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mesh model, feature extraction, gamma correction, coordinate mapping

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Application of Virtual Trial Makeup Based on Video

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Abstract: To try different cosmetic products in a convenient and low cost way, a virtual make-up algorithm based on a plane mesh model is proposed. The feature points are extracted from the face in the video by the Harr cascade classifier and the Dlib library. *A mask pattern is built on the different parts of the face dynamically according to the texture coordinates of the plane mesh model. Theory is used to control the display area of the main texture of the planar mesh model. The mapping relationship between the main texture and the feature point coordinates of the planar mesh model is established***.** To solve the influence of illumination on face detection and makeup effect, *Improved Gamma correction is used to adjust the adaptability of different light levels in the face.* This algorithm can give the cosmetic picture to the plane grid model, and map the face feature points in the video, so as to achieve the effect of the virtual trial makeup. It is verified by the application of the AR test makeup software. Compared with other image processing algorithms, the algorithm has better simplicity.

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基于视频的虚拟试妆应用研究

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摘要：为了以便捷、低成本的方式尝试不同化妆产品，提出了一种基于平面网格模型的虚拟试妆算法，通过 Harr 级联分类器和 Dlib 库对视频中的人脸提取特征点，根据平面网格模型纹理坐标对人脸不同的部位动态构建一张掩膜纹理，用来控制平面网格模型主纹理的显示区域，建立平面网格模型主纹理与特征点坐标的映射关系。为解决光照对人脸检测和上妆效果的影响，采用了改进的 Gamma 矫正调节脸部不同光线下的适应性。通过该算法可以将化妆品图片赋予平面网格模型，并与视频中人脸特征点进行一一映射，从而达到虚拟试妆的效果，经过在 AR 试妆易软件中应用验证，与其他基于图片处理的试妆算法相比，该算法具有更好的简便性。

关键词：网格模型；特征提取；伽马矫正；坐标映射
中图分类号：TP391.9　　文献标识码：A　　文章编号：1004-731X (2018) 11-4195-08
DOI: 10.16182/j.issn1004731x.joss.201811018

Introduction

With the continuous improvement of people's quality of life and the continuous improvement of society, in the cosmetics industry, China is now the second largest consumer market for cosmetics. According to the China economic times, there are about 5000000 kinds of cosmetics in China, and it is a matter of great concern for consumers to choose safe and effective products in the face of such a huge variety of data. Trying makeup stage might be trial

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makeup, but due to the trial people too much, or missing days placed a long time, for easy allergy of skin will inevitably bring some problems such as skin allergy, with the increase of number of consumers at the same time, also will waste material. In order to eliminate the above problems, the common solution is to use computer technology for virtual test. As VR (virtual reality) and AR (augmented reality), the rapid development of advanced technology, the virtual try makeup can give provide harmless makeup effect, combining the beauty industry and computer technology, has become a hot research problem in the field of computer graphics.

At present, in view of the virtual test makeup, there are few aspects of the paper and the most common is based on the images on the makeup. In 2007, Tong et al[1]. makeup transfer algorithm based on the sample, you can through the mouse will sample the dressing style to another person's face, the method using image distortion, segmentation, repair and other steps. In 2009, Guo et al[2]. proposes the improvement to the method of Tong, the method is to use a single sample to makeup face image style of migration, thus simplifies the complexity of the operation of the makeup, the method by Poisson equation highlights and shadows of image fusion, due to the continuity of Poission equation is not enough, there are still defects from visual effect. In 2010, ZhenBeiBei et al[6].proposes to realize digital face makeup method based on the sample, the method of sample selection of images have certain limit, can't very good automatic transfer colour makeup effect, and steps are also very complicated. In 2013, Du et al[3].put forward virtual makeup migration method based on the sample, the method can face of different examples of local area to migrate, depends on more than make up good effect, through the image fusion technology to try makeup effect. In 2015, Lin jianchu et al[7]. proposed a method for the application of the image makeup of fidelity face, which drew on the use of structural information in topological deformation[8], and increased the fidelity of the skin after makeup.

Above comprehensive analysis, the main difference with the proposed on the implementation method is different, in this article, based on planar grid model of virtual test makeup algorithm, this algorithm first compensate the light face image captured by the camera in real time, and then extract the facial feature points, and through the feature point coordinates of plane grid model dynamically generate a mask texture, to control the display area of the main texture, its main texture rendering for cosmetics, and finally make the texture feature points to establish a mapping relationship. The advantages of the algorithm are as follows: 1. Good real-time performance；2. Good lighting compensation; 3. Give the effect of different cosmetics to the main texture and improve the flexibility of the application.

1 Construction of planar grid model

The modeling tool of flat grid model is 3ds Max, and its modeling methods include polygon modeling, surface modeling, synthetic modeling, surface film modeling, NURBS modeling and so on.

This paper adopts the method of polygon modeling, such as point, line, surface, etc., to show the structure of the model, and then to make the splice. Due to the extraction of facial feature points, the facial feature points extracted are 68, in order to ensure the grid model of main textures and to extract the feature points of mapping, so the plane grid model should be made up of 68 vertices. Then, the constructed grid model is exported to the file format of OBJ, which is imported into Unity3D and given to

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the mesh model. As shown in Fig. 1 grid model diagram, Fig. 2 gives the material and marks the grid model's vertex index.

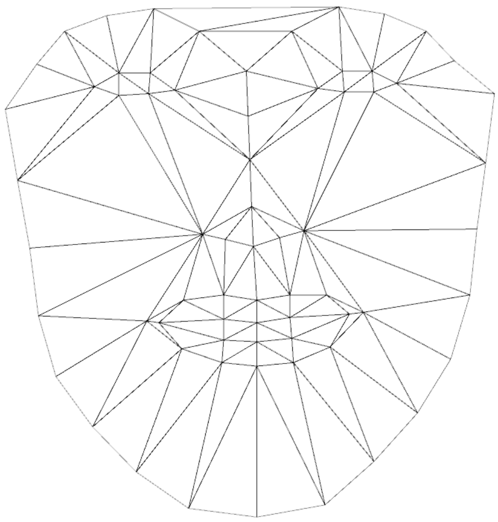


Fig. 1 Grid model

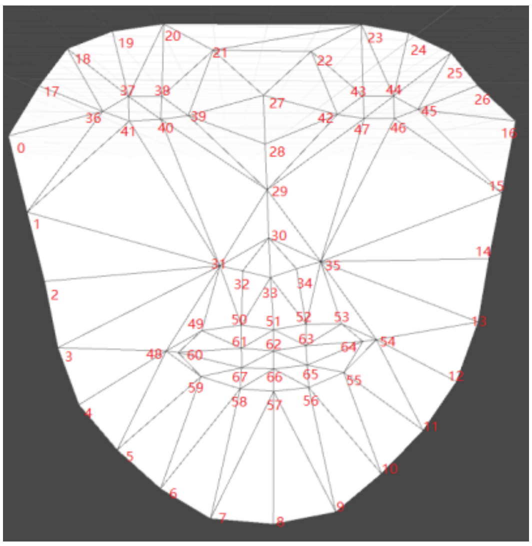


Fig. 2 Endow the material

Change the Shader script for the mesh model, defining two textures for the main and mask textures in the script. The main texture and the mask layer RGBA texture's color space for operation, by using a single linear superposition model as shown in formula (1), so that the mask texture plays a role in controlling the display area of the main texture.

$$C_p(i)=\begin{cases} kC_d(i)\times\dfrac{C_m(i)}{255}+kC_d(i)\times\left(1-\dfrac{C_m(i)}{255}\right) & i\in d \\ 0 & \text{other} \end{cases} \quad (1)$$

In the formula, C_d and C_m are the color components corresponding to the texture and mask texture respectively. C_p is the color component of the face image produced by the makeup, i is the subscript of the corresponding pixel points. k indicates the disturbance parameters of the color component control, its default value is 1, d is the mask area of the mask texture.

2 Application method of plane grid model

The virtual trial makeup method based on the flat mesh model needs to import the cosmetic effect photo as the main texture of the mesh model, which is denoted as D; the mask texture is generated dynamically according to the main texture coordinate of the model. By extracting the facial feature points of video texture mapping and grid model, so as to get the video facial makeup of the composite image S, in order to eliminate the influence of ambient illumination, the illumination compensation is performed on the video. The algorithm flow is shown in Fig. 3.

2.1 Dynamically generated textures

The dynamic mask texture is mainly to control the facial region that needs to be tested. Firstly, the texture coordinates of the mesh model, such as the texture coordinates of the mouth and the eye texture coordinates, form the boundary of a region, and all the pixel units in the boundary range are filled to the specified color. The filling algorithm of irregular shape mainly includes seed filling method and scanning line filling method. The main differences are: 1. Seed filling method iterates and fills the polygon internally according to the seed point, until the boundary stops. This method takes up a lot of stack space, and the calculation efficiency is not high. 2. The scan line filling algorithm uses the intersection point between the scan line and the polygon edge to judge whether it needs to be filled. It only needs to press the starting point of each horizontal pixel into a special stack, without the need to press all the adjacent points into the stack, thus saving the stack space. The experimental analysis of the polygon with two filling algorithms is shown in Tab. 1.

The experimental results are the filling of different algorithms for the eyes and the mouth. From Tab. 1, it is known that the effect of seed filling will be partially blurred and the efficiency is low. Therefore, the scan line filling algorithm is used in this paper. Fig. 4 shows the effect diagram obtained through the filling algorithm and fuzzy processing.

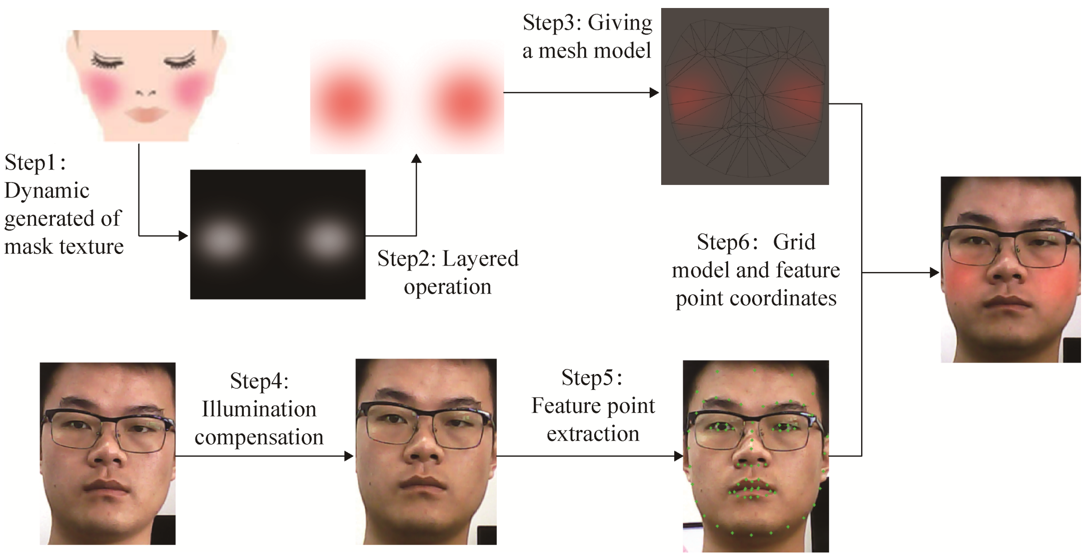
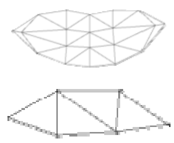
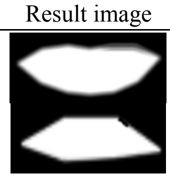
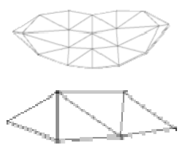
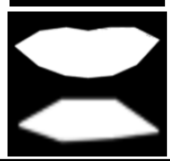
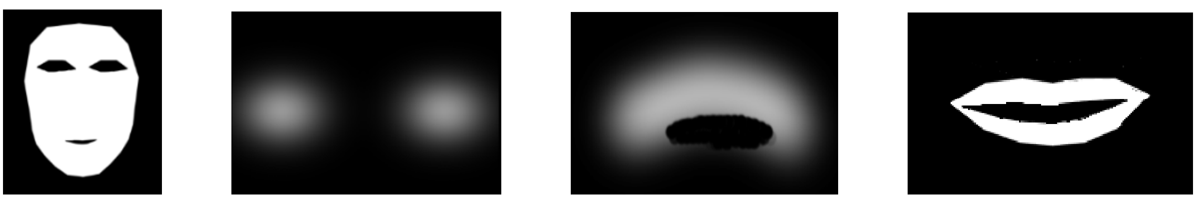


Fig. 3　Flow chart of virtual trial makeup algorithm

Tab. 1　Comparison results of different filling algorithms

Filling Algorithms	Original image	Result image	Time/ ms
Seed filling algorithm			2.3 1.86
The scan line filling algorithm			2.0 1.6



(a) Whole filling diagram　(b) Padding of the gills　(c) Eye shadow filling map　(d) Mouth filling map

Fig. 4　Filling diagrams

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2.2 Illumination compensation

In this paper, compensation for illumination has two main functions: one is to improve the accuracy of face recognition; and the other is to optimize the effect of test makeup. The illumination compensation mainly deals with frequency domain and spatial domain, and the frequency domain has DCT transform, wavelet transform, etc. Spatial domain has histogram equalization, Gamma correction and so on. Among them, the Gamma correction method has a wide application in overcoming the influence of illumination. In this paper, considering the video acquisition efficiency and computational complexity factors, there are many improved Gamma algorithms using Gamma function for illumination compensation. In this paper, a new correction method is constructed to compensate the illumination on the basis of reference [4] and reference [9]. Traditional Gamma correction usually selects gamma values, and each pixel in the image is corrected with the same gamma value, as shown in formula (2).

$$\mathrm{O}(\mathrm{x},\mathrm{y}) = 255 \times \left(\frac{F(x,y)}{255} \right)^{\gamma} \tag{2}$$

In the formula, O(x, y) represents the output image, and F(x, y) represents the source image, which expands and compresses the high light and dark parts of the image through the gamma parameter.

In this paper, the parameters of the gamma function are selectively adjusted by using the distribution of light components in pictures. The illumination component M(x, y) is extracted by Gauss function G(x) and convolution with the source image F(x, y). The formula (3) and formula (4) are shown.

$$G(x) = \frac{1}{2\pi\sigma^2} e^{\frac{x^2+y^2}{2\sigma^2}} \tag{3}$$

$$\mathrm{M}(\mathrm{x},\mathrm{y}) = F(x,y) \times G(x) \tag{4}$$

γ shown in the formula (5).

$$\gamma = (\frac{1}{2})^{\frac{128-M(x,y)}{128}} \tag{5}$$

The illumination component of the convolution kernel of different Gauss functions is different as shown in Fig. 5. When the convolution kernel of 13×13 size is selected, the compensation effect on illumination is better.

Original map　　3×3　　7×7　　13×13

Fig. 5　Different convolution kernel effect diagram

2.3 Feature point extraction

In this paper, Harr cascade classifier is applied to face detection and location[10], then the feature points detection method of Dlib library[5] is called to extract and align. As shown in Fig. 6 flow chart.

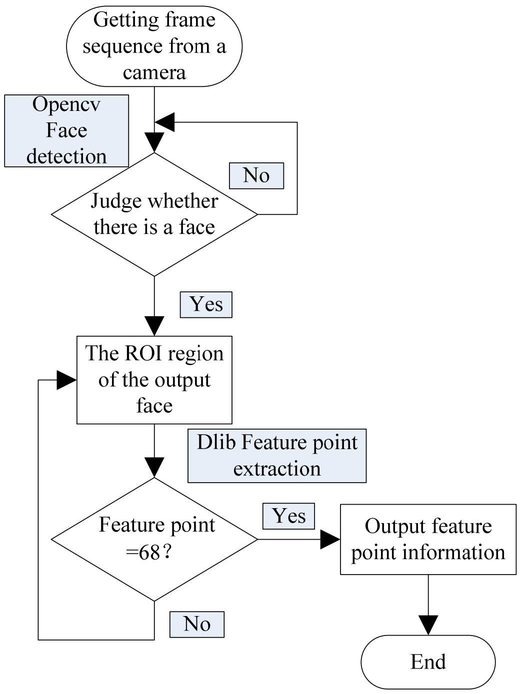


Fig. 6　Feature point extraction flow chart

The feature points extracted from the Dlib library are 68 feature points, which do not include the feature points of the forehead region. In order to meet the demand in the trial makeup, the feature points in the forehead region need to be calculated according to the extracted feature point coordinates. The calculation method was calculated by the ratio of three courts and five eyes in the medical beauty standard, and the proportion of three courts and five eyes cases was shown in Fig. 7. The results are shown in Fig. 8~9.

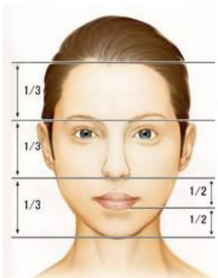


Fig. 7 Three courts and five eyes

Fig. 8 No forehead region

Fig. 9 Forehead region

2.4 Mapping of texture coordinates.

Texture coordinate mapping is the vertex coordinates of 3D model to find the corresponding texture location in 2d texture. So we need to determine the vertex coordinates of the 3d model and the texture coordinates of the two-dimensional texture.

It is only necessary to determine the corresponding relationship between the model's 68 vertex coordinates and the texture coordinate of the model, as shown in the pseudocode. The vertex coordinates of the grid model are to map the coordinates of the feature points to the vertex coordinates of the plane grid model by extracting the 68 feature points of the face in the video frame sequence. Set $V(D)$ as the mesh vertex coordinates, $F(D)$ is used to obtain the coordinate set of the feature points in the video. The W gets the video width for the camera, the H gets the height of the video for the camera, and the ε is the disturbance error when the video is mapped. Then, the calculation formula of $F(D)$ mapping to $V(D)$ can be obtained:

$$V(D).x = F(D).x / W + \varepsilon \tag{7}$$

$$V(D).y = F(D).y / H + \varepsilon \tag{8}$$

The texture coordinate of the mesh model is the coordinates of feature points in the face texture. Let $UV(D)$ is the texture coordinate set of the grid model, $FaceUV(D)$ is the coordinate set of the standard face texture feature points obtained, TW is the width of the texture, TH is the height of the texture.

$$UV(D).x = FaceUV(D).x / TW \tag{9}$$

$$UV(D).y = (TH - FaceUV(D).y) / TH \tag{10}$$

The pseudo-code process is shown below.

1、FaceVector3 ←GetFacePoints() // Obtaining face feature point coordinates in video

2、MaskFaceVector3← GetMaskPoints()//Obtaining the feature point coordinates of the standard face texture

// Judge whether the number of vertices of the mesh model is equal to the number of FaceVector3.

3、**IF** ModelPointsCount == FaceVector3 **THEN**

// Mapping the coordinates of facial feature points to the vertex coordinates of mesh models

4、**FOR** i:=0 **TO** max FaceVector3.Length

p[i].x = FaceVector3[i].x/W;

p[i].y = FaceVector3[i].y/H;

5、**END FOR**

6、**END IF**

// Judge whether the number of UV coordinates is equal to the number of MaskFaceVector3.

7、**IF** ModelUVLength == MaskFaceVector3 **THEN**

```
    // Mapping the feature point coordinates of the standard
face texture to the texture coordinates of the mesh model.
    8、FOR i:=0   TO   max MaskFaceVector3.Length
          uv[i].x = MaskFaceVector3[i].x/TW;
        uv[i].y =(TH - MaskFaceVector3[i].y)/TH;
    9、END   FOR
    10、END IF
    // Updating the grid model
    11、Mesh.vertices = p;
    12、Mesh.uv = uv;
    13、Mesh.RecalculateBounds();
    14、Mesh.RecalculateNormals();
```

3 Application results and discussion

3.1 The application results

In this paper, the application method of the planar mesh model in the virtual trial makeup is applied in AR Makeup Application Software. This experiment is completed on the computer of Intel (R) Core (TM) i5-4590 3.30GHz CPU, 4G memory, Windows10 operating system, and the development platform is Unity3D engine. Fig. 10 shows the effect diagram of cosmetics used in the experiment. Taking into account the protection of cosmetics copyright, the cosmetics effect picture in this article is sketched by oneself. In order to verify the rationality of this method, the literature [2-3] are used for comparison as shown in Fig. 11~13. Literature [2] and document [3] will make a slight change in the facial skin color of the target image in the migration of the make-up effect, which cannot bring a sense of authenticity to the make-up, As the main texture of the plane mesh model is mapped with the feature point of the face, the skin color of the target map is changed to avoid changing the skin color. The effect of this method can be obtained from the effect of Fig. 13.

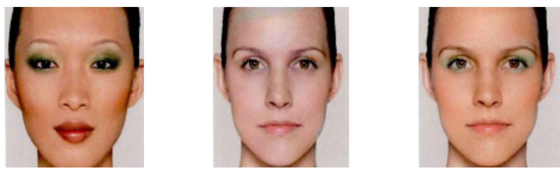
(a) Eye shadow (b) Eyelash

(c) Blush (d) Eyebrow

Fig. 10 Cosmetic effect map

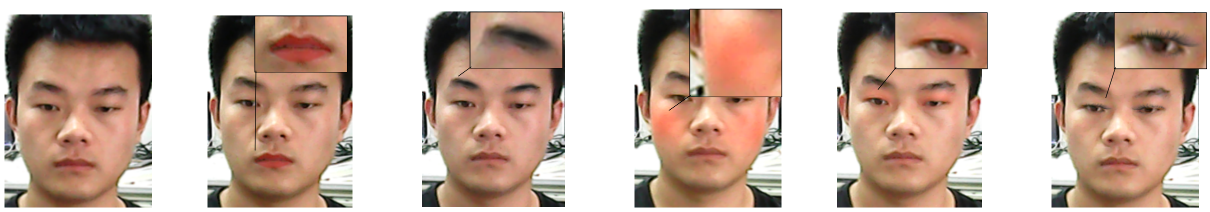
(a) Sample diagram (b) Target graph (c) Design sketch

Fig. 11 Document 2 effect diagram



(a) Sample diagram (b) Target graph (c) Design sketch

Fig. 12 Document 3 effect diagram



(a) Original map (b) Lipstick effect (c) Eyebrow effect (d) Blush effect (e) Eye shadow effect (f) Eyelash effect

Fig. 13 Experimental results in this paper

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3.2 Discuss

There are many APP applications on the market that are similar to virtual trials, but there are no academic papers on academic research that can be compared. The method proposed in this paper can not only achieve better results in the trial makeup, but also can be used for different styles of face migration, such as facial mask and other entertainment applications. See Fig. 14.

(a) Before changing face

(b) After changing face

Fig. 14 Face change effect

4 Conclusion

In this paper, a method of virtual trial makeup based on planar mesh model is proposed. This method solves the problem that the make-up cannot see the effect of the makeup in real time, improves the real time of the makeup effect, and uses an improved gamma function to compensate the illumination in the video, thus improving the accuracy and the makeup effect of face recognition. In this paper, the main texture of the plane mesh model is mapped with the feature points of the face, which greatly reduces the computational complexity, and the trial makeup does not affect the other areas of the face in the video, and has good fidelity. In this paper, we can change the main texture of planar mesh model to replace the cosmetic effect diagram and have good expansibility. It has a good practical value after being tested in AR test.

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