

Intelligent Digital Virtual Clothing Display System Based on LDA Mathematical Model

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Abstract—In order to understand the intelligent digital virtual clothing display system based on mathematical models, the author proposes a research on an intelligent digital virtual clothing display system based on LDA mathematical models. The author first analyzes the realization of clothing matching function, and selects the cooperation between human skin color and clothing field as the influencing factors of clothing color matching and style matching based on expert knowledge and historical experience. Secondly, based on the different characteristics of different skin tones and the knowledge of clothing color matching, a set of clothing matching recommendation plans is presented to recommend suitable colors for users to refer to. Additionally, clothing style recommendations and choices are set, divided into upper and lower clothing, allowing users to choose more independently, the system itself also provides certain reference matching knowledge. Finally, the clothing matching rules were converted into computer image data, through analysis of the current market and existing research results, it was decided to implement a clothing matching display system based on VR technology, while providing recommended clothing matching solutions, a three-dimensional space was constructed to display clothing, allowing users to watch the effects of clothing matching according to their own choices, provide a new way for users in the clothing industry who have this demand.

Keywords—Mathematical model; virtual technology; clothing display

I. INTRODUCTION

With the continuous and rapid development of society, meeting people's daily clothing needs is becoming increasingly important. Clothing matching not only refers to the matching of clothes themselves, but also needs to be selected based on the appearance characteristics of the wearer. It is also necessary to consider the occasion of the wearer to match different clothes, in order to provide suggestions for clothing matching. The matching effect of clothing is a Visualization display. Under the fashion trend of clothing fashion from top to bottom, the four major international fashion weeks are a very important platform, which can gather the eyes of manufacturers, consumers and suppliers to display clothing with seasonal fashion trends and drive the economic development of the clothing industry. However, due to the significant amount of time, space, money, and energy consumed in hosting it once, there are many difficulties and limitations.

The rapid development of multimedia technology and computer science technology has provided excellent technical support for the practical application of virtual fitting. The

mature application of virtual reality technology in many fields has prompted more researchers to conduct research on this technology. At present, virtual reality technology has been applied in all aspects of the social economy and has strong expressive power and realism. Clothing matching is an important way of expressing culture and art, with a strong artistic atmosphere and a combination of innovative matching and cultural connotations. This study analyzed the digital display design of a clothing matching display platform, and used virtual reality technology to complete the design of the virtual clothing display platform scene. Its interactive function can also be completed using the Unity3D engine. The main value of this research achievement lies in using virtual reality technology and clothing display platforms as carriers to demonstrate different ways of clothing matching. Applying virtual reality technology to the display of new clothing styles can reflect stronger interactivity and fun, and also enable users to better understand and match clothing. At present, with the rapid development of virtual reality technology, research and development work based on user actual needs is also constantly deepening. Starting from the current development status of the clothing industry, how to integrate virtual reality technology with modern clothing trends has become a focus of attention [1-2].

II. LITERATURE REVIEW

The LDA model (Latent Dirichlet Allocation, LDA) is essentially a Bag-of-words model, it believes that a document is composed of a group of words, and there is no sequential relationship between words. The LDA model presents the themes of each document in the document set in the form of a general distribution. After analyzing some documents and extracting their themes (distribution), topic clustering or text classification can be performed based on the topic distribution. At present, the application of LDA model is very extensive, and the specific value of LDA model has been realized in multiple domain modules. In 2022, scholars Zhang, X. D. F., and others proposed an SS-LDA model for short text analysis [3]. In the field of clothing matching, Tian, F. et al. used LDA models to analyze virtual clothing display systems and combined them with SVM algorithms to obtain color designs for clothing matching [4].

Virtual Reality (VR) is a major branch of computer simulation, which refers to the formation of a three-dimensional virtual world through computer simulation. It can simulate people's senses such as sight, hearing, and touch, allowing them to see content in the three-dimensional real space more accurately and without obstacles. The images displayed by virtual reality technology have a strong sense of

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authenticity and immersion, which can make people immersive. The practical application of virtual reality technology needs to go through three stages: The first stage is the three-dimensional digital simulation process, which presents the content that can be represented by VR in the form of digital simulation, which is also more realistic; The second stage is the interaction between humans and the environment through writing script programs; The third stage is to integrate the first two processes, and finally create a comprehensive virtual reality environment to complete the interactive experience. The tools and software used can be roughly divided into three types: (1) The typical development method of scenario modeling software is 3DStudio Max; (2) The typical development mode of Model figure management software is Zbrush; (3) The typical development method of script development management software is the Unity3D engine, which is mainly designed and programmed in C language. The data is stored in Extensible Markup Language (XML) documents [5-6].

The author mainly analyzes the virtual fitting mechanism based on virtual reality technology, the network clothing display technology based on object Panorama, the design and implementation of clothing display system, and finally establishes a more complete virtual VR clothing display system.

III. METHODS

A. Virtual Fitting Function

Adopting a case-driven virtual fitting mechanism, using case-based reasoning to obtain clothing display cases that best match the user's physical characteristics and personalized display of clothing. First, define the characteristic parameters of people and clothing, and then collect clothing cases and form a case database. After inputting the user's body shape characteristic parameters, retrieve the clothing display cases that best match the user's body shape characteristics through the case reasoning mechanism in the case database, and obtain personalized clothing display effects that match the user's body shape characteristics. Regarding case search, searches for the closest case (the clothing display instance that best fits the user's body shape) by calculating similarity, and designs an instance retrieval algorithm based on similarity calculation. The calculation steps mainly consist of two parts: parameter weight calculation and similarity calculation.

In the process of image matching and image search, the virtual fitting mechanism has shown good adaptability. Compared with global characteristics, local characteristics do not have close connections, therefore, even if there are defects in the graphics, it will not have a negative impact on the coordination between other features. Analysis and research on local feature extraction algorithms have shown that they exhibit strong robustness and can effectively eliminate the possibility of partial interference, enabling the smooth completion of feature extraction work. In terms of the current situation where images can be locally obtained, even if the scale remains unchanged, the use of feature transformation algorithms is still relatively common. In terms of rotation interference, brightness interference, light noise influence, and other aspects, its robustness is also high. In addition, the

advantages of high efficiency and scalability are also evident. The calculation process of body shape parameters is shown in Fig. 1 [7-8].

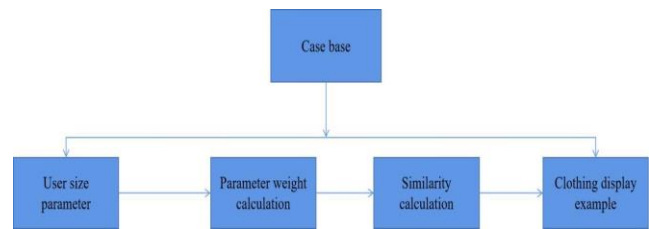


Fig. 1. Calculation of body shape parameters.

B. Panorama Display

In order to meet the new demand for clothing presentation in the clothing matching platform and according to the defects in the current virtual reality clothing presentation methods, the author selects the clothing presentation method based on the object Panorama, and the general process is as follows: Firstly, complete the image collection, secondly, splice the collected images, and finally use virtual reality technology to present the overall effect of the clothing. This process needs to input human organ data first, establish a basic Model figure, and then establish a complete set of Mannequin according to the human characteristics of different age groups (such as children, women, and the elderly), and carry out clothing matching in the virtual reality platform to show the clothing matching characteristics of different types of people. This clothing display method has the advantages of real-time and interactivity, allowing viewers to naturally and dynamically observe the overall display effect of clothing from various angles, making consumers more confident in choosing clothing and enhancing their shopping desire. The image display process is shown in Fig. 2.



Fig. 2. Image display process.

In the process of detecting image signals of clothing and presenting their characteristics, the application range of global feature extraction calculation is large, and the main characteristics can be divided into three types: One of them is the appearance characteristics, which is to extract the external contour shape of the clothing and determine its style characteristics. For example, through convolution calculation, the target contour shape can be obtained. Then, the initial shape is processed to eliminate the influence parts outside the target contour shape line, and a feature matrix can be obtained. Finally, the target graphic area is effectively extracted. The second is the surface texture characteristics, which extract various textures that appear on the surface of clothing images to determine the fabric characteristics. The third is color characteristics, which use color information to achieve identification purposes. When expressing color characteristics, color histograms are an effective way. After defining commonly used color spaces, calculate each pixel in the clothing image to form a correct understanding of color distribution, and have outstanding advantages in robustness [9-10].

IV. EXPERIMENTS AND ANALYSIS

A. Clothing Matching Scheme Display Design

1) *Analysis of clothing matching factors:* The author chooses to analyze and organize the knowledge based on traditional clothing matching expert knowledge and historical experience, and obtain corresponding clothing matching rules for the clothing matching recommendation scheme in the system. The clothing matching recommendations formed through expert knowledge have strong professionalism and are easy to use. The VR system is not limited by time and space, allowing users to apply clothing matching knowledge from a more intuitive perspective and see the display effect after matching. Experts recommend personalized clothing by analyzing the user's own skin color, hair color, pupil color, and other physical signs to find the most suitable color range for clothing. Then, according to different body shapes, choose the appropriate clothing outline shape, and judge the clothing style based on the environment. This determines the main color and fabric selection, and finally matches the entire set of clothing. After in-depth analysis, it is found that in order to achieve a beautiful and appropriate effect in clothing, it is necessary to consider three factors: the wearer's own physical characteristics, environment, and matching rules.

The characteristic of the virtual scene and display model designed in this system is that there is no difference in time and space in the virtual scene, and there is no consideration of time and place factors; the female human body modeled through Maya is a thin body with a standard Y-shape, with black hair and pupil colors. Therefore, the appearance of the above factors cannot be changed, so only the skin color of the human body is considered in this system. And considering that there are many and complex details involved in clothing matching, the principle of "minimum system" will be adopted in the clothing matching rules to reduce some details and focus on analyzing and exploring the selection factors.

Based on the analysis and consideration of various factors mentioned above, when designing clothing matching rules, the author chooses skin color in individual characteristics and the clothing occasions in TPO dressing rules as factors that affect clothing matching. Clothing is no longer a separate individual, and users' needs and characteristics are reflected in the attributes of clothing products. Skin color and dressing occasion are the influencing factors of clothing color, while dressing occasion is the influencing factor of clothing style, according to the application of matching rules, the color and style of clothing are influenced by skin color and the occasion in which the clothing is worn, thus obtaining a complete display rule for clothing matching [11-12] as shown in Fig. 3.

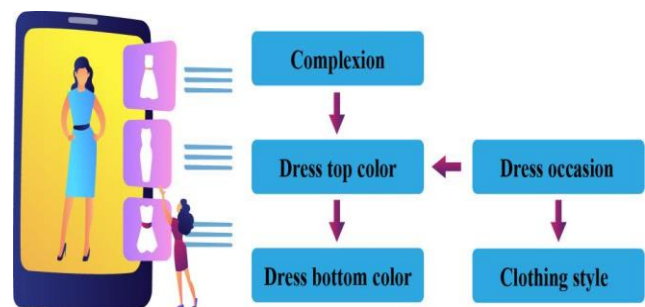


Fig. 3. Relationship between clothing factors.

2) *Analysis of human skin color factors:* Due to differences in innate skin color genes, living environment, and daily sun protection, adults have various skin types. Some have snow-white skin tones, while others have dark and yellowish skin tones. These differences can lead to different visual effects when choosing clothing of the same color. This is whether traditional clothing is suitable for one's temperament. Through the classification of different skin colors, the characteristics of their skin colors are analyzed, and the clothing color matching methods suitable for different skin colors are obtained to make the matching reasonable, highlight the advantages of human skin color, improve the bad skin color, and bring good mental outlook.

The author uses the skin color classification method of the twelve season color theory, in which the human skin color is divided into twelve types: Light spring, warm spring, pure spring, light summer, soft summer, cold summer, warm autumn, soft autumn, deep autumn, pure winter, cold winter, and deep winter. According to the spring, summer, autumn, and winter seasons, it is divided into four modules to elaborate on different skin color characteristics [13-14]. Spring is a season of recovery and vitality for all things. The colors of spring are warm, soft and light, giving people a soft and comfortable feeling. The overall skin color of the spring type is soft, as shown in Table I, summarizing the three skin color characteristics of the spring type.

TABLE I. CLASSIFICATION CHARACTERISTICS OF SPRING SKIN TONE

Skin color name	characteristic
Light spring type	With a clear skin tone and a hint of cream
Pure spring type	Skin tone that leans towards natural tones, mostly with light ivory skin tone
Warm Spring Type	The skin is relatively thin and transparent, with a darker warm tone compared to the light spring type

Summer brings with it the feeling of vibrant pink lotus growth under the white sunlight. So the overall skin tone of the summer style is a medium brightness skin tone with a pink tone. Table II analyzes the different characteristics of summer skin tone, which can better grasp skin tone.

TABLE II. CLASSIFICATION CHARACTERISTICS OF SUMMER SKIN TONE

Skin color name	Characteristic
Light summer type	A pink and tender skin with a light pink tone, compared to other summer styles, its brightness is lower
Soft summer type	Medium to light skin tone, with a rose pink complexion with a hint of gray tone
Cold summer type	A clear waxy yellow or rose pink color indicates a low purity cyan tone in the skin tone

Autumn is the season of falling leaves, so the main color tone of the autumn type skin is yellow, and the overall skin texture is not clear and transparent, with a slight sense of heaviness. Table III provides a brief description of the skin color characteristics of the autumn type.

TABLE III. CLASSIFICATION CHARACTERISTICS OF AUTUMN SKIN TONE

Skin color name	Characteristic
Soft autumn type	The face is light yellow, and the skin color is textured, not clear and transparent
Warm Autumn Type	With a golden tone, it is a yellow skin with high brightness
Late autumn type	The deep orange color of yellow is darker and lower in purity in late autumn compared to warm autumn

The color sensation brought by winter is a cool and harsh winter with cold white as the main tone, and the overall characteristic of winter skin tone is a bias towards cyan skin tone. Table IV provides a description of the characteristics of winter skin tone.

TABLE IV. CLASSIFICATION CHARACTERISTICS OF WINTER SKIN TONE

Skin color name	Characteristic
Net winter type	With a green background tone, a pale and light turquoise complexion, the overall color of the skin is white in tone
Frozen type	The skin tone ranges from cyan white to turquoise brown, but overall the skin tone has a higher brightness and is brighter
Deep winter type	Dark yellow skin with lighter purity ranging from dark wheat to turquoise brown

B. Analysis of Dressing Occasion Factors

In the TPO matching rule, it is required that when choosing clothing and considering its specific style, people should ensure that the clothing and its specific style are coordinated and consistent with the time, place, and occasion of the clothing, producing a harmonious and matching effect. In social life, according to the different Role people play,

when going in and out on different occasions, the user's clothing reflects the wearer's purpose expectations, different clothing will leave different impressions on others, and clothing styles and colors play a certain role in expressing the user's clothing purpose.

Based on the analysis of the significant characteristics and purposes of different dressing occasions in real life, it is decided to divide their dressing occasions into five scenarios for further analysis and exploration:

- Leisure occasions: Places where leisure activities can take place, such as entertainment, shopping, and home activities. In these occasions, people are in a relaxed state, pursuing freedom, comfort, convenience, and an unrestrained state [15-16].
- Sports occasions: The awareness of national sports to strengthen the body is strengthened. More and more people choose to carry out sports activities in the gym or outdoor sports venues. According to different sports methods, different clothes are selected to match sports, so that clothing can play an auxiliary role and bring comfort to the wearer.
- Workplace: Work is a social occasion that occupies a significant portion of people's daily lives. Wearing classic and formal clothing can leave a good impression on the wearer.
- Banquet Occasion: In banquets and other occasions, people often dress with a purpose in mind, and the appearance of the clothing represents a spiritual outlook that the wearer wants to showcase. Wearing bright and luxurious clothing is the first choice for gatherings.
- Resort: The resort itself indicates that people are happy and comfortable in this occasion, without any constraints. The main design concept is strong, showcasing the beautiful and generous state of the wearer.

1) *Color matching rules:* By combining colors, better visual effects can be achieved. The rational use of color matching rules can be applied to clothing matching to achieve harmonious effects. Colors can be divided into two categories: Colored and achromatic. Achromatic refers to neutral colors, which are commonly referred to as black, white, and gray; Colorfulness is composed of three major attributes of color: Hue, brightness, and purity, among which brightness and purity together constitute hue.

According to the three attributes of colors, hue refers to the appearance of different colors, composed of three primary colors: Red, yellow, and blue. It is divided by the wavelength of light. In daily life, the most common basic colors are "red, orange, yellow, green, blue, and purple".

C. Clothing Color Matching Design

Clothing color can give the most intuitive visual impression in the overall combination of clothing. By combining users' skin color choices and the occasion of

clothing wearing, using reasonable color combinations can fully demonstrate personalized clothing style and taste. In clothing matching, fully grasp the purity, brightness, and hue attributes of colors, cleverly blend and match colors to display good visual effects [17].

1) *Clothing style matching design*: The style of clothing refers to the style and shape of clothing, which is generally divided into upper and lower clothing for separate matching. In the classification of upper clothing, there are T-shirts, vests, shirts, pullovers, suits, jackets, vests, polo shirts, etc, in the classification of bottoms, there are pants, casual pants, straight pants, cropped pants, shorts, short skirts, long skirts, one step skirts, pleated skirts, puffy skirts, and so on. Different clothing styles bring different visual experiences to people.

According to the style characteristics and overall shape effect of the clothing style, when the clothing is suitable for the atmosphere of the occasion, it is considered as the suitable style type for wearing in the occasion.

The combination of upper and lower clothing styles can generate a variety of matching styles. Combining the visual effect of the outer contour of clothing styles, by analyzing the main clothing occasions in daily life, Table V recommends two sets of clothing styles for each of the five selected clothing occasions.

TABLE V. RECOMMENDED STYLES FOR DIFFERENT DRESSING OCCASIONS

Dressing occasions	Style Recommendation	Main Features
leisure time	T-shirt, jeans, jacket, wide leg pants	The style is loose and comfortable, with a simple design that does not emphasize the waistline
motion	Vest, Leggings, sports sweater, culottes	Lightweight and vibrant, with a variety of close fitting styles to protect the body
work	Suit set, shirt, one step skirt	Formal, classic cut, smooth lines, and streamlined styling
banquet	Fish tail dress, short dress	Lightweight and elegant, with strong characteristics and personality, the style and style are exaggerated, highlighting the figure
spend one's holidays	Dresses, short tops, hot pants	The characteristics of clothing styles are comfortable, natural, lightweight, and simple in style

2) *Overall clothing matching plan*: The overall matching scheme of clothing is to determine the optimal color range of clothing based on the skin color characteristics selected by the user. The theme color and style of clothing are determined for different dressing occasions, and the clothing matching rules are designed to obtain the suitable clothing matching recommendation scheme in the design system.

The design concept of this set of clothing matching is to first determine the color range of the clothing top based on the twelve determined skin color classifications, and compare the relationship between cold and warm tones and brightness purity. Then, according to different dressing occasions, the theme color is selected, and the color of the lower garment is selected. Finally, the color matching of the entire set of clothing is completed. The recommended style combinations are only influenced by the factors of the dressing occasion, so in the previous section, the style combinations have been completed.

The matching design of clothing colors is only based on qualitative semantic descriptions, and in order to apply it in computer mode, it is necessary to quantify it. The most commonly used RGB mode is to mix and overlay different proportions of red, green, and blue colors to generate different colors, similar to pigment mixing and color matching in painting. The famous Pantone clothing color card uses RGB mode to represent different colors. However, according to the previous analysis of clothing color matching, the matching rule recommended by experts is to match colors based on the three attributes of colors, and the color generation principle of HSB mode is more suitable for the transformation of the author's matching method to express different colors [18].

In HSB color mode, there are three attribute sliders: hue, which is the hue ring, and complete colors are represented as a 360 degree hue wheel; the range value of purity is 0-100%, with increasing purity and the purest color expression; the range value of brightness is also 0-100%, with increasing brightness and reaching the brightest color.

In order to achieve the recommended scheme for clothing color in the system, it is necessary to convert the RGB values of conventional colors into HSB values. Based on these three attributes, the matching rules can be applied to effectively obtain the recommended scheme for clothing matching. The following are the conversion formulas for the two modes, as shown in Eq. (1) - Eq. (3).

$$H = \begin{bmatrix} 60 \times ((G - B) / \Delta \times \text{mod}), C_{\max} = R \\ 60 \times (\frac{(B - R)}{\Delta} + 2), C_{\max} = G \\ 60 \times (\frac{(R - G)}{\Delta} + 4), C_{\max} = B \end{bmatrix} \quad (1)$$

$$s = \begin{bmatrix} 0, C_{\max} = 0 \\ \frac{\Delta}{C_{\max}}, C_{\max} \neq 0 \end{bmatrix} \quad (2)$$

$$B = C_{\max} \quad (3)$$

Correctly convert the clothing colors in the Pantone color card into hue, brightness, and purity values, and convert the semantic descriptions of twelve human skin tones and clothing occasions into their HSB mode color tone matching values

and hue matching values. Based on the clothing matching rules obtained in the previous text, the use case for determining a set of clothing matching is presented here;

Based on the user's choice of pure spring skin color, the recommended clothing color range is high brightness, high purity, and color values without cold or warm tones. The numerical range converted into computer HSB mode is: Brightness value 70% -100%, purity value 70% -100%.

Choose a banquet occasion for dressing. Based on the requirements of the theme color, which is bright and eye-catching, choose a red hue value of 0 degrees here. According to the method of contrasting colors in color matching, the lower garment can be matched with color values within the range of 0 degrees and 120 degrees, or neutral colors without warm or cold tones can be selected as a match, such as black. This completes the color recommendation for the entire set of clothing for subsequent clothing matching displays.

Translate the clothing matching rules into different numerical ranges for the three major attributes in computer HSB mode, and determine that the color HSB value within the numerical range is the color recommended for matching. If it is not within the numerical range, it is not recommended. Based on this, a case study of clothing color matching required in the system is formed [19-20].

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V. CONCLUSION

By analyzing the clothing matching experience in expert knowledge, combined with the characteristics of the system, selecting factors related to human skin color and dressing occasions for analysis, and combining color matching rules to determine the color matching of clothing; Combining TPO matching rules to match clothing styles, comprehensively completing clothing matching recommendation schemes, and applying them to the implementation of clothing matching functions in the system.

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