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Application of Depth Convolution Virtual Reality (VR) in Traditional Sculpture Design under Digital Modeling

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Abstract: - Virtual reality technology continues to be used in other technical fields, art forms are becoming more and more abundant. Virtual reality technology provides convenience for art creation. The combination of art and technology can become a new art form, digital art, and has become a trend of art development. The earliest sculpture art in the art field is no exception, and has also blended with the virtual reality technology. Because the artistic presentation of traditional sculpture art is a relatively complex materialization process, the thinking presentation and creation process of sculpture art need to go through a series of processes to complete the final sculpture works of art; This makes sculpture art more complex and more difficult to operate than other arts when using virtual reality technology. If virtual reality technology wants to integrate perfectly with sculpture art, it needs to combine the process of sculpture art and provide different digital technology methods in different links. This document uses linear combination to solve two level problems, which is a very effective adaptive algorithm. The empirical results show that the improved fusion algorithm can re analyze the importance of the positive process in the rapid development of virtual reality technology, and the rapid development of virtual reality technology is crucial to shaping the value of this theme. Compared with traditional methods, the accuracy of this experiment is increased by 13.4%, and compared with the algorithm TIN, the time complexity and space complexity are 97% and 54% lower respectively.

Keywords: digital modeling; Virtual reality; Sculpture design; Optimization of fusion algorithm

I. INTRODUCTION

With the development of virtual reality technology, I entered the art field on the plane, from painting, animation, photography, film and television, advertising, design and other fields, to architecture, decoration, garden, sculpture and other fields. Virtual reality technology has been integrated into art [1]. In recent years, under the situation that the creation tools and methods of traditional sculpture art are mature and solidified. And the continuous updating of technology, the limitations of traditional sculpture creation have been completely broken, making sculpture art diversified [2]. The sculpture art with virtual reality technology as the creation means has become a new topic for the development of modern sculpture art. The current sculptors should not only have a solid artistic foundation, but also master a certain degree.

At the beginning of the birth of human civilization, the bud of sculpture art also emerged. Using virtual reality modeling software to build virtual scenes and models; The essence of virtual reality engine is a software framework, which is used to realize interactive functions in virtual scenes; Virtual reality open platform provides developers with various software toolkits to improve application development efficiency [3]. The hardware requires peripherals such as mouse, keyboard and handle. The fully immersive virtual reality system also requires different hardware peripherals such as VR glasses, headphones and head mounted displays, so that users can stay in the virtual environment and get a sense of existence.

As an ancient art form, sculpture first appeared in the primitive period. At first, carving and carving techniques were mainly used. The necessary technique of sculpture appeared with the help of Neolithic pottery. Since then, there have been three kinds of carving, carving and sculpture techniques that we now commonly use as methods of sculpture creation [4]. Carving and carving are the act of subtracting materials from the materials to be modeled, and plastic is the act of "polymerization" of materials, and the act of adding [5]. And they are also directly affected by social ideology in different times [6]. In "traditional sculpture", sculpture is static and visible, a physical and touchable virtual reality object, and a molded visual space image to express artistic thinking. Sculpture is regarded as a typical plastic art and also as a space art [7].

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More and more sculpture artists begin to use computers to create virtual sculptures. Sculptors can not only use computer software to design the sculpture, but also simulate the space environment where the sculpture works will be placed, so as to get a better display effect [8]. With the expansion of virtual space and physical space for ships to berth, the application of virtual reality technology is also greatly expanded. People have entered the digital era, and digital mechanical production under virtual reality technology has replaced more and more manual production by mechanical production. Virtual reality technology liberates people from production, produces quickly and accurately, and enables rapid social development and continuous improvement of people's quality of life. Virtual reality technology has become the symbol [9].

The application of virtual reality technology in sculpture art can bring great comfort in the process of sculpture art creation and inject new blood into modern sculpture art. Virtual reality technology has made sculpture art change a lot [10]. First of all, virtual reality technology makes the creation of sculpture art diversified; Now sculpture art creation does not rely entirely on manual operation, but has begun to rely on virtual reality technology to create art on the computer. Artists' creative ideas can be quickly presented; The design modified sculpture manuscript can be restored and repaired by one click, and the plastic art form can be distorted and deformed at will. The sculpture manuscript is modeled and created in the virtual reality software, without considering the gravity problem, which can break the creation limit of the sculptor and let the sculptor devote himself to the plastic art creation. Secondly, virtual reality technology makes sculpture art digitalized. The characteristics of sculpture art are virtual reality, three-dimensional, space, and tactility, which make sculpture art unique. The preservation of sculpture works of art has always been a problem for sculptors. Now, the digital storage of sculpture art can save space and space problems, prevent sculpture damage, and at the same time, it can process and copy data at any time, and output sculpture works at any time [11]. Thirdly, the virtual reality technology makes the means of sculpture art production mechanized. Modern digital modeling and numerical control carving technology make sculpture art virtual reality, get rid of the traditional production mode of cumbersome workmanship, save production time and produce finished products.

Virtual reality technology can also replace the manual completion of complex modeling works to ensure exquisite and accurate workmanship. The collision and intersection between disciplines are more and more common. It is precisely because of this penetration and intersection that digital art emerged, and then virtual reality digital art developed. Nowadays, under the background that digital modeling has become a hot topic, a series of rapid prototyping technologies have gradually attracted people's attention, such as CNC engraving technology and digital incremental molding technology. With the penetration of digital modeling into various manufacturing industries, sculpture art that requires the participation of manufacturing technology has also been greatly affected. The traditional creation and shaping way of sculpture art is in sharp contrast with modern design means and rapid prototyping technology. The advantages of digital modeling modeling technology in practical application force sculpture art to make changes in shaping way [12]. However, the participation of new technologies will not only bring some value to the sculpture art, but also bring some negative effects. At present, the amount of value and the depth of influence are unknown. It is a general trend to apply digital modeling design and digital modeling molding technology to traditional sculpture art, which will also lead to a new round of discussion on the dialectical relationship between technology and art.

To sum up, the deep convolution virtual reality technology and traditional sculpture are both interrelated, complementary and complementary. Their common development provides more choices for sculpture art creation and promotes the diversity of our sculpture art culture today. In the era of digital art, the progress of virtual reality technology will have an impact on the development of sculpture design. We need to think slowly.

II. RELATED WORKS

Foreign research has already had a certain theoretical basis. The literature [13] emphasized that digitalization has become the fundamental driving force and important feature of the development of this era, and digital survival has become the survival and development mode of people in this era. The literature [14] points out that the appearance of cameras has shaken the tradition of western realistic painting with the goal of simulating real objects, but it does not threaten the art of painting. Instead, it helps the art of painting develop continuously, making the art of painting diversified. Similarly, virtual reality technology is applied to sculpture art as an auxiliary tool. The domestic research is not very in-depth, but there are also some achievements. Literature [15] points out that virtual reality technology integrates the aesthetic language of sculpture, obtaining the transformation from technology to art, and sculpture art also gains greater social function of aesthetic education.

Hundreds of papers related to technology have also been collected in BSCO foreign language journal database, China Journal Network and Wanfang database. At present, there is still a lack of complete theoretical system on the application of digital modeling modeling in sculpture art. It is pointed out that in the process of theoretical research and actual production of industrial equipment, in order to reduce research cost and improve research efficiency, it is necessary to use computer simulation technology to simulate and predict research results, which plays a decisive role in the research of high-risk processes. How to achieve the accuracy of prediction and simulation, the visualization of results and the ease of use of software are the core challenges of virtual simulation software development. The research mentioned that the current 2D simulation technology is mature and widely used, while the 3D simulation technology is an upgrade of the 2D simulation technology, which can solve the problem of single display effect.

The rapid development of virtual reality technology in recent years by using simulation technology as the system background to carry out theoretical research on computer graphics and the progress of computer underlying hardware equipment. Powerful virtual reality functions can provide near real visual effects [16]. The United States is the best virtual reality technology in the world. Relevant applications are widely used in military, medical, entertainment and other industries. The emergence of more and more virtual reality application development tools has lowered the development threshold of virtual reality applications. According to literature [17], since it is a relatively new design method to involve digital modeling design in sculpture design, and digital modeling and forming technology is in its infancy, most of the research achievements on this topic are one-sided and scattered discussions and studies on digital modeling design, digital modeling design in sculpture design, digital modeling and forming, and there are few systematic and comprehensive research materials related to the combination of the three.

For example, the films Beowulf, Transformers and Avengers Alliance all use digital modeling technology to build virtual role models to achieve shocking visual effects. In sculpture design, many sculptors have used virtual reality digital modeling to create sculpture models and make sculpture renderings. In sculpture production, the role of virtual reality digital modeling is basically used for data measurement for sculpture amplification [18]. At present, in China, virtual reality digital design has been incorporated into the teaching system of ordinary higher education, and many corresponding textbooks have appeared, but most of them are about modeling technology textbooks in film and television animation, so it is difficult to find virtual reality digital design books about sculpture art. According to literature [19], digital art is an art form that can neither be created nor appreciated without computers.

The combination of sculpture design and virtual reality technology benefits from the development of computer technology. It is closely connected with advanced virtual reality technology from the very beginning. All carving design activities carried out together with virtual reality technology must be based on virtual reality technology. Carving design and virtual reality technology must be based on virtual reality technology [20]. The development of sculpture design combined with virtual reality technology has played a positive role in the development and upgrading of computer technology, hardware, software and technology [21].

Literature [22] pointed out that, since the late 1990s, a group of scholars interested in studying the relationship between technology and art have emerged in China; Starting from their own fields of expertise, they carried out a variety of research and thinking, explored the realistic thinking brought about by the role of virtual reality technology in art, and compiled them into theoretical works, which laid a theoretical foundation for later researchers to study sculpture design combined with virtual reality technology. After the millennium, some domestic sculpture manufacturers introduced sculpture design and virtual reality printing technology combined with virtual reality technology, and began to apply 3D sculpture means to sculpture production. Since the initial cost of digital sculpture hardware facilities and production materials is relatively expensive, the sculpture industry knows little about sculpture [23]. With the constant introduction and updating of computing technology and related software, the cost of hardware equipment and materials is declining, the technology of personnel in the industry is constantly improving, and the advantage of using virtual reality technology in the industry's workflow convenience is gradually prominent. More and more sculpture artists are difficult to resist the charm of sculpture design, starting to break through the barriers of art and technology industries, and are willing to accept and boldly try to make sculpture design combined with virtual reality technology [24].

In 2008, Digital Sculpture Exhibition made its debut in China. This Digital Stone Sculpture Exhibition shows the works of modern sculpture artists. They used the latest virtual reality technology and completed it after several months with the cooperation of high-level Chinese sculptors. At the beginning of the appearance of virtual reality technology, it was only used as a technical means. With the progress of the times and the inflow of Western sculptors' bold use of technology, artists began to realize that in the process of integration of technology and sculpture, in addition to technical means and tools, there are still unique things to explore [25]. Nowadays, sculpture works with digital characteristics emerge in endlessly. The integration of virtual reality technology and art has burst out a new vitality. Sculpture design combined with virtual reality technology has great prospects for future development.

To sum up, continuous application of virtual reality technology in sculpture art, has changed the sculpture creation process, creative materials, creative methods, etc., but also the direct force of the changes in artists' creative thinking and concepts, affecting the unprecedented changes in the sculpture creation process and aesthetic methods.

III. OPTIMIZATION OF FUSION ALGORITHM

After the convex hull triangulation is optimized to the initial triangulation, the non convex hull points can be inserted into the constructed triangulation one by one by using the interpolation method. When inserting point by point, then insert it into the triangle, and finally locally optimize to make the newly constructed TIN meet the LOP rule. The drafting ratio expression (1) is:

$$\varepsilon_t = \frac{T_t}{2\pi\left(\frac{d}{2}\right)^2}\left(\frac{1}{E}+\frac{dt}{\eta}\right) = \frac{T_0 + Fr + J\,\frac{dV}{dt}}{2\pi\left(\frac{D}{2}\right)^2}\left(\frac{1}{E}+\frac{dt}{\eta}\right) \quad (1)$$

The uncertainty of random variable X can be expressed as information entropy, namely Formula (2):

$$H(X) = -\sum_{x\in X} p(x) log \;\; p(x) \quad (2)$$

The conditional entropy of random variable Y with respect to X is Formula (3):

$$H(Y\mid X) = -\sum_{x\in X} p(x) \sum_{y\in Y} p(y\mid x) log \;\; p(y\mid x) \quad (3)$$

Where, information entropy $H(X)$ is related to the probability distribution of variable X. The greater the dispersion of random variables, the higher their uncertainty, the greater the information entropy, and the more information they describe. The mutual information of discrete random variables X and Y is expressed as formula (4):

$$I(X,Y) = H(X) - H(X\mid Y) = \sum_{x\in X} p(x) \sum_{y\in Y} p(y\mid x) log \frac{p(y\mid x)}{p(y)} \quad (4)$$

On the basis of the above concept of information entropy, the definition method of view mutual information based on saliency drive is given as Formula (5):

$$p(v_i) = \sum_{o_j\in O} A(o_j / v_i) / \sum_{v_i\in V}\sum_{o_j\in O} A(o_j / v_i) \quad (5)$$

This paper only calculates the conditional probability density of the visible film. For the occluded non visible film, the conditional probability density will be set to zero because the contribution degree of the relative viewpoint is zero, as shown in Formula (6):

$$p\left(o_j\right)=\sum_{v_i \in V} p\left(v_i\right) \cdot p\left(o_j / v_i\right) / \sum_{o_j \in O} \sum_{v_i \in V} p\left(v_i\right) \cdot p\left(o_j / v_i\right) \quad (6)$$

Given the random variable Y, let $p(y \mid x)$ be the conditional probability density distribution of Y under the condition that X is known. From the above formula, the mutual information of view set V and grid model O is defined as formula (7):

$$I(V,O)=\sum_{v_i \in V} p\left(v_i\right) \sum_{o_j \in O} p\left(o_j / v_i\right) \cdot log \frac{p\left(o_j / v_i\right)}{p\left(o_j\right)} \quad (7)$$

In general, $H(Y \mid X) \neq H(X \mid Y)$ and $H(X) \geq H(X \mid Y) \geq 0$. PMI can be redefined as Formula (8):

$$I\left(o_j, V\right)=\sum_{v_i \in V} p\left(v_i\right) \cdot \frac{p\left(o_j / v_i\right)}{p\left(o_j\right)} \cdot log \frac{p\left(o_j / v_i\right)}{p\left(o_j\right)} \quad (8)$$

It can be seen from the definition that mutual information describes the amount of information shared by two variables X and Y. The larger the value of mutual information, the stronger the correlation and dependence between variables. Mutual information satisfies symmetry, that is, $I(X,Y)=I(Y,X)>0$.

IV. METHODS

A. Data preprocessing and TIN data structure

Data preprocessing is mainly aimed at the imported raw data. Its function is to delete the duplicate points in the data file and purify the data. In this way, when designing convex hull and point by point insertion algorithm, it is not necessary to specially consider the repeated points in the data file, which can not only improve the execution efficiency of the algorithm, but also simplify the algorithm design. In the TIN model, the basic structural elements are triangle vertices, edges and faces, in which there are topological relationships between points and lines, points and faces, lines and faces, and faces and faces. Theoretically, the composition of a triangle and the topological relationship between its vertices, sides and triangles can be completely expressed by the three vertices of a triangle. This structure requires only two files, namely, the triangle vertex coordinate file and the three vertices of a triangle (usually represented by the serial number of points in the coordinate file) file. In this chapter, the point by point insertion method is used as the construction method, and the convex hull of two-dimensional discrete points is used as the initial polygon to realize the construction of TIN. Based on the research and analysis of the existing 2D convex hull search methods, an adaptive algorithm for finding the convex hull of 2D point sets by using the initial containment shell is proposed, and the triangulation of polygons is improved; The point positioning method in the network construction process is optimized, and the fusion algorithm is proposed. The process of TIN construction in this chapter is shown in Figure 1.

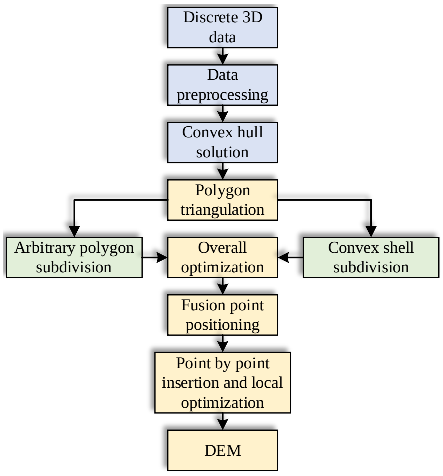

Figure 1 TIN Construction Flow Chart

Figure 2 is the schematic diagram of the sculpture production process under the traditional technical conditions.

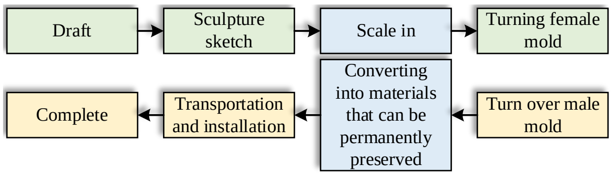

Figure 2 Sculpture production process under traditional technical conditions

With the continuous development of science and technology, all hardware levels are the gradual improvement of virtual reality technology. As shown in Figure 3, the hardware based virtual reality includes an output device and an input device. When building a service experience design model based on virtual reality technology, the default output device is the main device that starts the input device view consisting of a handle and portability, and the device depends on the search content.

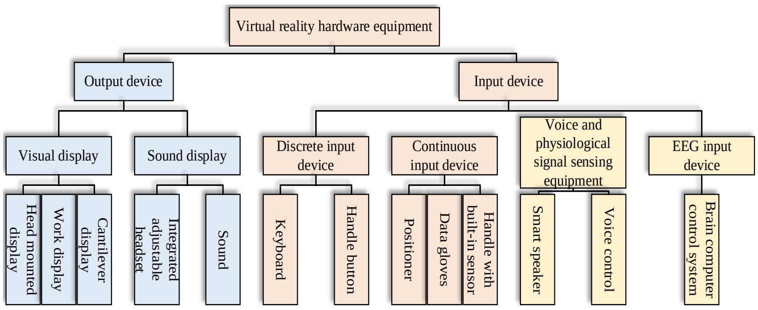

Figure 3 Virtual Reality Hardware Device

At present, the quality of VR hardware devices is mainly judged from three aspects: resolution, refresh rate and field angle. Several mainstream PCVR devices in the market are collated and compared, as shown in Table 1.

Table 1 Comparison of mainstream PCVR equipment

PCVR device	Oculus Rift S	HTC VIVE Pro	Valve Index
Resolving power	2880 * 1280 pixels	2880 * 1600 pixels	2880 * 1600 pixels
Refresh rate	80Hz	90Hz	120Hz-140 Hz
Field angle	115 degrees	110 degrees	135 degrees
Price	About 7000	About 8000	About 10000

After preprocessing the original discrete data, we can use the original data to build a TIN network. First, we solve the convex shell, then triangulate the convex shell and optimize the LOP. Finally, we insert the non convex shell points into the existing initial TIN network with the LOP rule using the point by point insertion method. The optimization process of fusion algorithm is shown in Figure 4.

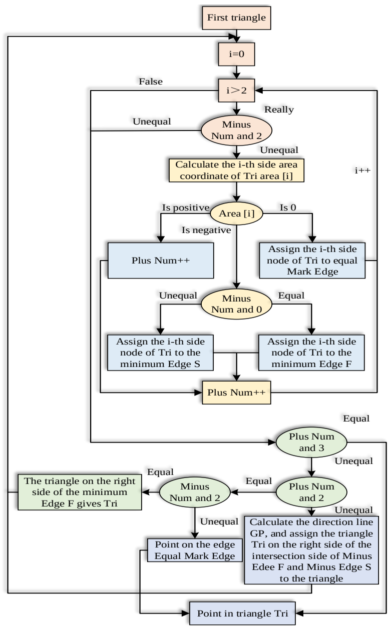

Figure 4 Flow Chart of Fusion Algorithm Optimization

This chapter introduces the basic concepts and properties of two-dimensional Delaunay triangulation, analyzes and studies the current popular TIN construction algorithms, and on this basis, uses convex shells as the initial polygon of point by point interpolation to complete the detailed algorithm steps of TIN network construction, as shown in Figure 5.

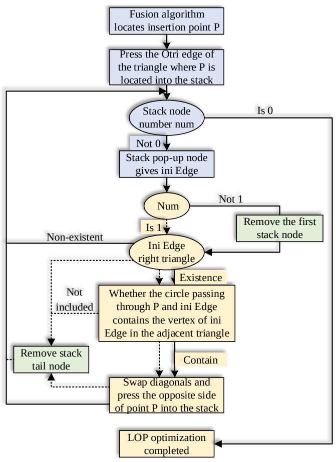

Figure 5 Flow Chart of LOP Algorithm Optimization

Sculpture, because of its particularity, started relatively late in the adoption of virtual reality technology. Now young sculptors have begun to operate digital modeling software to create works. Some new digital modeling has also made corresponding technical changes to facilitate sculptors' creation. At this stage, digital modeling is used as a tool to simplify the process of sculpture creation, integrate science and technology with art, and bring about a new revolution in art. In the virtual reality software, various materials can be created. In the two-dimensional software, various required materials can be tried for many times to create sculpture works, and the display effects of sculptures made of different materials can be studied, so that the display space of the same work can be maximized. There are unlimited possibilities, because the process of trying to deal with materials will have many unexpected effects and help sculptors generate new ideas and creativity. Virtual reality software makes the creation of sculptors fast and convenient, and virtual modeling promotes and improves the traditional sculpture creation process.

B. Detail optimization module

At present, CMFD framework is shown in Figure 6: CMFD algorithm framework based on traditional manual features (Figure 6 (a)) and CMFD framework based on deep learning (Figure 6 (b)).

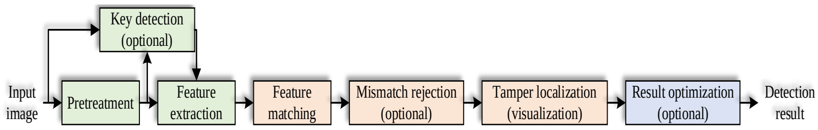

Figure 6 (a) Traditional manual feature method

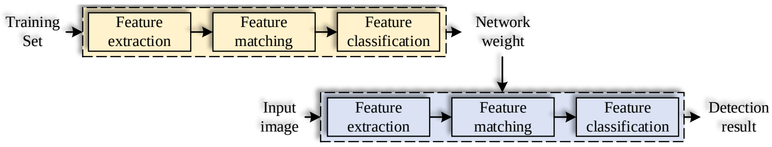

Figure 6 (b) Deep learning method

Figure 6 Virtual Reality Technology Inspection Framework

Unlike the image, the image [0,1] can be changed by drawing a complete source image density between the minimum value and the minimum value, as shown in Table 2. The output image intensity range decreases. The contrast adjustment within (0.01, 0.95) is almost imperceptible visually, while the contrast adjustment within (0.01, 0.8) will cause the image to be significantly darker visually.

Table 2 Methods and Parameters of Post processing Operation

Post processing method	Parameter setting
JPEG compression	Quality factor f= [20,30,40,50,60,70,80,90100]
Noise addition	Mean μ =0, variance σ^2 = [0.009,0.005,0.0005]
Image blur	Average filter size b= [3 * 3,5 * 5,7 * 7]
Brightness change	(Upper limit, $Lower\ limit\ m_b$) = [(0.01, 0.95), 001, 0.9), (0.01, 0.8)]
Color quantization	Quantized value n= [32,64128]
Contrast adjustment	(Upper limit, $Lower\ limit\ m_a$) = [(0.01, 0.95), (0.01, 0.9), 0.01, 0.8)]

This chapter proposes a detection algorithm (TIN) based on Super BPD and DCNN. Its algorithm framework is shown in Figure 7: Super BPD segmentation, feature extraction, autocorrelation matching, classification discrimination and detail optimization.

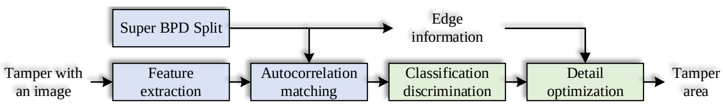

Figure 7 Detection framework based on Super BPD segmentation and DCNN

In the process of image copy paste tamper detection based on depth learning, local details after depth convolution are lost, the tampered area detected is not fine enough, and the edge effect is poor. TIN optimizes the edge of the roughly tampered area through the detail optimization module by combining the edge information extracted by the Super BPD segmentation module with the roughly tampered image output by the classification and discrimination module to locate the final tampered area as is shown in Figure 8.

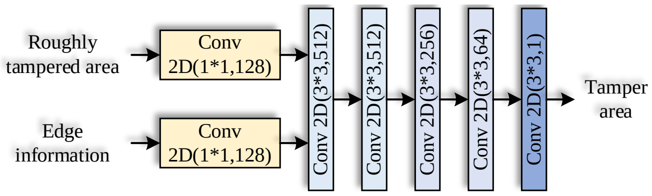

Figure 8 Detail optimization module

The roughly tampered area output by the classification and discrimination module and the edge information output by the Super BPD segmentation module are expanded to 128 dimensions. Then, four 3 * 3 roll layers are used to train and learn to detect the edge of the tampered image. Through BPD edge information, edges are added or subtracted from the roughly tampered area image to optimize the tampered area edges. Finally, 1 * 1 convolution layer is used for feature dimensionality reduction to obtain the final tamper detection area image.

The virtual reality software is used to create sculpture art. The virtual reality image takes the computer display as the carrier to convey visual information to the sculptor to form a visual communication. The sculptor uses the virtual reality modeling software to simulate the virtual reality scene, create virtual reality sculpture, transfer virtual reality things to the virtual space, and enhance the combination of sculpture works and virtual reality technology to shorten the distance between each other, aesthetic and artistic interaction. There are many kinds of virtual reality software, and their functions are somewhat similar, but they have their own specialties. When choosing software, sculptors can choose different software according to the artistic shape and effect of sculpture works.

To sum up, the virtual reality digital modeling is used to digitize the solid model, and the virtual reality virtual image designed on the computer is directly printed and carved solid works through 3D printing technology or digital carving, integrating design and manufacturing. The virtual reality technology can directly, quickly and accurately convert design ideas into real product models.

V. CASE STUDY

A. *Complexity analysis as test*

The robustness of TIN is tested on the CoMoFoD dataset, which contains six post-processing operations: brightness change, contrast adjustment, color quantization, image blur, JPEG compression and noise addition. The F value of TIN is better than that of traditional manual feature methods, because these manual features are greatly affected by attacks. Since the basic framework of feature extraction DCNN of TIN and Buster-Net is VGG, the robustness of algorithms trained and learned by TIN and Buster-Net is similar, and their F values are similar, as shown in Figure 9, Figure 10, Figure 11 and Figure 12.

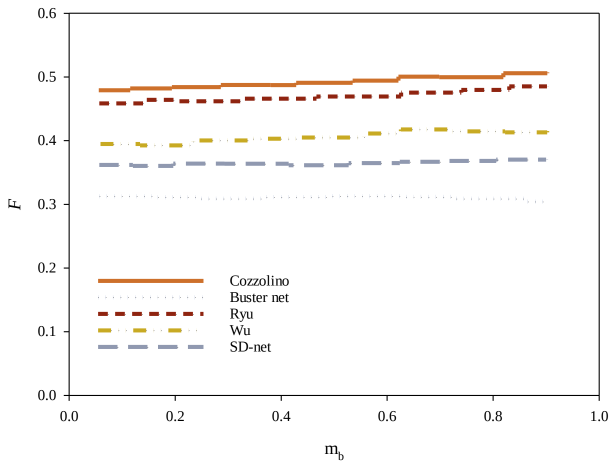

Figure 9 Robustness of TIN - brightness change

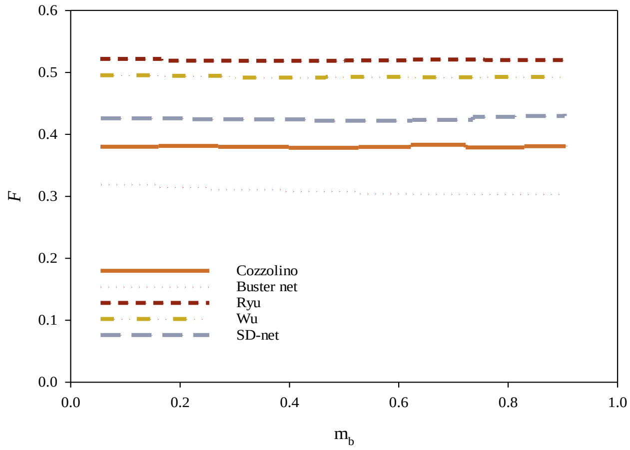

Figure 10 Robustness of TIN - contrast adjustment

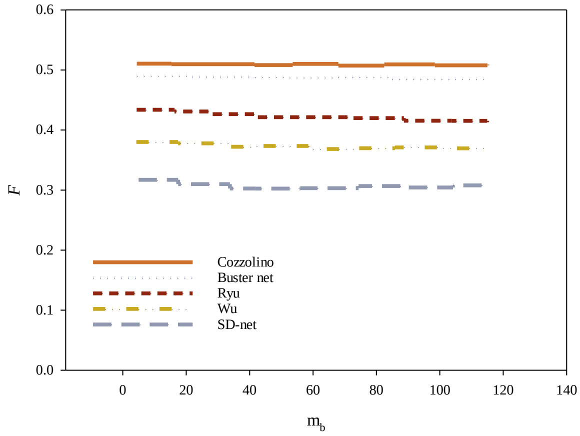

Figure 11 Robustness of TIN - color quantization

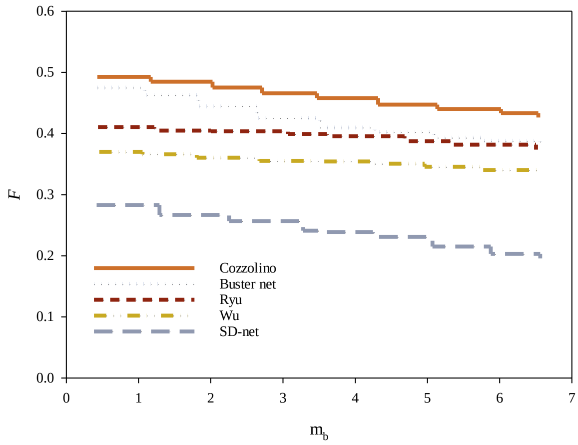

Figure 12 Robustness of TIN - Image blur contrast

Table 3 shows the detection results of TIN and 6 comparison methods on CoMoFoD dataset.

Table 3 Test Results of TIN and Other Methods on CoMoFoD Dataset

Method		Accuracy p	Recall rate r	F
Traditional method	Ryu	45.75	36.33	37.35
	Cozzolino	39.94	47.63	41.85
	Wang	49.06	57.43	46.46
Deep learning method	Wu	36.26	40.44	31.15
	Buster-Net	57.37	49.36	49.28
	AR-Net	54.24	46.57	50.07
	SD-Net	59.13	57.66	50.75

From Table 3, compared with traditional methods, TIN detection values are 4.33, 8.94 and 13.4 higher respectively, and the algorithm detection performance is better. Because the manual characteristics of traditional methods have some limitations, they are more suitable for some specific datasets, and the generalization performance is not strong. The memory consumption of TIN can be divided into the sum of the memory consumption of the partition and the memory consumption of the CMFD. As Table 4 for the specific data of TIN memory consumption.

Table 4 Complexity Comparison between TIN and Buster-Net

Complexity	SD-Net			Buster-Net
	Super-BPD	CMFD	Total	
Number of operations (G)	1453	97.49	1550.49	146.66
Training parameter quantity (M)	28.03	18.35	46.38	15.33
Memory consumption (MB)	4320.44	827.51	5147.95	2515.94

To comprehensively evaluate GR-Net, analyze the complexity of GR-Net, including time complexity and space complexity. GR-Net uses Dense-Net to extract deep features, reducing the amount of training parameters. In addition, GR-Net uses gated convolution to improve the efficiency of feature use, avoid repeated extraction of edge information, and has fewer parameters than the Super BPD segmentation module.

According to the experiment, the time complexity of GR-Net, that is, the number of floating-point operations is 46.83G; The training parameters of GR-Net are 9.22M; The space complexity of GR-Net, that is, the memory consumed by the neural network is 2345.40MB. In Table 5, the complexity TIN of GR-Net is compared with that of Buster-Net.

Table 5 Complexity Comparison of GR-Net with TIN and Buster-Net

Complexity	SD-Net			Buster-Net	GR-Net
	Super-BPD	CMFD	Total		
Number of operations (G)	1453	97.49	1550.49	146.66	46.85
Training parameter quantity (M)	28.03	18.35	46.38	15.33	9.24
Memory consumption (MB)	4320.44	827.51	5147.95	2515.94	2345.43

GR-Net uses Dense-Net, which is 68% lower in time complexity and 7% lower in space complexity than Buster-Net. Since GR-Net uses a gated convolution structure, it does not directly extract edge features from the tampered image. Compared with the algorithm TIN, the time complexity and space complexity of GR-Net are 97% and 54% lower respectively.

B. Optimization results of virtual reality experiment system

Table 6 shows the time required to select different views from the 3D model.

Table 6 Viewpoint selection time consumption

Model name	Number of patches	Time consumption (s)					
		Visibility and saliency calculation	Calculation of conditional probability density	Viewpoint mutual information evaluation	Viewpoint stability evaluation	Viewpoint visibility evaluation	Total
Octopus	15050	8.7193	2.135	1.745	1.983	0.175	14.755
Horse	17928	10.444	2.503	2.041	2.306	0.345	17.671
Rocker	18798	10.919	2.533	2.093	2.404	0.185	18.125
Bunny	34550	20.634	4.651	4.662	5.925	0.856	36.735
Pierrot	40000	24.491	5.602	6.803	7.788	0.683	45.357
Dragon	43545	22.555	5.723	7.314	7.875	0.782	44.255
Frog	49999	26.231	6.741	8.973	9.379	1.537	52.866
Armadillo	50000	26.215	6.755	9.099	9.486	2.688	54.222
Girl	50000	28.374	6.705	8.764	9.343	2.825	56.016
Budda	50000	28.777	6.688	8.796	9.284	2.577	56.111
Pegasus	50000	29.166	6.855	8.686	9.113	2.359	56.179
Two kids	50770	32.293	6.526	9.535	9.779	1.604	59.744

This paper has conducted 50 steering experiments, 25 of which did not use any redirection gain, and the other 25 used redirection gain based on virtual scene resultant force. The average values of the time related data recorded in this experiment to complete the entire experiment and the changes in the user's visual field angle are compared, as shown in Table 7, where NR represents the control group without redirection gain, and VR represents the experimental group using redirection based on virtual scene resultant force.

Table 7 Optimization of data related to steering test

Gain	Real scene angle and	T1	T2	TT
NR	749.5	3.14	2.42	12.45
VR	618.8	3.03	2.24	10.24

This paper has conducted 75 roaming experiments, 15 of which use the central guidance (S2C) algorithm to guide the user path. Similarly, the remaining four experimental groups have also conducted 15 roaming experiments respectively. Among them, except that the APF-O algorithm and APF-T algorithm, the remaining three groups use the 2:1 steering reset algorithm, as shown in Table 8.

Table 8 Optimization of data related to roaming experiment

Algorithm	DV	DT	RT	N	TT	RTP
O	70.5	70.6	5.5	24.7	210.8	60.28%
S2C	74.8	73.7	5.6	13.5	177.2	41.83%
APE-B	72.5	68.7	5.8	7.8	140.6	32.33%
APE-T	72.7	67.6	3.7	8.1	134.8	21.55%
APE-O	74.1	66.6	3.9	7.9	118.8	23.74%

The logic sequence diagram of the background server for online feedback of experimental experience is shown in Figure 13. After the user finishes setting the experimental parameters on the client, he will send an Http request. The corresponding experimental name and experimental parameters are the request parameters.

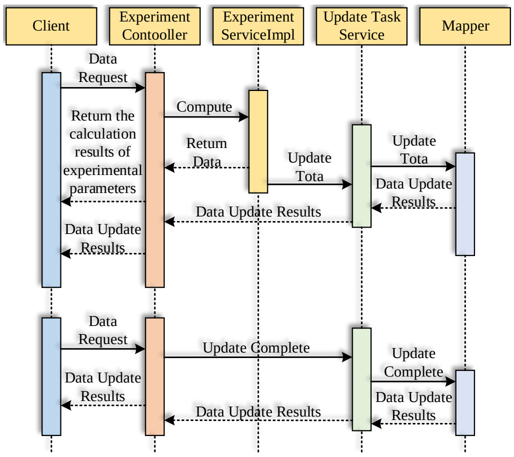

Figure 13 Logic sequence diagram of experimental feedback function

Because it is not affected by mechanics, material properties, volume size, observation angle and other factors in the virtual space, digital sculpture can realize the design of any complex shape. For example, due to the weight and characteristics of the material itself, modeling deformation often occurs in the creation; Due to the toughness and hardness of the materials, it is impossible to process complex shapes; The sculpture is too large to observe the whole, or too small to observe and shape the blocked part. In the software, we can get rid of the physical restrictions and observe the sculpture shape at will to zoom in or out. We can disassemble and reconstruct the structure of the sculpture shape. We can also use the commands in the software and the characteristics of parameters that can be set to achieve the design of complex realistic or abstract sculpture shape. The participation of virtual reality digital design means in sculpture design makes it more convenient for artists to create. In practical applications, it has two main purposes: first, to establish a digital sculpture model, and then render the sculpture effect map for decision makers to evaluate the scheme; The second is to establish a digital sculpture model to prepare for the use of digital molding equipment to produce solid models.

To sum up, the virtuality of digital sculpture makes sculpture creation no longer limited to physical materials and reality dimensions. The use of virtual reality digital modeling replaces traditional creation tools, making the sculpture creation process more smooth and free, and bringing broader creation space to sculpture art.

VI. Conclusion

The application of virtual reality modeling software in virtual reality technology in sculpture art is more and more extensive. The use of virtual reality modeling software has changed the artistic creation techniques of sculpture. In this paper, CMFD is studied, and a deep convolution network framework is used to optimize the edge detection by combining the tampered image edge information, which solves the problem of low edge detection accuracy of existing methods. Firstly, this paper constructs a virtual experiment project of carbon fiber precursor preparation process and its PID control process, restores the basic virtual experiment scene, and calls relevant algorithms in the background of the system, so that the system has the ability of mechanism simulation. Blueprint communication is used to drive the virtual model with experimental parameters, so that the experimental phenomena can be updated in real time according to the changes of experimental parameters, further improving the authenticity of the virtual experiment demonstration effect. The experimental results show that, compared with traditional methods, the accuracy of this experiment is increased by 13.4%, and compared with the algorithm TIN, the time complexity and space complexity are respectively 97% and 54% lower.

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