial aspect, especially in the generation and optimization of metaverse scenes. Traditional feature description methods often focus on local details of images, however, in complex metaverse scenes, global information is equally important. In the metaverse scene, global information can capture the overall layout, color distribution, lighting trends, etc. of the scene. This global information provides context and background for the scene, which is crucial for accurately understanding and describing the scene. The content of feature representation based on global information is shown in Figure 1.

The feature description method in this article first uses the pre-trained CNN model to extract the primary features of the scene. Then, the global pooling operation is introduced to obtain the global feature description. This global feature describes the overall attributes and statistical information of the scene. In order to further enhance the ability of global feature description, context embedding technology is introduced into the study. This method combines global features with local features to ensure that global information is fully utilized in the subsequent optimization and generation process.

Collect various metacosmic scene data sets and make necessary preprocessing to meet the input requirements of CNN model. Using the pre-trained CNN model, feature detection is carried out on the scene data of the meta-universe, and rich scene feature information is obtained.

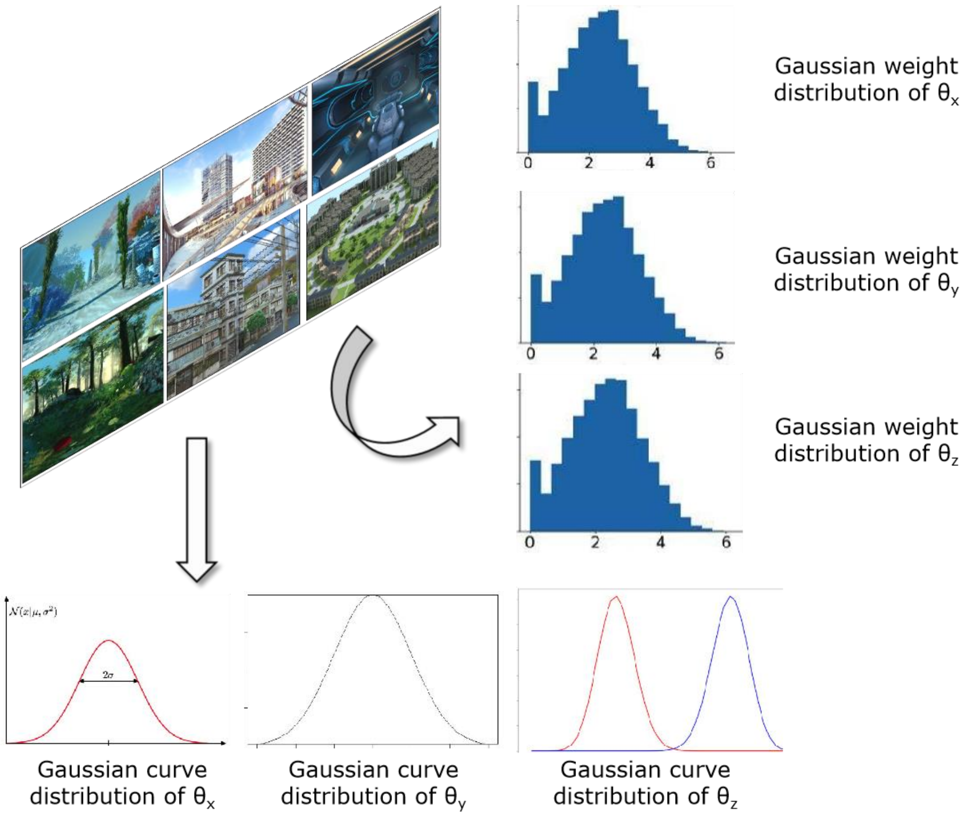

Figure 1: Feature description algorithm based on global information.

According to the extracted features and the defined objective function, the global optimization algorithm is used for multiple rounds of search and optimization, and the optimized metaverse scene configuration is generated. The optimization of metaverse scene involves many aspects, including object placement, illumination adjustment, texture optimization and so on. We can design a unified framework and optimize multiple tasks at the same time by multi-task learning. This can share the feature detection network and improve the performance of the algorithm.

$$N = \frac{\sum n_k a_k}{\sum a_k} \tag{1}$$

$$n = \frac{N}{|N|} \tag{2}$$

$$x = \frac{\sum x_k a_k}{\sum a_k} \tag{3}$$

$$d\ \ P,TM\ \ = \min\ d\ \ P,X \tag{4}$$

$$n_i \quad i = 1,2,3,\ldots,k \tag{5}$$

$$n_p = \frac{1}{k}\sum_{i=1}^{k} n_i \tag{6}$$

The structure of a CNN based scene image recognition network typically consists of multiple layers that collaborate to extract meaningful features from input images and ultimately perform scene classification. The first layer of the network is the input layer, which receives the original image data. These data can be RGB images or preprocessed images. Convolutional layers are the core part of CNN, responsible for extracting features from input images. The convolutional layer contains multiple convolutional kernels, each of which can learn and extract a specific feature, such as edges, corners, etc. By sliding the convolution kernel and performing convolution operations at each position, the network can generate a feature map that reveals which features exist in the input image.

After the convolution operation, it usually follows an activation function layer, such as ReLU (linear rectification function). The function of the activation function is to increase the nonlinearity of the network, enabling it to learn and represent more complex features. The role of the fully connected layer is to integrate all previously extracted features and classify the final scene based on these features. Figure 2 is a schematic diagram of the scene image recognition network structure based on CNN.

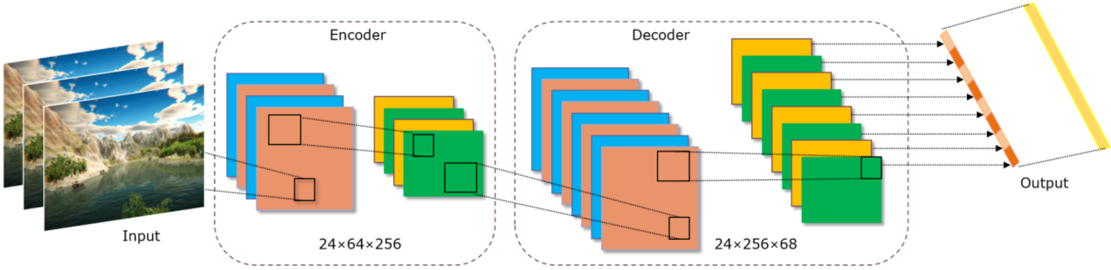

Figure 2: Network structure of scene image recognition based on CNN.

$$Y = \left(\frac{L}{f} - 1\right) Nd \tag{7}$$

$$R = \quad x, y, z \ \left| x^2 + y^2 + z^2 = \varepsilon^2 \right. \tag{8}$$

Firstly, the statistical distribution of discontinuous values of two consecutive frames in a shot is calculated, and then the Gaussian function with parameter μ, δ is used for modeling:

$$T = \mu + \gamma * \delta \tag{9}$$

Among them, γ is an important parameter related to the accuracy of detection performance.

In the case of two kinds of problems, the training errors of the final classifier trained by Adaboost algorithm are:

$$\prod_{t=1}^{T} \left[2\sqrt{\varepsilon_t \ 1 - \varepsilon_t} \right] = \prod_{t=1}^{T} \sqrt{1 - 4\gamma_t^2} \leq \exp\left(-2 \sum_t \gamma_t^2 \right) \tag{10}$$

Where $\gamma_t = 0.5\text{-}\varepsilon_t$ indicates the degree to which weak classifier h_t is better than random guess.

The similarity of samples is approximately measured by calculating the quantity of pixels shared by corresponding positions in histograms of different samples:

$$D \ f_k, f_{k+1} = \frac{\sum_{i=0}^{n-1} \min\left[H_{f_k} \ i, H_{f_{k+1}} \ i \right]}{\sum_{i=0}^{n-1} H_{f_k} \ i} \tag{11}$$

Where n represents the quantity of gray levels of the histogram, $H_{f_k}(i)$ represents the quantity of pixels of the kth frame on the ith gray level, and $\min\left[H_{f_k}(i), H_{f_{k+1}}(i)\right]$ represents the quantity of pixels shared by the two histograms. $D(f_k, f_{k+1}) \in [0,1]$, the closer the ratio is to 1, the more similar the two pictures are.

The purpose of image segmentation is to segment scene images into different regions or objects. In the generation and optimization of scenes in the metaverse, scene image segmentation plays a key role, helping to more accurately understand and operate various components of the scene. Before image segmentation, it is needed to preprocess the original scene image. This includes normalization of image size, conversion of color space, and removal of noise. The purpose of preprocessing is to make the image more suitable for subsequent neural network processing. In the encoder, convolutional layers and down-sampling layers are used to gradually extract image features and reduce the size of the feature map. The basic stage of the segmentation scheme in this article is shown in Figure 3.

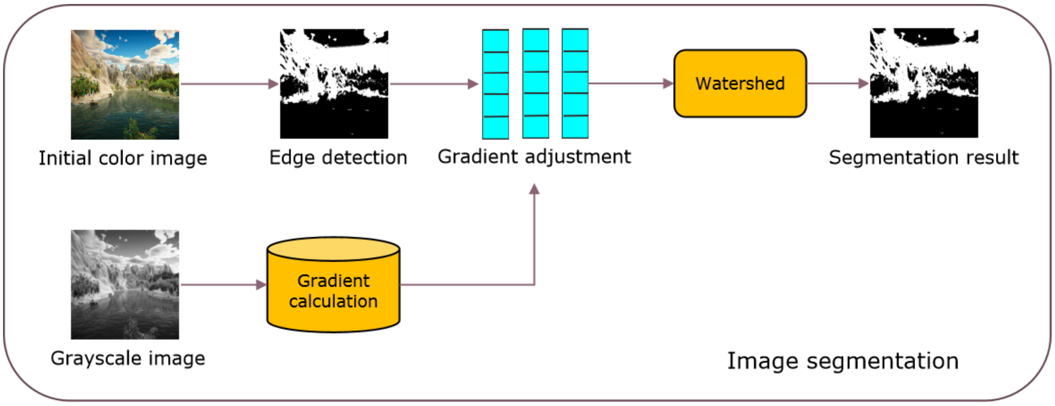

Figure 3: Basic stage of segmentation scheme.

In the stage of generating and optimizing metaverse scenes, user feedback is crucial. A user feedback loop can be established to incorporate user feedback and opinions into the optimization objective function, in order to better meet user needs and expectations. By continuously collecting and utilizing user feedback, the optimization effect and user experience of the algorithm can be further improved.

4 RESULT ANALYSIS AND DISCUSSION

This study used a large metaverse scene dataset for experiments. This dataset contains various types of metaverse scenes, including urban landscapes, natural landscapes, indoor environments, etc. Each scene provides high-quality images and corresponding annotation information for training and testing the performance of algorithms. The results show that under the same computing resources, the algorithm proposed in this article can achieve better optimization results and avoid the problem of local optima.

The CNN based scene generation and optimization algorithm used in this article may be more efficient, ensuring performance while reducing system response time. By utilizing global information, the system can better understand user needs and provide more appropriate and natural interactive feedback. From the interactivity scoring results in Table 1 and Figure 4, it can be seen that the metaverse interaction system constructed in this article is significantly superior to the virtual system constructed using traditional methods in terms of interactivity. This result proves the effectiveness of our method in improving user experience and interactivity.

Sample set	*This system*	*Ref [12]*
100	80.96	78.32
200	76.82	68.59
300	89.55	78.72
400	75.35	66.22
500	76.28	70.64
600	93.36	80.34
700	96.77	86.68
100	80.47	78.5

Table 1: System interactivity rating.

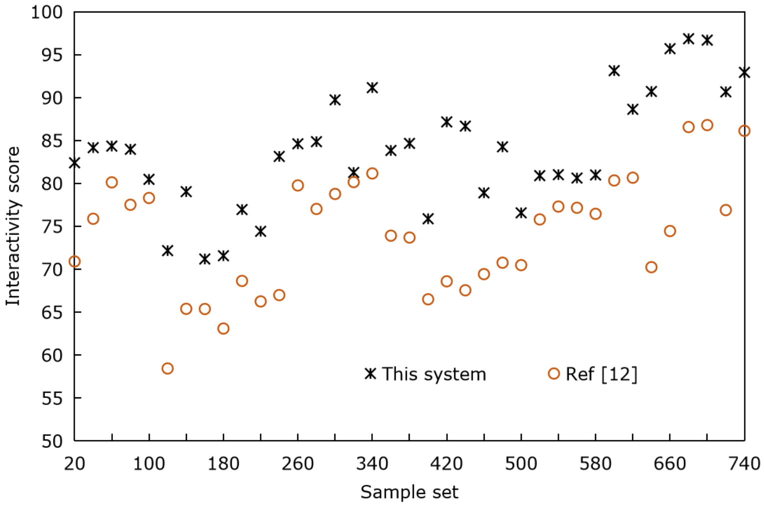

Figure 4: System interactivity rating.

Virtual systems built using traditional methods often face the problem of limited interactivity. This is caused by issues such as rigid user interface design, unnatural operating methods, or delayed system response. The metaverse interaction system constructed in this article improves the overall performance of the system by optimizing scene generation and algorithms, making interactions smoother and more natural. In addition, this study emphasizes the importance of global information in scene generation and optimization, which also helps to enhance the interactive experience between users and the system.

From Figure 5, it can be observed that the training loss of the metaverse scene generation algorithm converges rapidly during the training process. This means that the algorithm quickly learns the inherent laws and patterns of the data during the training process, and can predict new input data with lower errors. Below, we will analyze this result in detail.

A high-quality and diverse dataset plays a crucial role in fast convergence of training losses. If the dataset can fully represent various situations and features of the metaverse scene, then the algorithm can learn and converge faster. The CNN based scene generation algorithm used in this article may have a good model structure, which enables the model to efficiently learn the features of the data. Fast convergence means that the algorithm can learn the key features required to generate metaverse scenes faster. In this way, when generating new scenes, the algorithm can generate scene images that meet the requirements more accurately and efficiently. This has important value for quickly generating high-quality metaverse scenes in practical applications.

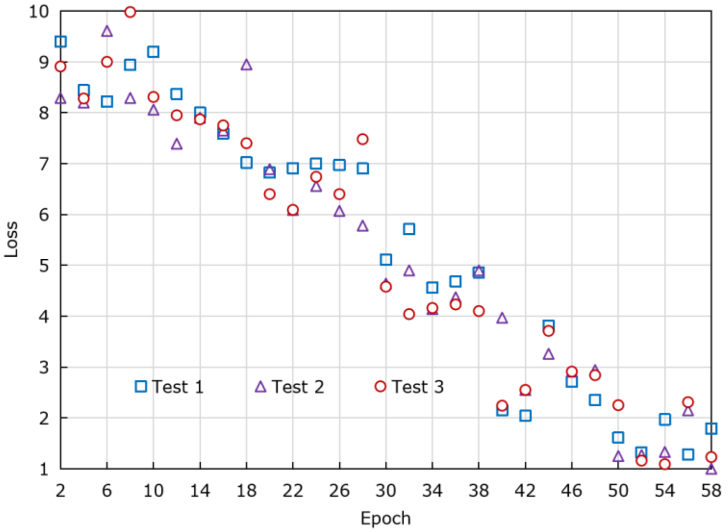

Figure 5: Training situation of the algorithm.

The modeling accuracy directly reflects the algorithm's ability to fit data and its degree of approximation to the real world. High modeling accuracy means that algorithms can more accurately capture the inherent laws and patterns of data, and generate results that are closer to the real situation. Table 2 and Figure 6 show the modeling accuracy of the proposed metaverse scene generation algorithm compared to other comparative algorithms. From the figure, it can be clearly seen that the modeling accuracy of the method proposed in this article is significantly higher than that of the comparison algorithm, reaching over 95%. This result proves the superiority and effectiveness of the proposed algorithm in terms of modeling ability.

Iterations	*Proposed method*	*BPNN*
40	93.55	80.36
80	92.37	85.3
120	90.88	78.73
160	90.11	80.17
200	92.99	82.31
240	94.88	77.77
280	81.11	92.26

Table 2: Accuracy comparison of algorithms.

Figure 7 shows the comparison of the quantity of wrong pixels per frame between the metaverse scene generation algorithm and other methods. This means that the algorithm in this article has higher accuracy in pixel-level details and can generate images closer to the real scene.

The quantity of wrong pixels is an important index to evaluate the accuracy of image segmentation. It reflects the difference between the image generated by the algorithm and the real image at the pixel level. A lower error pixel number representation algorithm can restore the details and contours of the real scene more accurately. This algorithm may pay more attention to the preservation and restoration of details in the stage of scene generation. By effectively capturing and utilizing global information, the algorithm can generate more detailed and realistic scene images and reduce the occurrence of wrong pixel numbers.

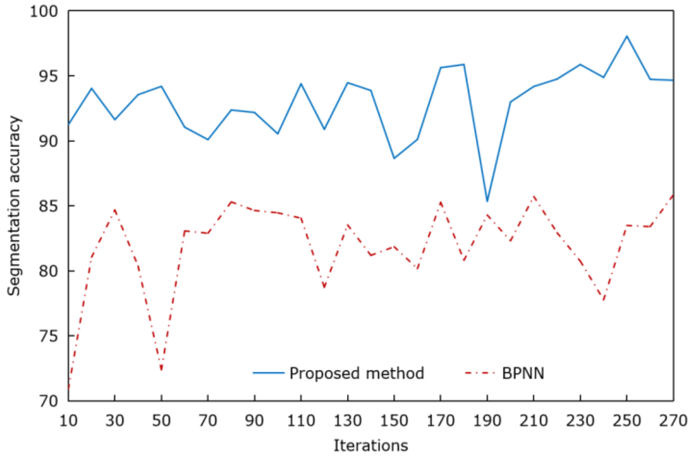

Figure 6: Accuracy comparison of algorithms.

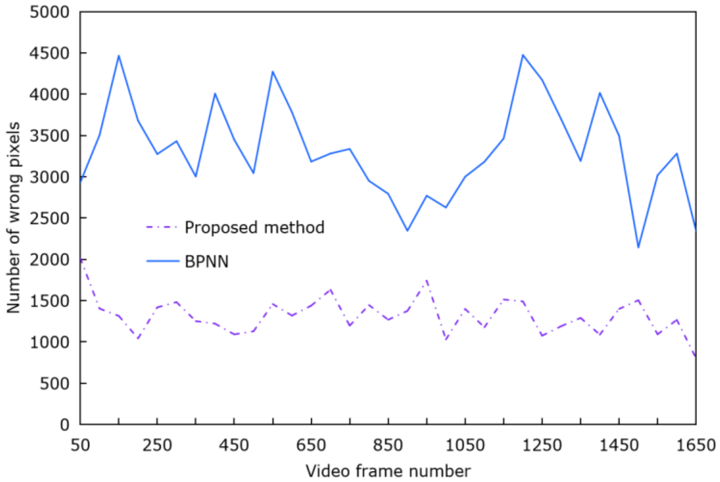

Figure 7: Comparison of the quantity of wrong pixels per frame.

In the application scenario of metaverse, accurate image segmentation and detail restoration are very important to provide immersive user experience. The superior performance of this algorithm on most video frames means that it can generate more realistic and delicate scenes, reduce users' visual discomfort and illusion, and improve the overall quality of user experience. The algorithm is expected to solve the problems of low efficiency and uneven quality existing in traditional methods, and realize high-quality and high-efficiency metaverse scene generation and optimization.

5 CONCLUSIONS

As an important part of the meta-universe, the generation and optimization of meta-universe scene is of great significance for improving user experience and expanding application fields. The aim is to achieve high-quality and efficient metaverse scene generation and optimization. In scene image recognition, feature description based on global information improves the accuracy of recognition and makes the algorithm more efficient and reliable. In the aspect of scene image segmentation, through comparative experiments, the segmentation scheme proposed in this article is more accurate and can effectively distinguish the various components in the scene. The metaverse scene generation algorithm in this article realizes high-quality and efficient scene generation, optimizes the user experience, enhances the interactivity of the system, and provides strong technical support for the development and application of the metaverse.

The algorithm uses the scene features extracted by CNN and combines the global optimization strategy to generate high-quality and efficient metacosmic scenes. The algorithm solves the local optimal solution problem in the traditional optimization algorithm, and searches and optimizes the scene configuration in the global scope, thus improving the realism and immersion of the metaverse scene. Future research work will continue to explore the optimization and improvement direction of the algorithm, including multi-task learning, combining with GAN, user feedback loop and more global optimization strategy, so as to further promote the growth of metacosmic scene generation and optimization technology.

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