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Clothing Design System based on Intelligent Image Rendering Technology

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Abstract:

In order to improve the color expression effect of clothing design, this paper combines the intelligent image rendering technology to construct the clothing design system. Moreover, this paper studies the algorithm idea of the rendering algorithm and its neural network structure, and uses the shader file to simulate the forward propagation of the neural network framework to perform pixel-by-pixel parallel computing. In addition, in this paper, the scene environment information and the parameter set obtained by training are multiplied by a series of matrix vectors to calculate the ambient light occlusion results. Finally, this paper studies the image rendering process through simulation to improve the effect of clothing design. The simulation results show that the clothing design system based on intelligent image rendering technology proposed in this paper has good results.

Key words: intelligent image; rendering technology; clothing design; system

1 INTRODUCTION

In the process of clothing design, its style, production process and color matching will have a corresponding impact on the visual experience of consumers. Therefore, it is necessary to pay attention to all aspects of clothing design. Moreover, a reasonable color matching scheme can bring good visual impact to customers, which is in line with consumers' aesthetic concepts. On the basis of reasonable color matching, with good clothing style and excellent production technology, the specific value of clothing design can also be effectively reflected. Therefore, in the process of clothing design, it is necessary to pay attention to the basic principles of color matching and its application, so that the clothing design can achieve better results and meet the aesthetic level of the public in modern society.

In the evolutionary process of human beings, the reason for feeling the colorfulness of the world through the eyes is that the existence of light absorbs or reflects different light on the surface of the object, which produces a certain color feeling in people's eyes, so that people can have a corresponding visual experience [1]. Therefore, based on the principle of refraction and reflection of light, people's eyes can see the color of the surface of the object and perceive the existence of light. On this basis, the light source becomes the basic condition for color formation. By studying light in combination with color, it can be found that the combination of light and photosensitive vision can perceive color, and people have different experiences with different colors, and there is a certain connection between these elements [2]. After people's living standards are getting higher and higher, in order to satisfy people's aesthetic taste in clothing, corresponding clothing colors are produced, which is also the most primitive instinct of human beings to decorate and beautify themselves with colors. For example, in primitive society, people will smear mineral pigments and plant pigments on their bodies. At the same time, some people wear brightly colored animal feathers, bark, and dyed shells on their bodies in order to decorate themselves, which initially shows people's awareness of the aesthetic awareness of clothing colors [3].

Because people have a sense of hierarchy, the use of color reflects the differences of the ruling class in the feudal society and the relevant normative requirements. With the further development of society, the changes of colors in modern society and the beauty they produce are more in line with the characteristics of the times. Moreover, with the changes in people's ideas and aesthetic standards, there will be corresponding changes. Therefore, in modern society, color matching reflects more diverse characteristics. The Modern Optical Research Center divides colors into two types: achromatic and chromatic. Among them, the achromatic system is mainly black, white and gray. Although there is no achromatic system in the visible spectrum in terms of physics, from the perspective of people's psychology and objective cognition, achromatic has the properties of complete color at the same time. The actual role of this part of the color in the overall color system cannot be ignored. Some well-known fashion designers have successfully created some classic fashion design works through black, white, gray and achromatic collocation design, which has become a model for other designers to reference and imitate in the process of clothing collocation design.

This paper combines the intelligent image rendering technology to build a clothing design system, and studies the image rendering process through simulation to improve the effect of clothing design.

2 RELATED WORK

3D garment CAD technology refers to the whole process of 3D body measurement, 3D garment design, 3D cutting, 3D fitting and 3D dressing effect display on electronic computer [4]. By consulting a large number of Literatures, it mainly summarizes the research situation of 3D virtual technology in three aspects: cloth simulation, 3D virtual suture technology and human body modeling, 3D software types and applications [5].

In the clothing virtual technology, the cloth simulation technology is the key, and the human body model is the carrier, which is mainly used to present the cloth simulation effect. Literature [6] used a 3D digitizer to obtain the 3D space points on the human body model (human platform), and then obtained the 3D digitized human body model by fitting the 3-order B-spline surface. Cloth simulation includes cloth texture simulation and cloth drape simulation. To digitize the texture of fabrics, digital scanning of real fabrics can often meet the requirements. Of course, there are other simulation methods of cloth texture [7]. In terms of cloth simulation, cloth simulation involves a wide range of techniques, such as mechanical simulation, numerical integration, collision detection, constraint and stitching, and rendering techniques, which are used to present the effect of simulated clothing [8]. The goal of mechanical simulation is to generate a model that allows us to quickly and realistically simulate the basic properties of fabrics; numerical integration is a key technique for the efficient execution of simulation systems and is often used in particle system models; collision detection algorithms usually vary according to geometric properties, specific There are boundary methods, projection methods, subdivision methods, infinite proximity methods, etc.; constraints and stitching refer to the purpose of moving to, or simply keeping stitched together by an additional action or restriction; rendering techniques are the appearance of cloth to some extent Rendering, such as through shading and lighting, to make the simulation of cloth more realistic [9].

Literature [10] established a general elastic model and applied it to the drape simulation of clothing. At this time, the simulated cloth texture can be clearly distinguished from metal and plastic; Literature [11] proposed a method based on surface deformation. The physical model of clothing realizes the fluttering of flags and the swinging of curtains; Literature [12] uses a hybrid model of geometry and physics to simulate clothing wrinkles, and Literature [13] uses an elastic model to simulate the dynamics of wrinkles on handkerchiefs Formation; Literature [14] started from the research of cloth simulation, and realized the physical simulation of cloth under the action of gravity and the collision detection and response of cloth, floor and ball. The deformation calculation of the cloth is realized by the calculus method, and the mechanical model of the cloth is constructed by using the particle-bounce model. Literature [15] uses the particle-spring model to simulate cloth, in which there are three types of springs: structural springs are used to connect closely connected transverse and longitudinal particles to fix the cloth structure; shear springs are used to connect in a Adjacent mass points on the diagonal can prevent the cloth from twisting and deforming; the tension spring is used to connect the two particles that are separated by a particle in the longitudinal and lateral directions, so that the edge of the cloth is smooth when folded. Literature [16] uses collision detection The method is to perform collision detection between clothing and human body, and process the penetration point of the detected clothing model, so that the clothing can automatically adapt to the new human body model to achieve the purpose of reuse.

Literature [17] divides the surface of the human body into 6 parts according to the shape of the human body, and triangulates the point cloud of each part of the human body separately, and then proposes a method of dividing a single contour into multiple contours. The human torso, arms, and torso and legs are synthesized, and finally a complete human triangular mesh surface model is generated; the Literature [18] does not support non-standard human bodies in the existing clothing human modeling methods, and proposes a universal three-dimensional clothing human body. Modeling method of the table. Based on the analysis of the existing standard and non-standard human body 3D scanning data, the general human body template database and the corresponding automatic selection algorithm are established to solve the non-standard human body modeling distortion problem by defining the parameters suitable for the general human body. The template matching algorithm extracts similar parts from it and performs curve fitting and interpolation processing to generate a human body model. In view of the disadvantages of traditional 3D scanners such as high price and complicated operation, Literature [19] proposes a reconstruction method based on an inexpensive depth camera (such as Microsoft Kinect). 3D human body model. The method uses iterative nearest point search to determine the corresponding point pairs between the input point cloud and the deformable model, fits the deformable human body model to the scanned point cloud data, and iteratively generates a high-precision 3D human body model.

3 INTELLIGENT IMAGE RENDERING TECHNOLOGY DESIGN

Computer graphics is the study of how to represent graphics in computers, and the related principles and algorithms for computing, processing and displaying graphics using computers. In order to adapt to hardware of different specifications and interfaces, the current graphics rendering has a fixed workflow, so it is called a graphics rendering pipeline. The graphics rendering pipeline mainly includes two functions: one is to convert the 3D coordinates of objects into 2D coordinates in screen space, and the other is to color 0 for each pixel of the screen. The graphics rendering pipeline has developed from a fixed pipeline to today's programmable pipeline, which not only provides more functional support, but also gives developers more freedom to play. The programmable pipeline is shown in Figure 1.

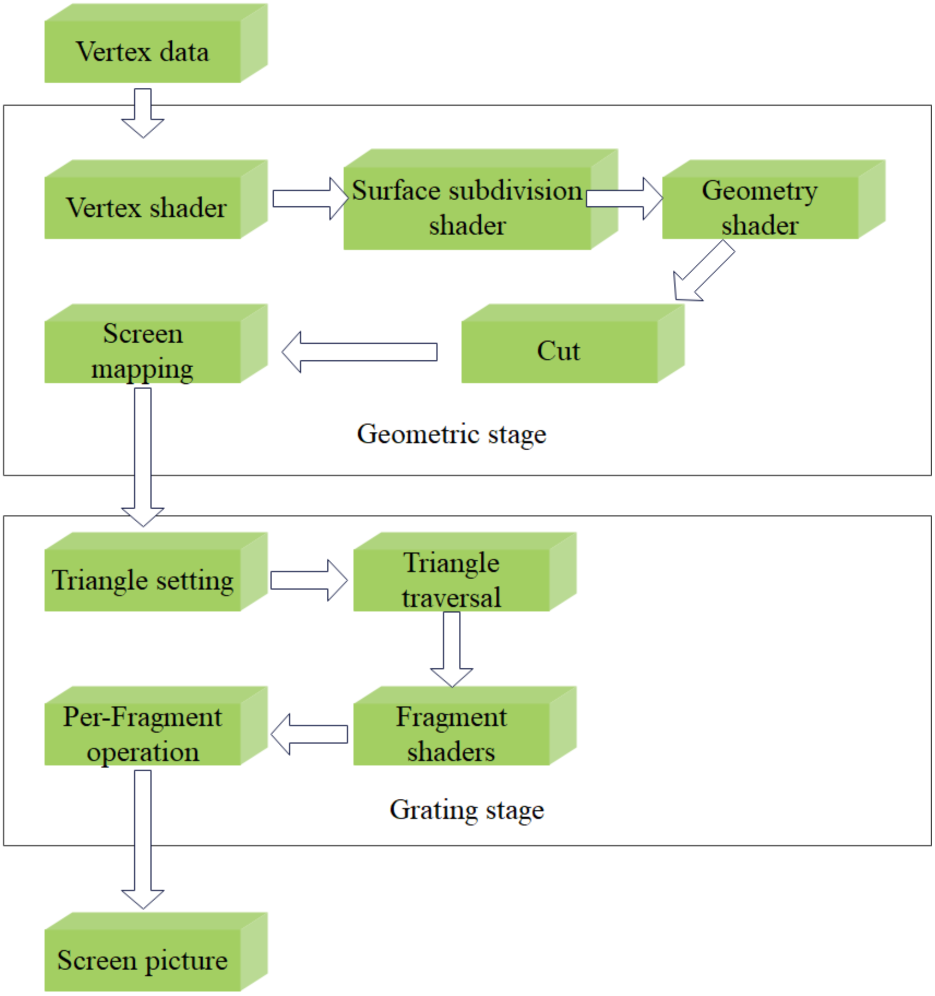

Figure 1 Programmable graphics rendering pipeline

Triangle setup and triangle traversal in the rasterization stage is done automatically by the hardware, and it does the operations of triangle assembly and traversal. Fragment shaders are used to perform shading calculations and rendering operations for each fragment on the screen. At this stage, lighting calculations and shadow processing are performed, which is where the advanced effects of the rendering pipeline are generated. The final fragment-by-fragment operation stage will perform operations such as fragment testing, color mixing, and transparency culling.

Among them, vertex shader, tessellation shader, geometry shader and fragment shader are fully programmable and can generate various rendering effects according to requirements.

The lighting model is a typical lighting empirical model, namely:

$$I_{Phong} = k_a I_a + k_d \left(n \cdot I\right) I_d + k_s \left(r \cdot v\right)^{\alpha} I_s \quad (1)$$

Among them, k_a, k_d, and k_s are the environmental reflection coefficient, diffuse reflection coefficient and specular reflection coefficient of the material, respectively, and I_a, I_d, and I_s represent the ambient light reflection, diffuse reflection and specular reflection components of the light source color, respectively, v is the vector pointing to the camera. The factor α is the glossiness of the material and controls how wide the highlights are in the highlight areas. The larger α is, the smaller the bright spot is. In addition, the reflection vector r can be calculated by the reflection equation according to the light incident vector 1 and the point normal n:

$$r = 2\left(n \cdot I\right)n - I \quad (2)$$

From formula (2), we can see that if we determine the color of the light source and the reflection coefficient of the material of the object, the color of the reflected light reaching the observer from a certain point on the surface of the object is only related to the incident angle of the light source and the viewing angle. This simplification allows us to quickly calculate lighting results in dynamically changing virtual scenes.

In the lighting model, the angle between the observation vector v and the reflection vector r is not allowed to be greater than 90 degrees, otherwise, the dot product of the two will become negative. We will truncate this negative number to 0 when calculating, so that the specular highlights are completely invisible. After that, another method for calculating specular highlights was proposed. The Phong lighting model using this method is called the Blinn-Phong lighting model:

$$I_{Blinn-phong} = k_a I_a + k_d \left(n \cdot I\right) I_d + k_s \left(n \cdot h\right)^{\alpha} I_s \quad (3)$$

The specular highlight calculation principle is not to calculate the reflection vector, but to replace it with a vector h called a half-angle vector (Half-Angle). It is the intermediate vector between the ray incident vector 1 and the observation vector v:

$$h = \frac{l + v}{\left\| l + v \right\|} \quad (4)$$

After introducing the concept of half-angle vector, the angle between the observation direction and the reflection direction will not affect the result. That is, when the viewing direction is approximately parallel to the surface of the object, the highlights are more concentrated and closer to the real effect. These two models simplify the real lighting structure, the rendering power is insufficient, and the plastic effect is heavy. If we want to simulate a rendering effect close to the real scene, we need to build a physically based lighting model.

Ambient occlusion uses a simplified lighting model to analyze and calculate the light path. The principle and idea of the algorithm are not complicated.

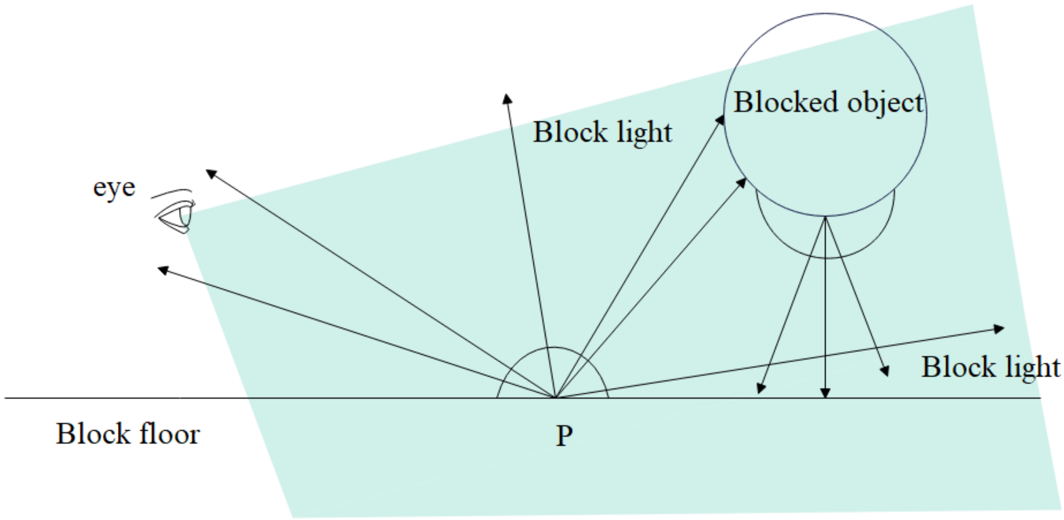

Figure 2 Ambient occlusion shadow formation principle

As shown in Figure 2, when we want to calculate the AO value of point p, countless rays are emitted in the hemisphere space P where the normal n of point p is located, and these rays will interact and reflect with objects in the scene. If the light does not collide with the object in a certain range of space, it is assumed that the light is not blocked and can enter the human eye. Otherwise, as occluded, it needs to be added to the AO calculation. Therefore, the typical AO calculation formula can be expressed as:

$$AO(p,n) = \frac{1}{\pi}\int_{\Omega} V(\omega, p)\max(\omega \cdot n, 0)\,d\omega \quad (5)$$

Among them, v is a binary function, if the light is blocked by the object, its value is 1, otherwise it is 0. o represents the direction vector emitted from point p. The AO value is calculated by integrating the AO values of the rays emitted from all directions of the hemispherical space above the p point.

By emitting countless rays, the AO value of the current point is obtained separately and then the integration can only be established under ideal conditions. In practice, we need to use Monte Carlo integral transformation to discretize it:

$$AO(p,n) = \xi V(\omega, p)\max(\omega \cdot n, 0) \quad (6)$$

The computational burden of the algorithm after discretization of light sampling is greatly reduced, and it is feasible to a certain extent. However, its computational cost is still very high and cannot be directly applied to real-time rendering.

The calculation principle of SSAO, in simple terms, is that for each pixel in the screen space, in the sampling space around it, according to the comparison of the depth value of the sampling point and the depth buffer, it is determined whether the sampling point is inside the object. If it is inside the object, it will occlude the pixel, and the AO value of each sampling point is calculated by a mapping model related to the distance and angle of the pixel. The sum of the occlusion values of all sample points is the ambient occlusion value of the pixel.

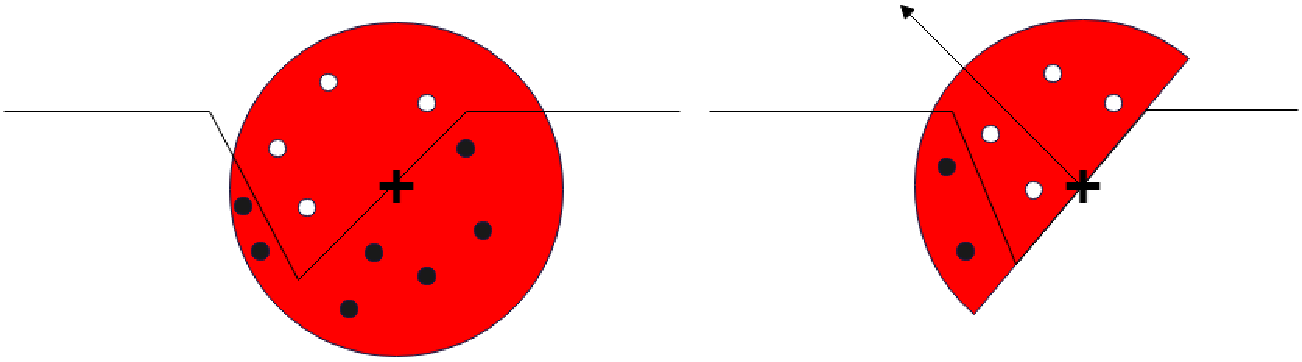

Figure 3 Spherical and hemispherical sampling ranges of pixels

The sampling method of SSAO algorithm has experienced the development process from spherical sampling to normal-oriented hemisphere sampling. The latter strips out sample points that shouldn't be added to the calculation, eliminating the greying feel of ambient occlusion, resulting in a more realistic effect. In Figure 3, it is assumed that we know by calculation that in the sampling space of the central pixel, the depth of the black sampling point is higher than the depth value of the point in the depth buffer. They will increase the occlusion factor, whereas white sampling points will not increase the occlusion factor for that pixel. The higher the number of black sample points in the sample space, the darker the shadow density obtained by the fragment.

The Horizontal Baseline Ambient Occlusion (HBAO) algorithm is an improved version of the Screen Space Ambient Occlusion (SSAO) algorithm, which uses a physics-based algorithm that mimics an ensemble with depth-buffered sampling. In SSAO, occlusion is judged by depth, while HBAO directly uses the depth information corresponding to one direction of the screen space as height information, and performs ray marching along this direction to judge whether occlusion is occluded.

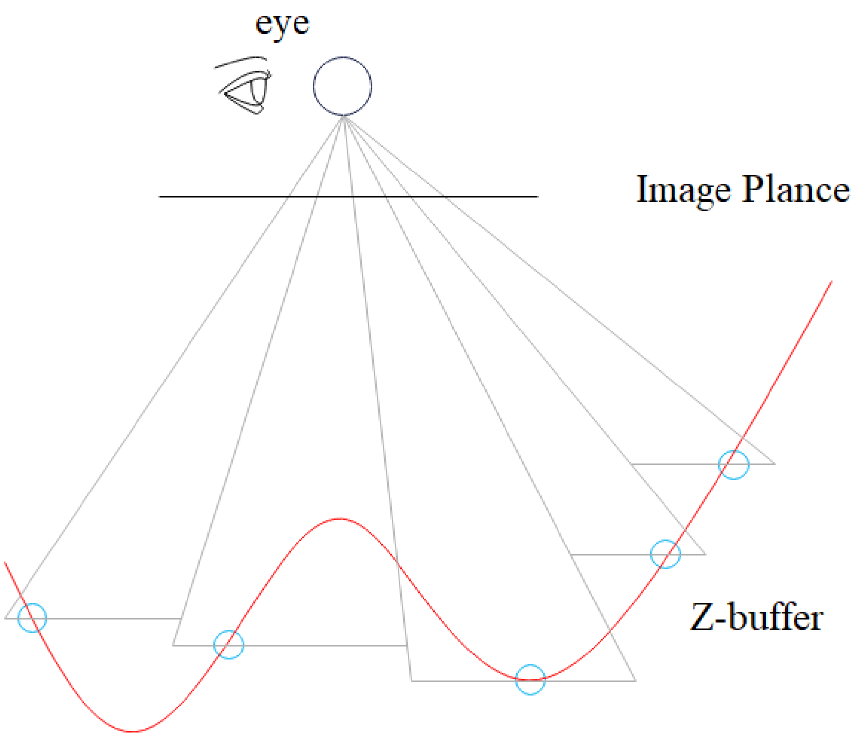

Figure 4 Stepping principle of HBAO algorithm

First, at any point in the screen space, the 360-degree range around it is equally divided, and light stepping is performed in each direction. For each direction, as shown in Figure 4, the direction of stepping along the light is the direction shown in the image Plane. For each step, the depth information is sampled once to determine the angle:

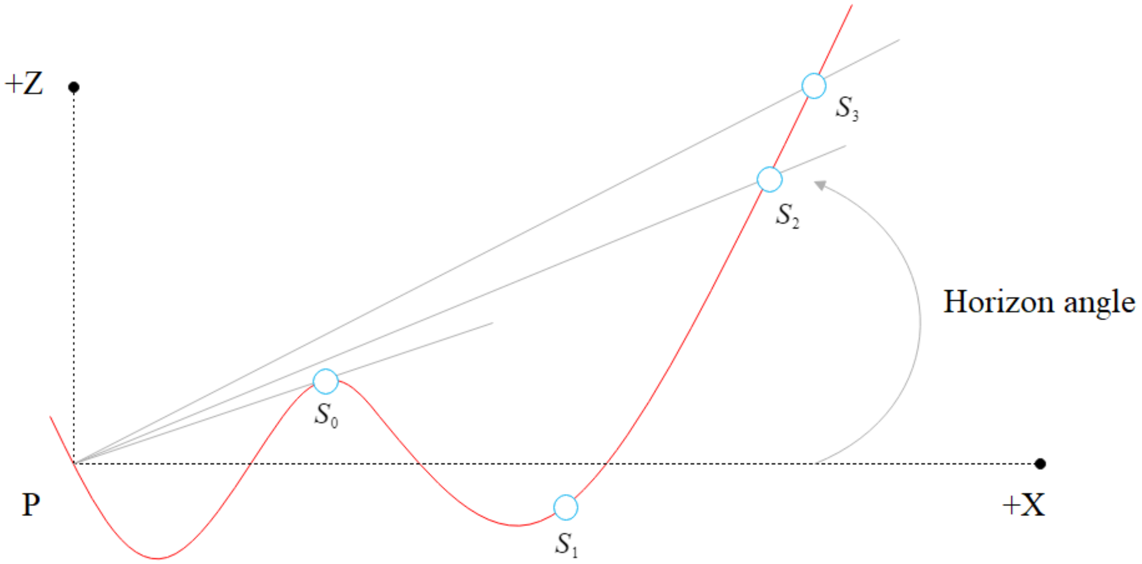

Figure 5 The principle of occlusion judgment of HBAO algorithm

Specifically, the angle comparison and the calculation of the AO value are performed. The sampling positions in Figure 5 is an example. We assume that the P point is the current pixel point, the positive direction of the X axis is the direction of light stepping, and S_0 is the first sampling point. If the angle value formed by PS_0 and the positive direction of the X-axis is greater than the preset threshold, it is considered that S_0 is blocked. For the second sampling point S_1, if the angle formed by PS_1 is smaller than PS_0, the occlusion of S_1 is ignored. The angle formed by S_2 is greater than the angle of S_0, which is included in the occlusion, and the same is true for S_3. The advantage of this is that it can avoid adding false occlusion points like S_1 into the calculation, and the final AO result is more accurate.

The convolutional neural network is a deep neural network with a convolutional structure. Each layer has multiple feature maps, and each feature map uses a convolution filter to extract the feature information of the input image. Typically, each feature map has multiple neurons for data processing.

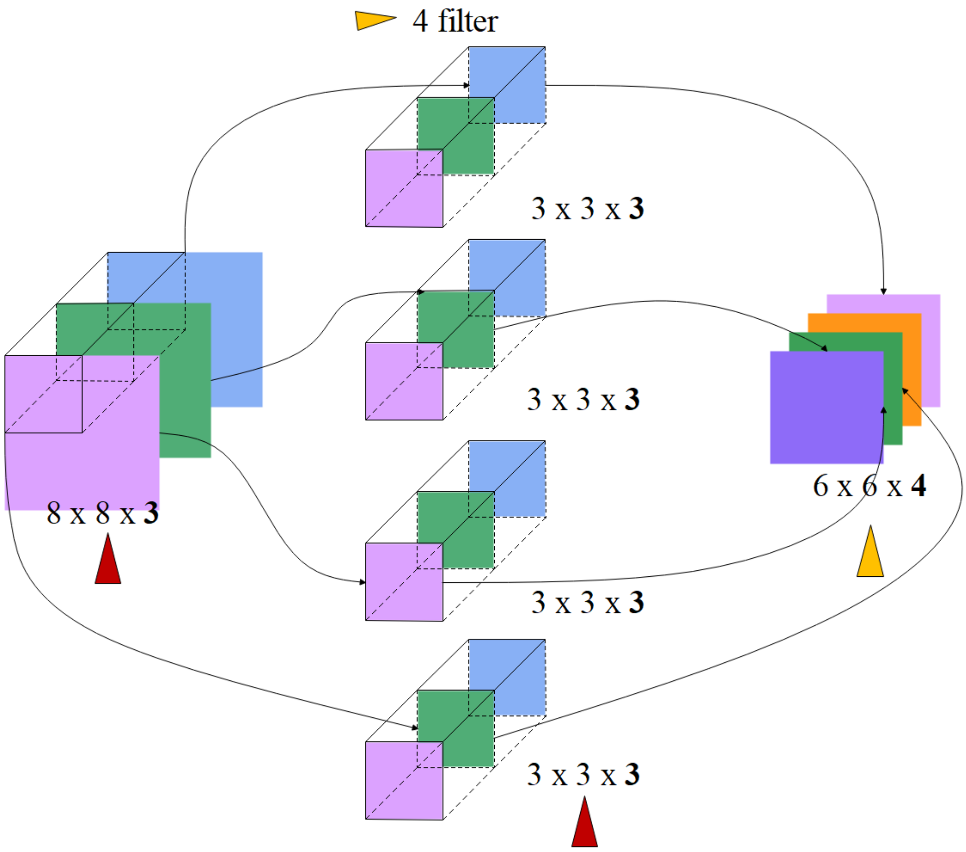

Figure 6 Convolutional layer function

Convolution layer. Through the convolution operation in the convolution layer, we can extract the features of the image, and the convolution operation can make certain features of the original image stand out, and can also be used for noise reduction. In general, the output feature map will become a scale size of 1/n of the input feature map.

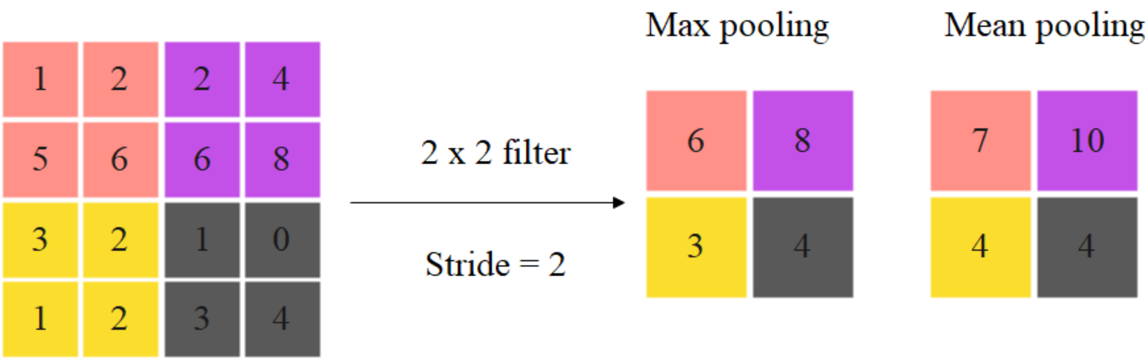

Figure 7 Pooling layer function

Pooling layer. The purpose of the pooling layer is to extract the main features of a certain area and reduce the number of parameters to prevent the model from overfitting. The basic idea is to reduce the input image, reduce the pixel information, and retain only the important information. Common pooling methods include mean pooling and max pooling. Generally speaking, the stride of the pooling layer is greater than 1. After passing through the pooling layer, the scale of the feature image is compressed, the secondary information is discarded, the receptive field is enlarged, and the computational efficiency is improved. Figure 7 shows a typical pooling operation with a pooling region of 2 and a stride of 2.

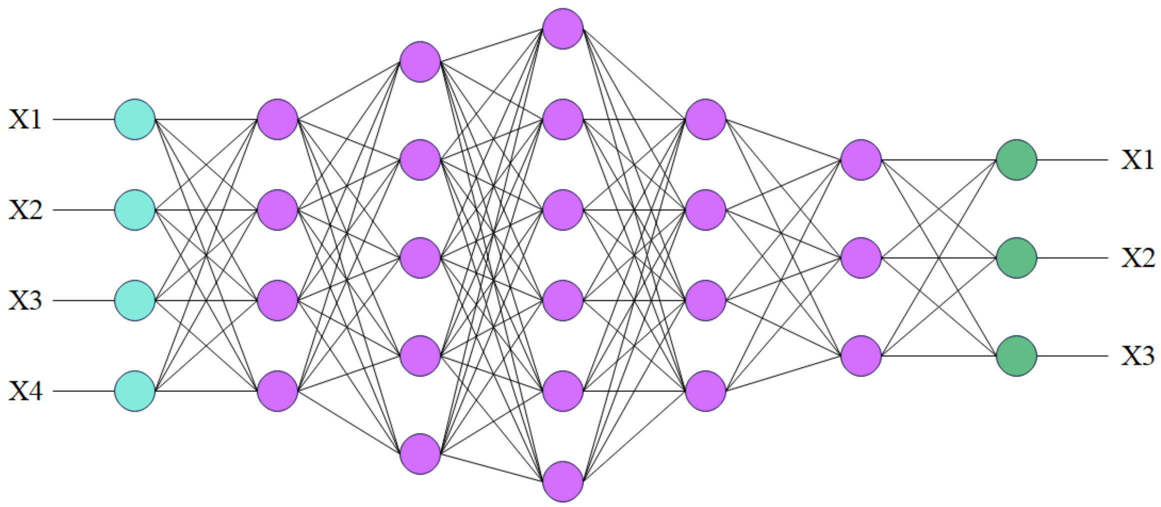

Figure 8 Fully connected layer function

Fully Connected Layer. The fully connected layer is the most common computing layer in neural networks, because each unit in this layer is connected to each unit in the previous layer, so it is called "full connection". If the previous layer is a fully connected layer, the fully connected layer can be converted into a convolution operation with a convolution kernel of 1×1. If the previous layer is a convolutional layer, it is converted into a convolution with a convolution kernel of h x w, where h and w are the height and width of the resulting image of the previous convolution, as shown in Figure 8.

In general, after each layer is calculated, it is necessary to introduce a nonlinear activation function and perform a normalization operation. The role of the nonlinear activation function is to improve the nonlinear nature of the network structure, to approximate any nonlinear function arbitrarily, to enhance the logistic regression ability of the model, and to achieve more powerful functional requirements. Some typical activation functions include Sigmoid, Tangent, ReLUl, and LeakyReLU. The ReLU function is the most widely used. For each pixel x in the input feature map, the size of the output pixel y at the corresponding position is:

$$y = \max(0, x) \quad (7)$$

The AONet structure is divided into four layers. In the operation of the nth layer (n=1, 2, 3, 4), $\phi_n(x)$ is:

$$\phi_n(x) = P\operatorname{Re}LU(W_n x + b_n, \alpha_n, \beta_n) \quad (8)$$

Among them, $\operatorname{Re}LU(x, \alpha, \beta) = \beta \max(x, 0) + \alpha \min(x, 0)$, this activation function is improved from the Parametric Rectified Linear Unit function proposed in the literature, and an additional scaling parameter β is added to achieve forward activation. In formula (8), the definition domain of each parameter of each layer is: $\{W_0 \in R^{w^2 4\times 4}$, $w_1 \in R^{4\times 4}$, $W_2 \in R^{4\times 4}$, $W_3 \in R^{4\times 1}$, $b_0 \in R^4$, $b_1 \in R^4, b_2 \in R^4, b_3 \in R^1$, $\alpha_0 \in R^4, \alpha_1 \in R^4$,
$\alpha_2 \in R^4$, $\alpha_3 \in R^1$, $\beta_0 \in R^4$, $\beta_1 \in R^4$, $\beta_2 \in R^4$, $\beta_3 \in R^1\}$ The AONet network structure is shown in Figure 10. The upper sub-image is the basic structure of the neural network, and the lower sub-image is the texture (32×32 in size) formed after the four convolution kernel parameters are stored as pixel values in the W convolution layer after the training is completed.

Regularization term to form the cost function (Cost Function). If we assume that x is the input data after data preprocessing, and y is the AO value of the corresponding position of the labeled data map, our cost function can be expressed as:

$$Cost(x,y,\theta)=\left\|y-\Phi_3\left(\Phi_2\left(\Phi_1\left(\Phi_0\left(x\right)\right)\right)\right)\right\|+\gamma|\theta| \quad (9)$$

Typically, the γ value is set to 0.01 to reduce the probability of overfitting. In the actual training process, part of the data is randomly selected as the cross-validation data set to evaluate the above cost function to obtain the appropriate θ value.

4 CLOTHING DESIGN SYSTEM BASED ON INTELLIGENT IMAGE RENDERING TECHNOLOGY

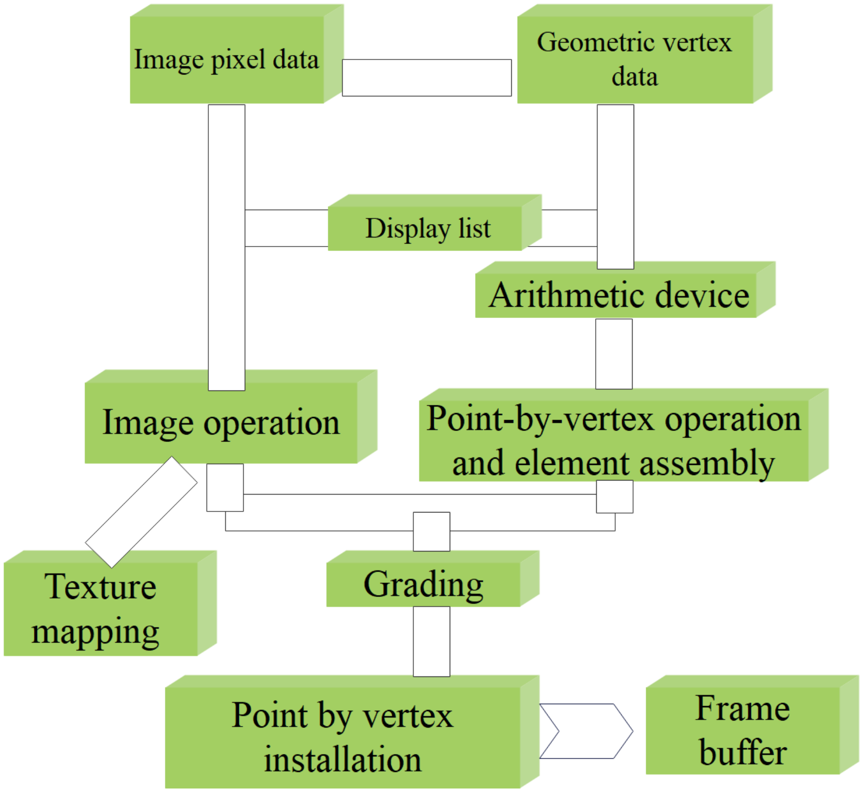

Figure 9 Smart clothing image rendering technology

Based on the algorithm in the third part, the smart clothing image rendering technology proposed in this paper is shown in Figure 9 below. Under the rendering system of this paper, the color matching of clothing is set, and the result is the design case shown in Figure 10.

(a) Color matching 1

(b) Color matching 2

(c) Color matching 3

Figure 9 Color matching example

Based on the above research, the effect of the clothing design system based on intelligent image rendering technology proposed in this paper is verified, and the effect of statistical image rendering technology on clothing design is improved. The statistical evaluation results are shown in Table 1.

Table 1 Design effect of clothing design system based on intelligent image rendering technology

Number	clothing design effect	Number	clothing design effect	Number	clothing design effect
1	90.53	25	89.47	49	90.98
2	89.88	26	95.61	50	93.94
3	96.12	27	88.56	51	92.74
4	96.71	28	93.57	52	92.01
5	96.84	29	96.92	53	90.41
6	94.68	30	90.86	54	89.56
7	94.12	31	91.61	55	92.70
8	88.10	32	96.92	56	89.03
9	88.90	33	88.39	57	89.89
10	94.56	34	96.38	58	93.02
11	90.87	35	91.37	59	91.68
12	92.23	36	89.95	60	91.83
13	91.59	37	96.36	61	96.36
14	91.12	38	92.47	62	89.21
15	96.95	39	92.60	63	88.56
16	95.40	40	90.53	64	95.61
17	89.73	41	90.50	65	96.06
18	94.38	42	96.43	66	89.45
19	95.81	43	93.53	67	93.57
20	96.77	44	89.56	68	88.06
21	91.01	45	95.34	69	89.57
22	90.80	46	89.71	70	93.41

23	90.63	47	91.36	71	91.88
24	92.02	48	95.69	72	89.18

It can be seen from the above simulation research that the clothing design system based on intelligent image rendering technology proposed in this paper has good results.

5 CONCLUSION

In clothing art, people mainly use hue to distinguish colors. The specific feeling of coldness or warmth when people see different colors is a feeling produced by the different hues of the colors. The application in the field of clothing design can play the specific application value of excellent color matching through the matching of similar hues and the same hue or the matching of contrasting hues, which presents people with a differentiated visual experience. This paper combines the intelligent image rendering technology to construct the clothing design system, and verifies the effect of the clothing design system based on the intelligent image rendering technology proposed in this paper. Moreover, this paper counts the effect of image rendering technology on clothing design, and studies the image rendering process through simulation to improve the effect of clothing design. The simulation results show that the clothing design system based on intelligent image rendering technology proposed in this paper has a good effect.

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REFERENCES

[1] Bogović, S., Stjepanovič, Z., Cupar, A., Jevšnik, S., Rogina-Car, B., & Rudolf, A. (2019). The use of new technologies for the development of protective clothing: comparative analysis of body dimensions of static and dynamic postures and its application. Autex Research Journal, 19(4), 301-311.

[2] Tselepis, T. J. (2018). When clothing designers become business people: a design centred training methodology for empowerment incubation. International Journal of Fashion Design, Technology and Education, 11(3), 299-309.

[3] Abdullajonovna, R. M., Kizi, S. F. A., & Khayitovna, M. G. Expert Analysis of the Quality of Materials for Special Clothing. JournalNX, 7(03), 399-402.

[4] Jin, B. E., & Shin, D. C. (2021). The power of 4th industrial revolution in the fashion industry: what, why, and how has the industry changed?. Fashion and Textiles, 8(1), 1-25.

[5] Starkey, S., Alotaibi, S., Striebel, H., Tejeda, J., Francisco, K., & Rudolph, N. (2021). Fashion inspiration and technology: virtual reality in an experimental apparel design classroom. International Journal of Fashion Design, Technology and Education, 14(1), 12-20.

[6] Jasiuk, I., Abueidda, D. W., Kozuch, C., Pang, S., Su, F. Y., & McKittrick, J. (2018). An overview on additive manufacturing of polymers. Jom, 70(3), 275-283.

[7] Mackey, A., Wakkary, R., Wensveen, S., & Tomico, O. (2017). “Can I Wear This?” Blending Clothing and Digital Expression by Wearing Dynamic Fabric. International Journal of Design, 11(3), 51-65.

[8] Black, C., Freeman, C., & Rawlings, A. (2018). Problem-based learning: Design development of female chef’s jackets. International Journal of Fashion Design, Technology and Education, 11(1), 123-128.

[9] Zhao, Y. (2018). Manufacturing personalization models based on industrial big data. Journal of Discrete Mathematical Sciences and Cryptography, 21(6), 1287-1292.

[10] Gill, S., & Parker, C. J. (2017). Scan posture definition and hip girth measurement: the impact on clothing design and body scanning. Ergonomics, 60(8), 1123-1136.

[11] Park, J., Park, K., Lee, B., You, H., & Yang, C. (2019). Classification of upper body shapes among Korean male wheelchair users to improve clothing fit. Assistive Technology, 31(1), 34-43.

[12] Miell, S., Gill, S., & Vazquez, D. (2018). Enabling the digital fashion consumer through fit and sizing technology. Journal of Global Fashion Marketing, 9(1), 9-23.

[13] Kim, S. Y., & Ha-Brookshire, J. (2019). Evolution of the Korean marketplace from 1896 to 1938: A historical investigation of Western clothing stores' retail and competition strategies. Clothing and Textiles Research Journal, 37(3), 155-170.

[14] Milošević, P., & Bogović, S. (2018). 3D technologies in individualized chest protector modelling. Textile & Leather Review, 1(2), 46-55.

[15] Maxmudjon, T. (2021). The figurative expression of the composition of costume. Innovative Technologica: Methodical Research Journal, 2(10), 38-42.

[16] Louis-Rosenberg, J., & Rosenkrantz, J. (2020). Anti-Entrepreneurs Using Computation to Unscale Production. Architectural Design, 90(2), 112-119.

[17] Seo, S. K., & Lang, C. (2019). Psychogenic antecedents and apparel customization: moderating effects of gender. Fashion and Textiles, 6(1), 1-19.

[18] Kwon, Y. M., Lee, Y. A., & Kim, S. J. (2017). Case study on 3D printing education in fashion design coursework. Fashion and Textiles, 4(1), 1-20.

[19] Ihsan, A., Fadillah, N., & Gunawan, C. (2020). Acehnese traditional clothing recognition based on augmented reality using hybrid tracking method. Indonesian Journal of Electrical Engineering and Computer Science, 20(2), 1030-1036.