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Computer Aided Interactive Design of Optimal Interpolation Curve

Qingnan Ji[1], Lu Liu[2], Jinxia Wang[3] and Juan Du[4,*]

[1]Department of Art and Design, Shaanxi Fashion Engineering University, Xi'an 710000, China, n240321@126.com.cn
[2]Department of Art and Design, Shaanxi Fashion Engineering University, Xi'an 710000, China, l826591@126.com
[3]Department of Art and Design, Shaanxi Fashion Engineering University, Xi'an 710000, China, W15202422172@126.com
[4]Department of Sports, Chongqing Jiaotong University, Chongqing 400074, China, dujuan@stu.hunau.edu.cn

Corresponding author: Juan Du, dujuan@stu.hunau.edu.cn

Abstract. In many designs, it is need to interact with three-dimensional images. However, under the processing of the original three-dimensional image interaction system, the image interaction effect is poor, which can't meet the requirements of industry standards. The application of virtual reality (VR) can carry out visual simulation and make people form a good sensory experience, which is the most important choice in engineering design and image simulation. In this article, a computer-aided design (CAD) interactive design strategy based on the best interpolation curve is proposed. Deep learning technology is used to assist VR 3D image modeling, and the proposed VR 3D image modeling algorithm is used for image recognition. The simulation results show that compared with the support vector machine (SVM) algorithm, the VR image modeling method proposed in this article has the highest accuracy improvement of 25.76%, and can effectively solve the problems of unclear and insufficient stereo images. After the test, the system has a high definition of image recognition, and can accurately recognize and process images interactively. Therefore, in the process of interactive processing of 3D images, it is suggested that the 3D image interactive system should be designed reasonably according to the application characteristics and conditions of VR, so as to improve the design effect of the system and promote the good recognition and interactive processing of 3D images.

Keywords: Computer Aided Design; Virtual Reality; Three-Dimensional Modeling; Interpolation Curve.
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1 INTRODUCTION

With the integration of computer technology and many disciplines, 3D modeling technology has been applied and developed, and has been gradually praised by all circles. At the early stage of the development of 3D modeling technology, CAD can perform corresponding simple drawing operations, but can't perform in-depth model design [1]. The arrival of the 3D world is driving another technological revolution, the competition between enterprises and the market is becoming fiercer and fiercer, and the design of product models also brings greater pressure, so the design of product models needs higher requirements to meet the needs of customers [2]. Although the traditional CAD manufacturing system has high machining accuracy, it is difficult to meet the requirements of fast and flexible machining because it has to carry out CAD design first and then process according to the design data. Therefore, people are urged to study automatic machining technology based on rapid detection technology. With the continuous improvement of modeling technology and the deepening of CAD, three-dimensional information of entities can be obtained and processed step by step. For the design process of an entity, it usually takes a lot of reasoning to finally make a design decision. The application of VR can carry out visual simulation and make people form a good sensory experience, which is the most important choice in engineering design and image simulation. The difference between using computer to solve engineering problems and conventional manual calculation lies in its special calculation method. When the computer is used to complete the modeling of VR 3D images, numerical interpolation can be used to achieve high accuracy [3].

In many designs, it is need to interact with three-dimensional images. However, under the processing of the original three-dimensional image interaction system, the image interaction effect is poor, which can't meet the requirements of industry standards. VR is an advanced practical technology at present, and it is a three-dimensional environmental technology that integrates computer technology, simulation technology and electronic information technology. It uses three-dimensional models to display three-dimensional images that the human body cannot perceive, and through interactive processing of three-dimensional images, it can effectively identify images. As for the solid design of 3D modeling, the current software can carry out the overall design of 3D modeling, but it doesn't take into account the efficiency of sketch drawing, and the acquisition of sketch is also the basic part of 3D geometric modeling [4]. As the traditional VR 3D image interaction system has some problems in the application process, such as low image interaction effect and failing to meet the industry standard, it is difficult to ensure the good application and development of the system. It is need to upgrade and optimize the system hardware comprehensively based on the traditional system, and use modern instruments and equipment to enhance the resolution in the image recognition process. In this article, a CAD interactive design strategy based on the best interpolation curve is proposed, and the deep learning technology is used to assist VR 3D image modeling, so as to build a VR design 3D image interactive system [5].

This research puts forward the strategy of CAD interactive design of VR 3D images, and its main innovations and contributions are as follows:

(1) This article combines the best interpolation curve and deep learning technology to improve the three-dimensional interaction effect, innovate the system function, and solve the problem of poor image recognition effect caused by inaccurate algorithm calculation results.

(2) The model adopts CAD technology to determine the plane feature vector, and then builds the physical image model through the determined feature vector. Based on the model, the script is written to realize the 3D interaction based on VR.

2 RELATED WORK

CAD models are not only widely available, but also very useful in the growing field of manufacturing-oriented design, because they capture the design intent of engineers, including

manufacturability, through structural parameterization. Schulz et al. [6] developed tools that allow interactive exploration and optimization of parametric CAD data. In order to achieve the interaction rate, we use precomputation on the adaptive sampling grid and propose a new interpolation scheme, in which each sample is a grid with different combinations. It shows an example of how to use our method to interactively visualize and optimize objects with various physical properties. Tzevelekis et al. [7] proposed a new method to realize the automation of the geometric structure design and manufacturing process of impeller profile by using CAD/CAM technology. To this end, a newly developed application is built; Develop application programming interface objects for parametric instances to automate time-consuming and repetitive tasks for preparing 3D models and their direct manufacturing processes. In the first step of the application, the entire 3D model of the impeller type model is automatically generated from the interface based on the variable value as a user-defined entity. The modern paradigm of designing complex engineering systems focuses on interactive methods that can simultaneously handle the results of multidisciplinary applications. The research proposed by Vernengo et al. [8] focuses on the comparison of two different methods to deal with the change of hull shape, namely, the full-parameter model and the non-parametric method based on free-form deformation technology. Considering the ease of establishing the shape of the reference model and its transformation rules, and the number of free design variables generated therefrom, the comparison is made. Wei and Han [9] proposed to establish an information system for the management of surveying and mapping equipment. The system is based on CAD framework and implemented by MVC mode. This paper introduces the design, organizational structure, functional modules and related technologies of development and implementation of the database. The problems such as confusion of instrument use records, data loss and statistical difficulties in the management of surveying and mapping equipment in the experimental center were solved. In the field of CAGD/CAD, interpolation curves play an important role in shape representation and shape design. On the basis of traditional quintic Hermite interpolation curves, Zheng et al. [10] proposed a class of quintic generalized Hermite interpolation curves with local shape parameters. In the field of CAGD/CAD, interpolation curves play an important role in shape representation and shape design. Based on the traditional quintic Hermite interpolation curve, a class of quintic generalized Hermite interpolation curve with local shape parameters is proposed.

The research status of image-based modeling software and 3D modeling is analyzed, and the research of 3D modeling is quite meaningful both in practice and in theory. However, for ordinary users, the image-based modeling software involves many commands and tools, and it is difficult for ordinary users to complete the sketch and modeling design in a short time. In this article, a CAD interactive design strategy based on the best interpolation curve is proposed. The deep learning technology is used to assist VR 3D image modeling, and the 3D surface reconstruction technology is used to realize the transformation from point to surface, so that the product prototype can be quickly formed. Finally, the product design is completed by combining CAD and manufacturing system.

3 METHODOLOGY

3.1 Image and 3D Modeling Design

In the era of rapid information development, images can be used as a medium or carrier to capture the surrounding things. Usually, there are two types of pictures we see on computer screens: images and graphics. Graphics are vector graphics, and images are bitmaps. Graphics are composed of some points, straight lines, line segments, arcs and curves, while images store the content information of the viewed picture through rasterization. Scale space is the display of the same thing under different parameters. Through the change of scale parameters, a series of images with different resolutions will be obtained. The points that can be extreme points in different sizes and resolutions are the characteristic points. Scale invariance means that the same feature points can be detected in different scale spaces, while rotation invariance means that the

result of the inspection of the feature points of the image does not change when the illumination conditions of the image are changed after rotation. In the computer, the memory space is limited. Generally, the image compression is used to solve the problem that the image occupies a large space. Generally speaking, the types of images in computers mainly include gray images, binary images and true color images. Modeling is a process of modeling the system. Customers can build various models according to different purposes and uses. Geometric modeling technology is a relatively traditional method. In computer graphics, the shape, position and expression of objects are expressed in the form of geometric information and topological information, thus depicting illusory scenes.

Image modeling technology is very common. Its basic principle is to sample images by electronic devices such as cameras, and it uses techniques such as projection transformation, cropping and elimination. The image contains abundant scene information, which can be used to reconstruct a 3D model, and texture information can be obtained from the sampled image to realize mapping. In the process of image modeling, due to the projection, some information will inevitably be lost. Considering this, it is essential to manually add auxiliary information and constraints in the modeling process, so as to recover the three-dimensional information of image space and reduce the complexity of the algorithm. Figure 1 shows the structure of computer-aided image recognition system.

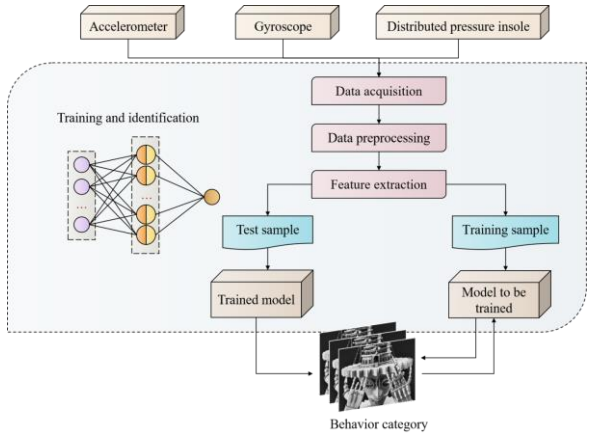

Figure 1: Structure of computer-aided image recognition system.

The error of the relative depth will directly lead to the accuracy of the reconstructed cuboid 3D stereo parameters. In photogrammetry and computer vision knowledge, the linear camera model is basically equivalent to the central projection imaging equation. Both of them express the relationship between projection point and space point. Because of their different starting points, they lead to differences in formulas, physical parameters, process processing, object processing and algorithms.

3.2 Interactive Design of VR 3D Images Based on CAD

The usual method of feature-level image fusion is to extract feature information from multi-source images and fuse them at feature level, which aims to increase the reliability of features in the fused images. This type of image fusion method belongs to the intermediate level. After the feature detection of the registered images, the extracted image features are described by making appropriate feature descriptors for feature matching, so as to calculate the transformation model parameters between image pairs. Among them, feature descriptor, as an important tool to

describe image features, is an important representation of image scene, usually in the form of multidimensional vector. In order to avoid the omission of the detected points, the detected feature points are tracked. The boundary points are identified by the gradient value or gray value of the image. The VR modeling system based on CNN is shown in Figure 2.

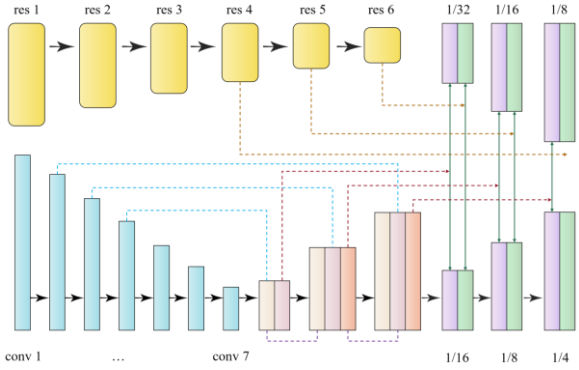

Figure 2: VR modeling based on CNN.

After the estimation of the image transformation model is completed, the image transformation model is used to transform the images to be registered. However, in the actual image transformation process, the images to be registered are transformed with corresponding parameters, and usually rotate and zoom, so that they are in the same coordinate system as the reference images. In the feature matching stage, it is an important factor of feature matching to realize fine feature matching by counting the similarity and uniqueness of feature point descriptors.

Generally speaking, interpolation is widely used in mathematics. Interpolation is to construct a curve that can pass through a given point in sequence, which is called interpolation for a given point. Let the gray value range of the original image $f(x,y)$ be $(g_{\min}, g_{\max})$, select an appropriate threshold T, and:

$$g_{\min} \le T \le g_{\max} \tag{1}$$

Image segmentation with single threshold can be represented by the following formula:

$$g(x,y) = \begin{cases} 1, & f(x,y) \ge T \\ 0, & f(x,y) < T \end{cases} \tag{2}$$

$g(x,y)$ is a binary image. The object can be easily exposed from the background through binarization. The key to binarizing images is the reasonable selection of threshold T.

$$y = x * w \in R^{u \times v} \tag{3}$$

Select the size of the feature:

$$u = \left[\frac{n - s + 2 \cdot Zeropadding}{Stride} \right] + 1 \tag{4}$$

$$v=\left[\frac{m-k+2\cdot Zeropadding}{Stride}\right]+1 \tag{5}$$

The key of convolution operation lies in reducing unnecessary weight connection and using local connection, as well as weight sharing strategy, which greatly reduces the quantity of parameters, thus avoiding over-fitting.

The input of the fitting problem is usually some data, and the output is a curve or surface composed of data. Most fitting algorithms can be divided into global fitting algorithm and local fitting algorithm. The global fitting algorithm is mainly used to solve optimization problems. For the global fitting algorithm, small changes will cause global riots. The local fitting algorithm is just the opposite. In VR modeling, let the normal vector of each triangle in the related triangle group of vertex v_i be n_k, the center x_k and the area a_k. Then the plane constructed by the normal vector and the center defined below is called the average plane of the vertex:

$$N=\frac{\sum n_k a_k}{\sum a_k} \tag{6}$$

$$n=\frac{N}{|N|} \tag{7}$$

$$x=\frac{\sum x_k a_k}{\sum a_k} \tag{8}$$

The offset from the point P in the three-dimensional space to the mesh model TM is defined as:

$$d(P,TM)=\min\left(d(P,X)\right) \tag{9}$$

Where $d(P,X)$ is the Euclidean distance from point P to point X. When displaying the triangle mesh shadow model on the computer, the normal vector of each triangle vertex must be obtained. For vertex P, there are k triangles around it. Let the unit normal vector of the i triangle be:

$$n_i \quad (i=1,2,3,\ldots,k) \tag{10}$$

Define the normal vector of vertex P as the average of all triangle normal vectors around it, and n_p represents the normal vector of vertex P, then:

$$n_p=\frac{1}{k}\sum_{i=1}^{k} n_i \tag{11}$$

Normalize it:

$$n_p=n_p/|n_p|=\frac{n_{px}\vec{i}+n_{py}\vec{j}+n_{pz}\vec{k}}{\sqrt{(n_{px})^2+(n_{py})^2+(n_{pz})^2}} \tag{12}$$

The data used in feature level image fusion is the statistics of pixel value information in the source image, and the commonly used feature level information of the image mainly includes regional statistics, target contour information, edge geometry information, etc. Because the feature level image fusion method directly extracts the feature level information of the image to be fused, the reliability of the processed object is increased, the introduction of false information during fusion can be reduced, and new composite features can be established based on the feature information.

The input signal $I(X,t)$ is first compared with N distribution models, and then the matching model is updated. if:

$$\left|I_j(X,t)-\mu_{ij}(X,t)\right|<\tau D_{ij}(X,t) \tag{13}$$

Then $I(X,t)$ and p_i models match. Where τ is a global threshold, i represents the i -th distribution model, and j represents the component in the (s,r,g) space. If $I(X,t)$ matches multiple p_i at the same time, the distribution model with large probability, small variance and small difference from $I(X,t)$ is selected for updating. That is, the distribution model that satisfies the minimum similarity distance $d_i(X,t)$ is updated. $d_i(X,t)$ is defined as:

$$d_i(X,t)=\sum_{j=s,r,g}\frac{\left|I_j(X,t)-\mu_{ij}(X,t)\right|D_{ij}(X,t)}{h_{ij}(X,t)} \tag{14}$$

Update match p_i as follows:

$$\mu_{ij}(X,t+1)=(1-\alpha)\mu_{ij}(X,t)\alpha I(X,t) \tag{15}$$

$$D_{ij}(X,t+1)=\min\left\{\left[(1-\beta)D_{ij}^2(X,t)+\beta\left(I(X,t)-\mu_{ij}(X,t)\right)_2\right]^{1/2},D_{\max}\right\} \tag{16}$$

4 RESULT ANALYSIS AND DISCUSSION

In order to achieve poor quality multi-source image registration, the registration algorithm with high robustness has always been a hot issue in the field of image registration. Feature-based region matching selects the image region blocks with obvious features in the images to be registered and matches them as the image registration features. This kind of algorithm requires very high accuracy of feature region extraction. In the hardware design, the original VR equipment is taken as the reference, and new related equipment is added. In order to make the system hardware connectible, the settings with the same voltage are selected for series connection, and the hardware design is completed. In order to verify the effectiveness and practicability of this CAD interactive design system, the performance of the system is tested and analyzed. In the experiment, we tested the time needed to retrieve VR images with different numbers of images and different nodes. The experimental results are shown in Figure 3.

It can be seen from Figure 3 that when the quantity of VR images is small, the more nodes there are, the more time it takes for image retrieval. When the quantity of VR images is large, the proposed virtual visualization scheme can obviously improve the retrieval efficiency.

Because the fusion result of feature-level image fusion method is usually the feature information data of the image, the amount of data to be processed by this type of method is much less than that of pixel data, and the requirement of feature-level image fusion method for image registration accuracy is lower than that of pixel-level image fusion method. As the most intuitive evaluation index to measure the image registration algorithm, the image registration accuracy has the ability to judge whether the algorithm meets the registration performance requirements. Figure 4 shows the comparison of modeling accuracy of different algorithms.

Compared with SVM algorithm, the VR image modeling method proposed in this article has the highest accuracy improvement of 25.76%, which can effectively solve the problems of unclear and not enough stereo images. The application of interactive function of VR 3D images can be processed by different guiding media, among which some guiding media belong to some features of virtual 3D images, and the other guiding media are some features of real 3D images. The two

guiding media combine with each other to form interactive processing function of virtual 3D images.

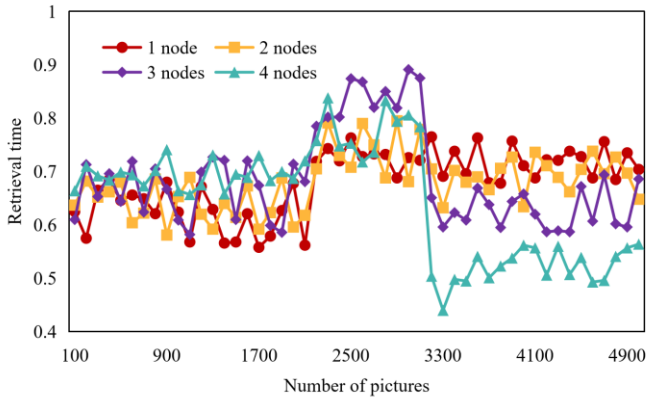

Figure 3: Time consumption of image retrieval.

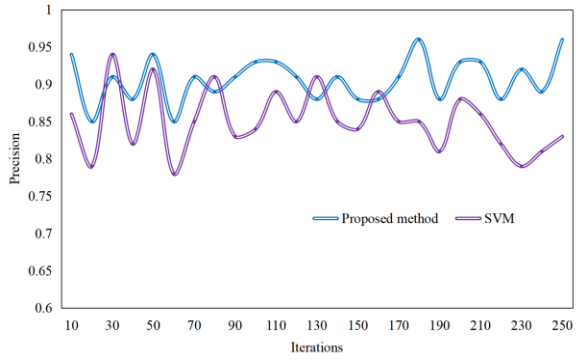

Figure 4: Accuracy results of different algorithms.

In an ideal image registration task, there should be no pixel error between the registered images. In a specific image registration scene, the pixel error between the registered images should be controlled within two-pixel points, otherwise, it is judged that the performance of the registration algorithm is insufficient to complete the existing image registration task. Compare the recall rate of the algorithm for VR image recognition, as shown in Figure 5.

The test results show that the recall rate of this algorithm for VR image recognition is increased by 19.68%. In the algorithm, it is usually need to set the salient features of the image that are easy to extract. Common image features include points, lines, contours and so on. By using image features to describe image information, the computational complexity of image registration is reduced, and then the robustness of image gray feature registration is improved.

The obtained 3D image feature vectors are used to construct the physical model of 3D images. Physical modeling can make the three-dimensional image adapt to the dynamic model, and through the physical model, the image can make corresponding response according to the external conditions, thus realizing the self-adjustment of the plane model. The classification technology is

used to build the physical model. Some complex and irregular images are set with similar features, and the physical model is built by the classified images.

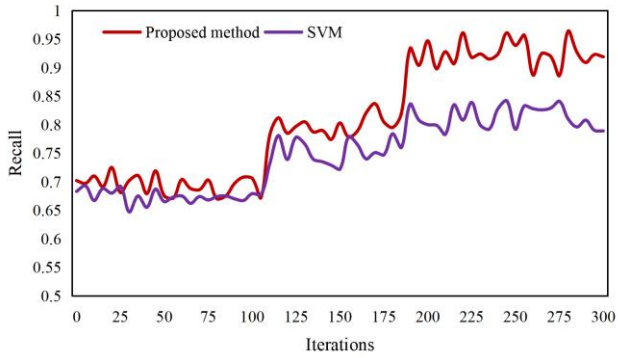

Figure 5: Comparison of recall rate of VR image recognition.

After the calculation and extraction of 3D image feature vectors are completed, it is suggested to design and build a physical model of 3D images. Through this model, 3D images can quickly and effectively adapt to the dynamic model, and at the same time, they can quickly make a series of responses according to the external environmental characteristics and conditions, so that the plane model has a good self-adjusting function. At the same time, we can also use classification technology to build corresponding physical models according to the actual situation, organically integrate images with complex and irregular characteristics to form a set of similar features, and use the classified images to build corresponding physical models. In order to further understand the performance of this algorithm, it is compared with the predicted value of WT algorithm and scatter plot, as shown in Figure 6 and Figure 7.

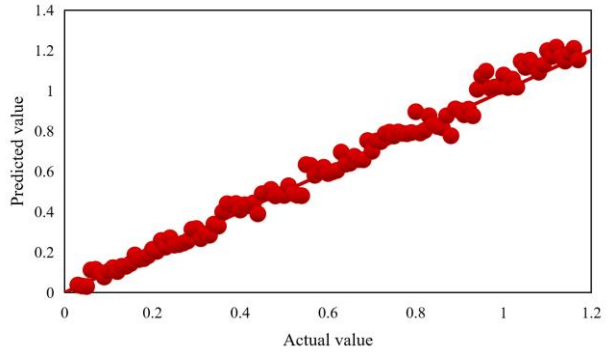

Figure 6: Scatter diagram of actual value and predicted value of this algorithm.

It can be analyzed that the VR interaction design model based on this algorithm is better than WT algorithm in terms of time measurement accuracy and efficiency. By using image features to describe image information, the computational complexity of image registration is reduced, and then the robustness of image gray feature registration is improved. The 3D image interaction system designed based on VR can be used for motion capture in the actual operation.

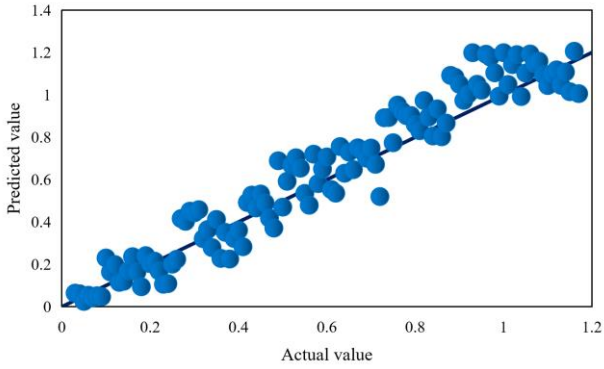

Figure 7: Scatter diagram of actual value and predicted value of WT algorithm.

The system can capture the 3D images in a specific scene by capturing the motions of the 3D images comprehensively, and the system can automatically calibrate and analyze the images, which can ensure the accuracy, reliability and rationality of image capture. In the actual operation process, the hybrid VR 3D image can be effectively generated. According to the specific operation steps, various feature elements of virtual and real 3D images can be accurately extracted, and relevant 3D images can be generated. Based on the integration of virtual and real 3D image elements, the 3D image generation effect and interactive performance are combined.

5 CONCLUSIONS

Computer vision in computer technology is a technology similar to the function of human eyes. Its purpose is to realize the process of converting 2D images into virtual 3D scenes. With the continuous improvement of modeling technology and the deepening of CAD, three-dimensional information of entities can be obtained and processed step by step. For the design process of an entity, it usually takes a lot of reasoning to finally make a design decision. In this article, a CAD interactive design strategy based on the best interpolation curve is proposed, and the deep learning technology is used to assist VR 3D image modeling, so as to build a VR design 3D image interactive system. Compared with SVM algorithm, the accuracy of the proposed VR image modeling method is improved by 25.76% at the highest, and it can effectively solve the problems of unclear and insufficient stereo images. When the quantity of test samples began to increase, the MAE of three-dimensional image recognition of each method showed a downward trend. However, compared with the other two methods, the method in this article has obvious advantages in 3D image recognition MAE. When the computer is used to complete the modeling of VR 3D images, numerical interpolation can be used to achieve high accuracy. The extraction of image feature points should be more reasonable. In the following research, more effective constraint criteria and mechanism should be explored, and the extraction results should be more specific.

Qingnan Ji, https://orcid.org/0000-0001-7410-0352
Lu Liu, https://orcid.org/0000-0001-9348-6254
Jinxia Wang, https://orcid.org/0000-0003-1222-6990
Juan Du, https://orcid.org/0000-0002-0534-7615

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