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Interactive 3D Digital Art in Modern Packaging Design

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Abstract: Interactive 3D digital art is a new emerging technology, and its most important feature is interactivity. With the continuous development of modern science and technology, interactivity will also become a major feature of related industries in the future. At present, this interactive 3D digital art is mostly used in the field of modern packaging design. Nowadays, 3D technology is a high-tech developed in the field of digital art design. This article mainly studies interactive 3D digital art technology, and applies them in the field of modern packaging design.This article aims to compare the new design of interactive 3D digital art with traditional design, and study some innovative and more effective applications that 3D digital art brings to modern packaging design.In this paper, through the RANSAC algorithm segmentation experiment and the improved ICP algorithm experiment and the effect comparison of some application examples, the improved algorithm improves the iteration time by 19.1% ~ 47.4%, and the segmentation error rate is also reduced from 11.1% to 6.3 %, And the artistic effect after comparison is more vivid. From this result, we can conclude that 3D digital technology has a significant effect on modern packaging design, and packaging design has more visual expression and visual impact. Bringing nearly 50% of the packaging design in the current market to modern three-dimensional digital technology to better meet consumer demand.

1. Introduction

Three-dimensional digital art technology is also rapidly developing. A technology. The development of three-dimensional technology has also adapted to today's fiercely competitive market, and the progress is also continuous. The progress of the two has promoted the progress of modern design. The development of three-dimensional digital technology is global. Not only does this market abroad, but also a large number of markets in China. In the past two years, China has paid great attention and help to three-dimensional aspects, which requires a large number of new design talents to further promote The progress of three-dimensional digital art.

Three-dimensional digital applications has actually existed for a long time, but it did not begin to develop rapidly until the beginning of this century. In Three-dimensional digital applications, binocular vision system can be used to reconstruct the specific process of related targets, and the information of related objects can be extracted [1-2].Under the continuous development of China's overall economy, people's living standards are getting higher and higher, and the requirements for product packaging are becoming more and more strict, which makes China's packaging design begin to face new development trends. Among them, three-dimensional digital art is a modern design art, which can effectively break the flat image in traditional packaging design and create it as a three-dimensional packaging image. In the past, simply packaging a product photo could no longer satisfy people's aesthetics. They needed a more artistic expression. The continuous development of three-dimensional technology, more and more fields involve three-dimensional technology, which includes modern packaging design. This new design will bring innovative changes to packaging design.

This article uses interactive three-dimensional digital art technology to conduct in-depth research on specific applications in the field of modern packaging design.The main work is completed as follows: First, it introduces some shortcomings in the current packaging design, and then describes the design method of 3D digital art, which involves Three-point lighting, coloring technology, etc. At the same time, it analyzes the implementation and filtering of the iterative closest point algorithm IPC under the modern fast-developing 3D technology. Among them, the RANSAC algorithm segmentation experiment and the improved ICP algorithm experiment in this article explain the innovation of modern 3D technology very well, and analyze the results. It is easy to see the perfection and advantages of the technology of 3D digital application on modern packaging. This article also gives an example of digital art performance examples under 3D technology, so as to better solve the digital art in 3D technology has brought more and better applications to the modern packaging industry, which has greatly increased the market consumption Satisfaction.

2. Related Work

Robert P Hamlin proposed a technique to measure the impact of packaging graphic design on consumer choice and purchase intention. His technology allows the comparison of several suggested graphic designs of the same product, among each other and their direct competitors, with up to eight designs. His method is based on a partially copied Latin square design, two of which contain four packaging graphic designs and five consumer groups as independent variables. The dependent variable is the consumer's choice. His experimental results show that graphic design has a huge and statistically significant impact on consumer choice of ceteris paribus. This test is able to distinguish packaging graphics designs that are only significantly different. His experimental results show that graphic design has a significant impact on consumer choices, but also show that this impact is closely related to products and circumstances. For any claim of a broader "experience summary" of the impact of graphic design or its components on food consumer choice, this may have considerable meaning. His method allows graphic design to be tested before entering the market. It replaces the viewpoint with a reliable and quantifiable output, which can easily interact with the econometric model and market share model developed in the selection modeling literature [3]. Maree Anne Mills' art using non-traditional media and emerging technologies (especially electronic or digital technologies) has the potential to create and nurture unique "public spaces" to express alternative worldviews. Although more and more publications focus on the artistic practice of contemporary people, they have not paid special attention to the surge in the number of people working in the digital media field. His background will be early research in the broader framework of digital art and attempts to explain a kind of kaupapa's creative practice [4]. S. Zhu believes that the rapid development of digital and information technology has brought new opportunities for the protection of traditional art forms. His experiment analyzed computer-aided 3D national art animation design based on Maya software. Through digital exhibition halls, virtual reality technology, digital technology can provide visitors with a real experience, and computer interaction can make people feel immersive. Through three-dimensional animation software, the author completed the national art animation design and demonstrated the production process [5].

3. Interactive 3D Digital Art Application in Modern Packaging Experiment

3.1 Three-Dimensional Digital Art

Three-dimensional digital art is based on three-dimensional technology, an art that cleverly combines human rational thinking and artistic feeling. It is the refining, combination and reprocessing of designer ideas and creativity. It is a three-dimensional rendering of width, height and depth in the computer plane Graphics are the true expression of the designer's thoughts and creativity. The three-dimensional graphics in the computer have a three-dimensional appearance[6-7], which looks very real, but does not have a real distance space. as the picture shows.

The word "digital" in three-dimensional digital art emphasizes the important feature of this emerging art, that is, "digitalization". This "digitalization" process is based on the computer graphics system, which includes hardware and software. The hardware part involves graphics input, processing, display, storage, and output. The software part involves graphics generation and display. , Processing algorithms, and storage and exchange formats of graphic data, interactive functions play an increasingly important role in digital art. The digitalization process of computers has brought inestimable influence to the art field. The simulation of objective things and the reproduction of the subjective virtual world of art creators, the realization of virtual reality of human interaction and human-computer interaction have opened up new possibilities for artistic creation.

3.2 Modern Packaging Technology

With the rapid development of science and technology, commodity packaging has become an important means to promote sales and enhance competitiveness. Many new technologies, new processes, and new ideas have been applied to packaging design, packaging technology, packaging equipment, new packaging materials, and new packaging industries. Packaging design has entered the age of computerization, and a design method that is suitable for fast updating and with the aid of computers and various information systems has emerged. Today's designers must have the basic skills of packaging design, and more importantly, they can think, appreciate, and understand creativity. Computer technology is based on the aforementioned skills. Packaging designers must also know the relevant packaging production process, how to select materials, and how to use modern packaging manufacturing equipment, such as pre-press process equipment, post-press processing equipment, etc. Computers and packaging software are the main hardware for packaging design in the future. The ability of designers to appreciate is the key to the success or failure of packaging design. The packaging process mainly refers to the manufacturing process in the packaging production process, such as packaging molding process, packaging modification (finishing process), etc., have gone through a process of improvement and perfection. Packaging molding includes the molding of metal packaging, plastic packaging, paper packaging, and other composite packaging. Extrusion, hot pressing, stamping and other forming for plastic packaging have gradually been used in the forming of cardboard packaging. In the past, the embossing (concave) forming of cardboard carton packaging was difficult and has been basically solved. Many packaging molding materials of different materials have been simplified and scientifically made with the help of air pressure, impact, wet processing, and vacuum technology.

3.3 Three-Dimensional Digital Art Design Method

(1) Lighting in a three-dimensional digital scene

Digital lighting is an important picture element of the three-dimensional visual art expression. The external and internal functions it displays need to be controlled and displayed in a suitable way. This control method is called "lighting". Lighting is the prudent control of light in order to achieve the aesthetic purpose of the external and internal functions of light[8-9]. The standard photography lighting technique is also called the law of photography. It is a triangular arrangement of main light, auxiliary light and outline light. The outline light is directly behind the object and directly facing the camera. The main light and auxiliary light are placed at opposite positions on both sides of the camera and hit the object. Forward. This technique is also commonly referred to as three-point lighting. As shown in Figure 1 below, the distant and near scenes under the influence of light affect each other.

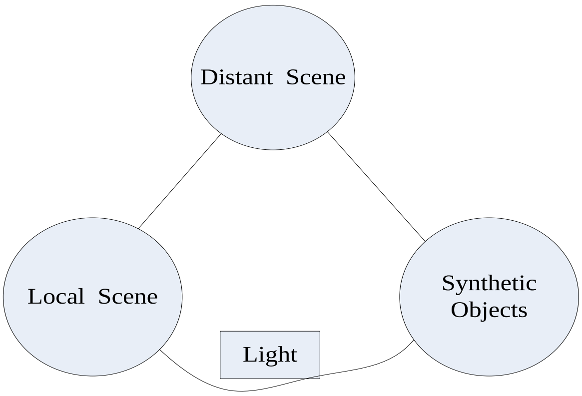


Figure 1. Interaction of scenes under light

Designers can carry out three-dimensional design in virtual space, such as interior design, installation design, etc.

(2) Achieve a sense of "truth"

When art and computer graphics meet and intertwined, "reality" has become one of the important creative methods of three-dimensional digital art. On the basis of simulating the "realistic" world, it can also create things that do not exist in the real world, surpass reality to "virtualize" a new art world, so that while we have the real art world, we also have another A virtual world, to achieve new visual and psychological experience, this is the new pleasure brought to us by three-dimensional digital art. With the participation of computers, virtual cameras were used to replace real cameras, and virtual digital lights replaced real lights to achieve the three-point lighting effect in the studio[10-11].

(3) Coloring technology

In 3D digital art, it can be simply divided into two categories. One is the establishment of three-dimensional digital model and its animation. The second is to realize the final output of the final image or animation through three-dimensional digital rendering.

1) Digital coloring

The visual appearance of the simulated three-dimensional environment is mainly determined by the coloring process. Just like the traditional way of painting, coloring, coloring, and portraying a virtual image or scene in the mind to make it appear. This is the process of coloring[12-13]. This process also exists in digital art. It is just to convert the image in the mind into a digital model, and then describe the digital architecture in the digital environment.

2) Digital lighting

Analog light sources are also essential for digital shading, and digital surfaces that are defined without them cannot be output. Its type, location, size, color, and intensity all require artists to customize.

3) Digital rendering

To output the result of digital coloring into visual information that can be recognized, this process is called rendering. Its noun form is now translated into a renderer. There are many rendering methods that can be used to transform the wireframe of a 3D model into a rendered image. In addition to skillfully placing light sources and specifying surface features of objects in the scene, users rely on the ability to use rendering methods or algorithms. Part of the reason for this is that most rendering methods are usually provided as "black boxes" that only accept geometric data and shading variables (such as lighting, color and surface characteristics), but cannot be modified by the user.

4) Renderman coloring language

The program used to describe the output of the light source and simulate how the light is attenuated in the surface and space becomes the programming language corresponding to the shader, that is, the shading technology language. Procedural coloring is the most powerful and vital part of Renderman language. RSL (Renderman Shading Language, Renderman Shading Language) is a powerful tool specially designed for depicting the interaction surface of virtual lights and digital surfaces based on C language. But even artists who have no programming experience can easily understand how it works[14-15].

3.4 Iterative Closest Point Algorithm IPC Implementation

1) Assuming that the given point cloud P is the target point cloud, denoted by $P=\{P_i | P_i \in \Re^3, i=1,2,...,N\}$, the number of point clouds is N_P, the given point Q is the reference point cloud, denoted by $Q=\{Q_i | Q_i \in \Re^3, i=1,2,...,M\}$, the number of point clouds is N_Q, and meets $N_P \le N_Q$. Determine the corresponding point pairs that have a mapping relationship between point clouds P and Q, and form a set. The search methods mainly include point to point, point to tangent plane, K-d tree search, octree search, etc [16].;

2) Find the initial rotation matrix T_1 and translation parameter R_1 according to the searched corresponding point pair set

$$P_1 = R_1 Q_0 + T_1 \quad (1)$$

Where P_1 and Q_0 represent the points in the target point set P and reference point cloud Q, respectively. The most typical methods for obtaining translation and rotation parameters are mainly quaternion singular value decomposition, etc [17-18].;

Use the translation and rotation parameter Q_1 pairs obtained above to perform coordinate transformation to obtain a new set of transformation points Q_2

$$Q_2 = R_1 Q_1 + T_1 \quad (2)$$

Repeat steps 2) and 3) to perform iterative calculations, where m represents the number of corresponding point pairs:

$$P_m = R_m Q_{m-1} + T_m \quad (3)$$

$$Q_{m+1} = R_m Q_m + T_m \quad (4)$$

The new transformation point set and reference point cloud obtained in step 4), these two point sets can be used during registration conversion Minimize the objective function:

$$f(R,T) = \sum_{i=1}^{N_P} \left\| Q_i - (RP_i + T) \right\|^2 \quad (5)$$

Among them i represents any point in the point cloud. Stop the iteration when the objective function is minimum, and get the mean square error d_{m+1}

$$d_{m+1} = \frac{1}{N_P} \sum_{i=1}^{N_P} \left\| P_i - R_{m+1} Q_m - T_{m+1} \right\|^2 \quad (6)$$

Assuming a given iteration convergence threshold τ, and $\tau > 0$, the mean square error $d_m - d_{m+1} < \tau$ between two adjacent iterations, the iteration is stopped. If formula (6) is not satisfied, repeat step 4) to iteratively calculate a new set of points until the requirements of the objective function are met.

3.5 Point Cloud Filtering

(1) Gaussian filtering

Gaussian filtering is a linear filtering algorithm suitable for processing images containing noise. This filtering algorithm can effectively perform edge smoothing while retaining the information characteristics of the original data. The basic idea is to weight each image[19-20], that is, each The value of each pixel is obtained by weighted average processing of itself and the pixels in the neighborhood

$$g(x,y) = \frac{1}{2\pi\sigma^2} \exp\left(\frac{-(x-\mu_x)^2 + (y-\mu_y)^2}{2\sigma^2} \right) \quad (7)$$

In the formula, $g(x,y)$ represents the gray value of the processed image, σ represents the mean square error, and μ_x and μ_y represent the average value of the pixels x and y, respectively. The Gaussian filter can filter out the high-frequency data information in the specified area, which is helpful for suppression Noise points that follow a normal distribution[21-22].

(2) Bilateral filtering

The bilateral filtering algorithm is an algorithm that corrects the image edge information by calculating the weighted average of pixels in the neighborhood of the image, using the neighboring points to determine whether the point belongs to a feature point, and then calculating feature points and non-features according to point clouds in different ranges The bilateral filtering factor of points realizes the bilateral filtering point cloud denoising based on feature selection. In this process, the sampling points that are too "different" from the sample points will be removed to ensure the integrity of the original features, thereby achieving the purpose of filtering[23-24]. The expression is as follows:

$$BF(u)(x) = \int_{\Omega} w_D(x,y) w_R(x,y) u(y) dy \quad (8)$$

In the above formula $w_D(x,y)$, it represents the weight coefficients of pixels in x and y dimensions, $w_R(x,y)$ is the similarity weight of pixel values, where:

$$w_D(x,y) = \frac{1}{Z_D(x)} \exp\left(-\frac{\|x-y\|}{2\sigma^2 R} \right) \quad (9)$$

$$w_R(x,y) = \frac{1}{Z_R(x)} \exp\left(-\frac{\|\mu(x)-\mu(y)\|}{2\sigma^2 R} \right) \quad (10)$$

The bilateral filtering algorithm can fully consider the gray value of the image pixels, and can calculate the distance between each pixel point and the center point, which can effectively remove noise points and retain the edge feature information of the image. Therefore, this paper adopts bilateral filtering algorithm to reduce noise[25-26].

3.6 Normal Estimate

Normal estimation is often used in computer vision and other fields. It is an important part of the 3D reconstruction process. The position of the light source can be estimated by means of shadows and other visual images. Assuming that given a geometric surface, it is not easy to simply calculate the normal of the point. After obtaining the data of the point cloud on the surface of the target object, there are two options: one is to use gridding technology to obtain surface information from the point cloud dataset , Calculate the surface normal; The second is to infer the surface normal of the data set with the help of approximation. The problem of surface normal estimation can be transformed into a process of solving its tangent plane, which is further transformed into a problem of MLS[27-28].

MLS is one of the classic methods for observing and processing data, mainly through the physical parameters and other parameters related to the mathematical model to solve the physical parameters, to obtain the minimum square sum of the objective function $H(x,y,z)$:

$$E = \sum_{i=1}^{n} \left(H(x,y,z)\right)^2 = \min \quad (11)$$

Suppose the point cloud data is $p_i = (x, y, z)$, where $i = 1,2,\ldots,$ n meets the equation group $AX = b$, where A is the matrix of $n \times m$, X, and b are vectors of $1 \times m$. Analysis, assuming that the covariance matrix C of p_i at any point is:

$$C = \frac{1}{k}\sum_{i=1}^{k}(p_i - \bar{p})(p_i - \bar{p})^T, C \cdot v_{\bar{j}} = \lambda_{\bar{j}} \cdot v_{\bar{j}}, j \in \{0,1,2\} \tag{12}$$

Where k represents the number of points closest to p_i, $\bar{p}$ is the center of k points, λ_j represents the j feature value, and $v_{\bar{j}}$ represents the j feature value feature vector[29-30].

3.7 Hardware Design

(1) Modeling: Maya, Zbrush;
(2) Motion capture: Motion capture system;
(3) Post-processing: After Effects.
(4) Instruments and equipment: Kinect equipment, Matlab,

3.8 Experimental Procedure

The general steps for the three-dimensional visualization of product packaging digital design are shown in Figure 2. Through this step, the visualization of modern packaging design can be achieved.

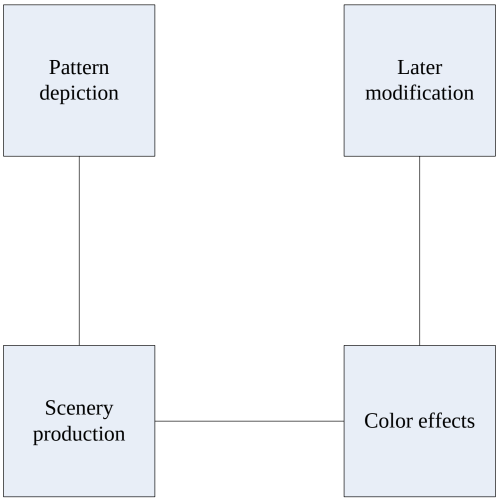


Figure 2. Production process planning

As can be seen from Figure 2, first use 3D studio MAX software to design and model the packaging structure; the divided graphic files of the graphic design graphics are divided into 3D studio MAX texture materials; use sub-object texture editing commands, Assign the texture material of each structural surface to the corresponding structural surface, and adjust the parameters to make the visualization effect consistent with its design concept; adjust the output perspective of the rendering and render the output. Finally, design evaluation of the output effect, if not satisfied, return to modify.

3.9 Experimental Design

(1) Improved RANSAC algorithm segmentation experiment

1) Experiment 1: Segmentation experiment of plane point cloud data

Set the initial threshold for plane judgment to 0.03, the threshold to the interior point to the plane to 0.01, and the angle threshold to the point cloud data of the desktop cup model collected by Kinect, including plane and non-plane point cloud data. The undivided initial point cloud data is a cylinder model obtained by using the RANSAC algorithm. This segmentation result obviously divides the effective point cloud data together, indicating that the cylinder is divided by the improved RANSAC algorithm. The model represents a plane point cloud data model segmented using the improved RANSAC algorithm, and the effect is good.

2) Experiment 2: Point cloud data segmentation experiment

For the segmentation experiment of the point cloud data in the indoor scene collected by the Kinect device, set the initial threshold of the plane to 0.01, set the distance between the inner point and the plane to 0.05, and set the angle threshold to the same as that of Experiment 1. It can be seen in the initial point cloud data that the point cloud data to be divided contains a large amount of background data and noise data. In order to effectively segment the target point cloud, the experiment first uses the RANSAC algorithm to process the initial point cloud data, and most of the background has been segmented The number of data and point cloud data has also been reduced from 217085 to 13652. However, in the figure, it can be clearly seen that the segmented target point cloud has unsuccessfully segmented point cloud data in the upper left, lower left, and upper right. In addition, the target point cloud segmented by the RANSAC algorithm is missing at the arm .

3) Experiment 3: Desktop cylinder model segmentation experiment

The desktop cylinder model segmentation experiment collected by Kinect set the initial judgment threshold of the plane to 0.04, set the distance from the inner point to the plane to 0.05, and set the angle threshold unchanged. The point cloud data to be segmented has three cylinders with different shapes on the desktop. The purpose of the experiment is to effectively segment the highest cylinder model. The experimental results after the RANSAC algorithm segmentation has effectively segmented the remaining two cylinders, but at the same time, the desktop point cloud data has not been effectively segmented. The point cloud data segmented by the algorithm in this paper effectively segmented the target point The cloud model is segmented, and the desktop point cloud data is segmented.

(2) Improved ICP algorithm experiment

1) Experiment 1 Bunny point cloud model

The Bunny point cloud models from different perspectives are used, namely the bunny_000.pcd model with 40256 point clouds and the bunny_045.pcd model with 40097 point clouds. In the experiment, the traditional ICP algorithm and the improved ICP algorithm were used to perform point cloud splicing, and the splicing effect was obtained. It can be seen from this that the traditional ICP algorithm has a large degree of misalignment during the splicing process, especially on Bunny's ears, back and entire body, it can be seen that a good splicing effect cannot be obtained.

2) Experiment 2 Dragon point cloud model

The Dragon point cloud model with a small number of point clouds is selected, and the experimental results are shown in the figure. The initial number of point clouds is 19318 and 30492 respectively. The picture is the result of stitching by traditional ICP algorithm. It can be seen that the stitching of Dragon point cloud on the torso and head is fuzzy, the posture is poor, and the stitching is misaligned. It can be seen from this that Dragon's torso is well spliced, especially when the foot and head are completely spliced, and the effect is excellent.

3) Experiment 3 Kinect 3D human point experiment

In order to further verify the universality of the algorithm in this paper, Experiment 3 uses a set of 3D human point cloud data collected by Kinect for the experiment. Two unspliced initial point clouds, the number of point clouds is 12675 and 14742 respectively. It can be seen from the figure that the unimproved traditional ICP algorithm has a head offset during stitching, and the arm parts and body parts also overlap, the posture is poor, and the stitching accuracy is low.

4.Discussion

4.1 RANSAC Algorithm Segmentation Experiment Analysis

In order to verify the performance of the improved RANSAC algorithm, the three sets of point cloud data collected by Kinect were respectively segmented using the RANSA algorithm and the improved RANSAC algorithm.

Table 1. Segmentation error before and after improvement

	Number of point clouds	Threshold setting		RANSAC		Algorithm	
		Judgment/ m	Distance/ m	Nun/ piece	Error/ mm	Nun/ piece	Error / mm
Test 1	307200	0.03	0.01	116336	45.6%	139897	37.9%
Test 2	217085	0.01	0.05	24123	11.1%	13652	6.3%
Test 3	94483	0.04	0.05	64093	67.8%	23315	24.7%

Using the number of point clouds in the three sets of experiments as reference data, the effectiveness and accuracy of the algorithm in this paper are quantitatively evaluated. Table 1 shows the comparison results. It can be seen from this table that the number of point clouds after the point cloud data in the planar point cloud data segmentation experiment 1 is 336,336 after RANSAC segmentation, and the number of point clouds after segmentation by the algorithm in this paper is 139,897, the error rate is reduced from 45.6% to 37.9%; point cloud data segmentation experiment 2 is a segmentation experiment performed on scene point clouds with a lot of noise point clouds and background point clouds. The segmentation error rate is also reduced from 11.1% to 6.3%. Point cloud data is effectively segmented and the effect is obvious , The accuracy is high, which proves the effectiveness of the algorithm in this paper; desktop cylinder model segmentation experiment 3 is a set of desktop point cloud data with a relatively small number of point clouds. After judging threshold and distance threshold are set reasonably, the two algorithms are segmented The error rate changed significantly. The point cloud data was reduced from the original 94,438 to 23,315, and the error rate was also reduced from 67.8% to 24.7%.

The original RANSAC algorithm and the improved RANSAC algorithm are used to perform image matching results. The number of iterations is compared with the events consumed, and each group of contrast images is compared in a loop. The total number of iterations and total time for each algorithm are counted, and the average is calculated each time. The number of iterations and time consumption required by the mismatch algorithm, and the minimum and maximum number of iterations and time consumption of each group of experimental images are recorded at the same time. Table 2 shows the comparison of the two algorithms.

Table 2. Performance comparison between traditional algorithm and improved algorithm

Atlas	Parameter	Traditional RANSAC algorithm	Traditional RANSAC algorithm
$\varepsilon = 58.96\% N = 128$	$k_{\max}$	12	2
$\varepsilon = 92.45\% N = 369$	$k_{\max}$	4	2
$\varepsilon = 74.85\% N = 385$	$k_{\max}$	9	2
$\varepsilon = 89.15\% N = 314$	$k_{\max}$	5	2
$\varepsilon = 88.09\% N = 482$	$k_{\max}$	2	2
$\varepsilon = 84.45\% N = 341$	$k_{\max}$	2	9

After comparing the hardware design related to the RANSAC algorithm in recent years, it is found that the traditional RANSAC algorithm and the improved RANSAC algorithm occupy LUTs, registers and other hardware resources and algorithm performance. The three-point collinearity and other abnormal problems may also cause The matrix equation has no solution or no unique solution, resulting in low efficiency in the logic use of hardware resources. As shown in Table 3, the improved RANSAC algorithm hardware implementation structure has a good use of logic computing resources and can work in a high-frequency environment.

Table 3. Resource occupancy and performance comparison table

	Method one	Method two	Ways to improve
Four input LUT	97972	6278	1284
Register	12724	6742	1287
SRAM	5746bit	3247859bit	6219bit
Soft core	-	1	-
Maximum frame rate	56fps	-	46fps
Largest feature point	128	512	1024

4.2 Experimental Analysis of Improved ICP Algorithm

In Experiment 1, the Bunny point cloud model was spliced with an improved ICP algorithm, and it can be seen that Bunny's ears, feet, and head are completely spliced compared to the traditional ICP algorithm, with a good posture, and a better comparison in the tail and back The traditional ICP algorithm has also been significantly improved. In Experiment 2, the Dragon point cloud model improved 19.11% in iteration time compared to the traditional ICP algorithm. It can be seen that the improved ICP algorithm greatly reduces the stitching error and reduces the iteration time spent when the initial point cloud has a good posture. It can be seen that the improved algorithm has decreased in calculation. Experiment 3 After the Kinect 3D human point experiment was spliced by the improved ICP algorithm, the iteration time was also reduced from the original 0.821 / s to 0.567 / s, an increase of 44.8%. The details are shown in Table 4 below.

Table 4. Comparison of splicing performance of two algorithms

Point cloud name	Number of point clouds	Traditional ICP algorithm		Improved ICP algorithm	
		Time/s	Error/mm	Time/s	Error/mm
Bunny	800353	1.5541	0.013	1.045	0.119
Dragon	49810	0.586	0.581	0.474	0.417
3D human body	27417	0.821	3.560	0.567	0.624

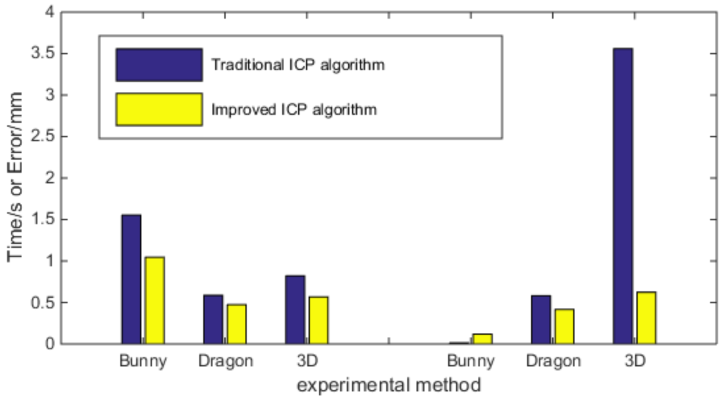


Figure 3. Performance comparison between the traditional ICP algorithm and the improved ICP algorithm

As shown in the comparison results of the stitching performance of the two algorithms in Figure 3 and Table 4, it can be analyzed that the improved ICP algorithm will greatly surpass the traditional algorithm. The iteration time and mean square error are evaluated as the standard of convergence effect. The mean square error is recorded as error and the iteration time is recorded as time. The improved ICP algorithm sets a threshold to restrict the search range on the search of the nearest point set to avoid The traditional ICP algorithm finds a corresponding point in the reference point cloud for each point in the target point cloud, which is a computationally intensive process. Instead, it removes points outside the threshold range, thereby reducing the search calculation. the amount.

The experimental results of the above three sets of point cloud data are shown in Table 4. It can be seen from the table that the iteration time is improved by 19.1% ~ 47.4%, and the mean square error is also better than the traditional ICP algorithm, which shows the effectiveness of the algorithm in this paper.

Table 5 shows the experimental data of the ICP registration part of the points and faces of the simplified CAD model, where R is the radius of the CAD model constructed, in mm; ER is the distance error after registration, in mm.

Table 5. ICP registration experimental data

R/mm	ER/mm	R/mm	ER/mm	R/mm	ER/mm	R/mm	ER/mm
410	6.1945	411	5.2121	412	5.4872	413	4.9170
414	6.1024	415	4.8915	416	4.8752	417	4.8475
418	5.3210	419	4.5982	420	5.5045	421	4.4184
422	5.1248	423	5.4712	424	5.2179	425	4.5461
426	4.2437	427	4.6529	428	4.2745	429	4.5984

4.3 Analysis of Advantages of Digital Design of Product Packaging Compared with Traditional Manual Design

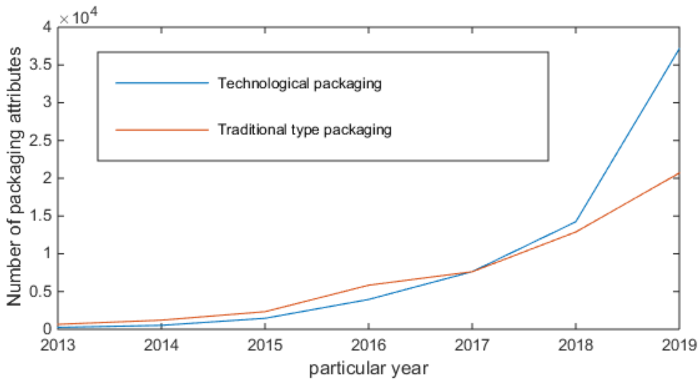


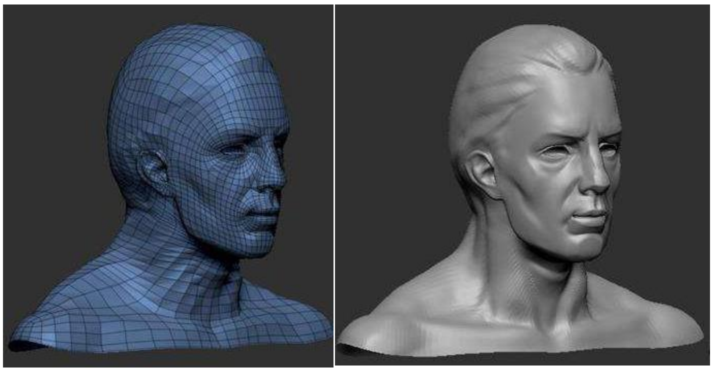
Figure 4. Development trend of traditional packaging design and technological packaging design in the past 7 years

Figure 4 shows the development trend of traditional packaging design and technological packaging design in the past 7 years. It is not difficult to see that the design with technology has attracted more and more consumers, and the three-dimensional digital art is the best performance of packaging design technology the way. In the entire design process, the "planar graphics processing" stage realized the transformation of hand-drawn manuscripts into electronic computer graphics. In this process, the main task was to complete the matching of graphics, copywriting, and color, and adjust some details. The visual habits of the users are analyzed to obtain the best implementation plan. Finally, in the "realization of three-dimensional visualization" stage, it mainly solves the structure and shape of product packaging, and realizes the structure of the packaging through three-dimensional virtualization technology and related data analysis. The shape is more in line with consumers' usage habits, and at the same time makes the entire design process faster and saves time and materials.

4.4 Examples of Artistic Expression of 3D Digital Lighting

(1) Three-dimensional visual analysis of product packaging digital design

In the process of making the character model, the Maya 3D animation software Maya produced by American Autodesk is used as the main tool, and Zbrush can be used to provide technical assistance for the characteristics of detailed sculpting effect. As shown in Figure 5, the left is modeling the character. In the process of using Maya modeling, there are mainly modeling methods using polygon, because the UV of the nurbs model is automatically generated and cannot be adjusted manually, so it is not convenient to use.



(a) **(b)**

Figure 5. Character modeling and basic characterization

As shown in the right side of Figure 5, this project first used Maya to complete the basic production of the model, and then used Zbrush software to finely sculpt its parts to make it more realistic and expressive in detail.

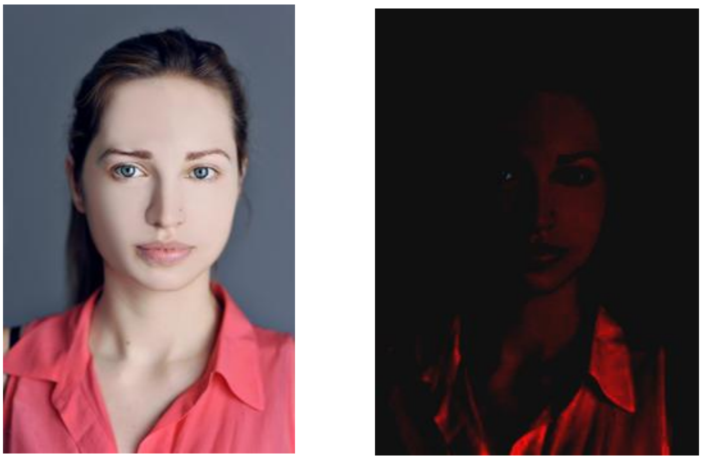
The special effect halo analysis, as shown in Figure 6 below, the street lamp itself will have halo in the humid air. First, set the light bulb to a yellowish self-luminous material, then set a floodlight at this position, and set it to volume at the same time Light and use light attenuation to make it a translucent halo around the bulb. In order to invade the bulb itself to appear more realistic, a halo special effect was set for the bulb in the video post rendering.

Figure 6. Analysis of renderings of street lamps and wall lamps

As shown in the right side wall lamp of Fig. 6, due to the lampshade, the direction of light projection has changed, and there will be a certain downward irradiation range. There is a blurry aperture on the ground. Spotlights, at the same time, in order to make the spotlight effect suitable for the blur effect of street lights, it is more natural to set the inner and outer aperture distances very open. The setting of the wall lamp is basically similar to the street lamp. The difference is that the wall lamp does not use a downlight, but a floodlight with a light attenuation set to illuminate the wall.

(2) Analysis of the impact of digital lighting on design

We used light to see everything true. In packaging design works, a very intuitive role of light is to highlight the main body. In the three-dimensional art creation, we can highlight the main body of the package through the brightness of the light and the specific directionality of the light to create a novel atmosphere.



(a) (b)

Figure 7. Initial point cloud image and Point cloud image after bilateral filtering

Figure 7 (a)shows the image information collected using Kinect, and Figure 7 (b)shows the result of processing the original image after a bilateral filtering algorithm. The bilateral filtering algorithm can fully consider the gray value of the image pixels, and can calculate the distance between each pixel point and the center point, which can effectively remove noise points and retain the edge feature information of the image. Therefore, this paper adopts a bilateral filtering algorithm to reduce noise.

(3) Scene analysis under 3D lighting

Figure 8. Street view under 3D lighting

As shown in Figure 8, the work represents a virtual street scene. Since the artistic requirements are not only true, it also considered how to present the atmosphere with subjective emotions as much as possible while showing the reality It is not a simple mechanical depiction of reality. Therefore, through refining, combining and reprocessing to realize the subjective virtuality of the real street. According to the needs, it is definitely the core element in the art work-lighting.

Through the simulation and discussion of digital lighting, as well as the analysis of examples, it has further enriched the methods and laws of verifying the artistic perception and technical feasibility. It can be seen that starting from the principles of art, the conclusion that the final return to the realization of artistic effects through the technical approach is of guiding significance for the creation of three-dimensional digital scenes. Only in this way can a satisfactory solution be given to the balance between art and technology in creation.

5. Conclusions

When the target is closer to the robot vision system, the vision system obtains the depth information of the target soccer ball is more stable and the accuracy is higher. When the target is far away from the robot's binocular camera, there is a small depth difference, and the matching effect is not significant.Three-dimensional digital art is an important medium for packaging design. It organically integrates with modern packaging design, making packaging design more visually expressive and visually impactful. Three-dimensional digital art can present three-dimensional digital images with length, width and depth on two-dimensional computer planes with only length and width, which can copy and reproduce the real world. Using 3D digital technology, designers can not only simulate the real world, but also create a virtual world, allowing viewers to deeply feel the new visual effects and psychological experience. Three-dimensional digital art has realized more practical application value for packaging design, and has continuously enriched the modern needs of society and designers for packaging design.

This paper proposes an improved RANSAC algorithm, which can achieve effective segmentation of point clouds, and has a good segmentation effect, which can improve the accuracy of segmentation while reducing the segmentation error rate. In the point cloud stitching stage, the improved ICP algorithm can get the point set with the closest Euclidean distance. Experimental results show that the improved algorithm not only reduces the amount of calculation, but also improves the accuracy and speed of the algorithm, and has obvious advantages.

This article mainly introduces the use of interactive digital three-dimensional art technology to carry out in-depth research and application of modern packaging design, combining the two methods with traditional packaging design, and designing and developing new packaging design. This time by comparing the advantages of the coordinate axis method to the traditional traversal algorithm under the latest ICP algorithm, the experiment is split in the RANSAC algorithm And improved ICP algorithm experiment performance analysis. As a result, it has brought in-depth changes in three-dimensional technology, and nearly 50% of the packaging design in the current market tends to be modern three-dimensional digital technology to better meet market demand.

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