Developing an Augmented Reality System of Nail Make-up

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Keywords: Augmented Reality, Nail Make-up, AR Projection

ABSTRACT

We developed system for AR application. In practice, we utilized color to extract nail area. Additional color projector, which is well calibrated, will cast desired patterns on nails. As a result, augmented and vivid patterns on nail are carried out by our formulated algorithm. It's useful for customers and nail-salon.

1 INTROUCTION

In recent years, the market for nail make-up is getting popular. How to make nail make-up process more comprehensive is benefit to everyone for much better makeup simulation experience. When people go to nail-salon, manicurists will provide their pre-made nail catalogue for imaging their make-up result. However, people may suffer from the difficulty to choose a proper pattern because of a wide variety of nail colors and patterns. Besides, everyone's skin color is different, this factor may affect overall appearance. If customers can't immediately try on their own hands, they will be difficult to make a decision. As a result, providing various augmented nail colors and styles will be a good choice to satisfy their imagination. Therefore, we intent to build a system to simulate nail makeup based on a projector and a color camera. In addition, the simulation system will minimize the cost of storing nail acrylic and modeling frames. And it prevents from the waste of fail makeup. Furthermore, manicurist's idea can be quickly realized by this system. The customer also can try a large number of nail patterns in a short period of time, and even be able to flexibly change the nail's color. This is why our system will effectively increase the customer experience.

To implement the AR nail makeup simulation, most of the current solutions are achieved visually through the displays. Noriaki Fujishima et al. [1] proposed a virtual nail art system, and the beauty brand, such as Virtual Nail Salon, had also introduced nail make up simulation mobile-phone app on the market. But we believe that experience the virtual result on screen is different from the reality, so we use specific encoding and decoding methods to project accurately pre-prepared texture on the nail. For several years, great effort has been devoted to the study of encoding of projecting patterns [2]. In this paper, we mainly use the encoding method of common binary code (e.g. [3-5]) with line shift technology [6] to complete this system.

2 EXPERIMENTAL DESIGN

2.1 Projector-Camera System

The projector-camera system we used is shown in Fig. 1. The projector is the model of BenQ Eco-friendly XGA Business Projector:MX528. It has a native resolution of 1024×768 pixels and it equipped a digital lighting processing (DLP) chip. The camera we used is a FLIR color camera, FL3-U3-120S3C-C Model, with a resolution of 4000×3000 pixels. Regarding the lens part, we used Tokina fixed focal lens: TC0814-3MPG model.

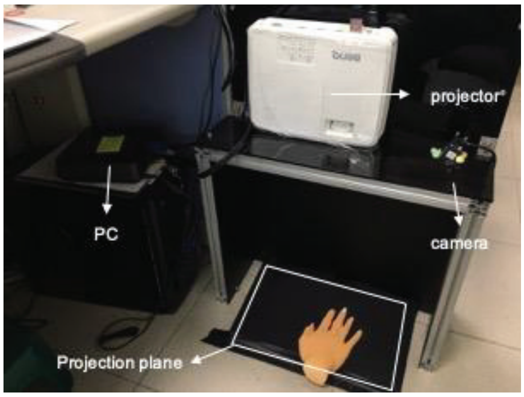


Figure 1. The projector-camera system we have used in our experiments.

Initially, we use our projector-camera mechanism to implement projection mapping by coaxial mode (e.g.[7-8]) or non-coaxial mode. That means the main optical axis of the projector and the camera could be the same or not. However, the coaxial mode will reduce the brightness of the projection, we choose non-coaxial mode. On the other hand, the non-coaxial method we adopt basically has the problem of limited viewing angle. It means the occlusion area data cannot be estimated, because there cannot be observed by the camera perspective. Since the projected surface (fake nail) is approximately flat in our application, this problem does not have much influence. In order to conduct the triangulation, the hardware position and distance we placed are shown in Fig 2. In addition, the brightness of the projector we use is about 3300 lumens, so our system can operate in a normal lighting environment.

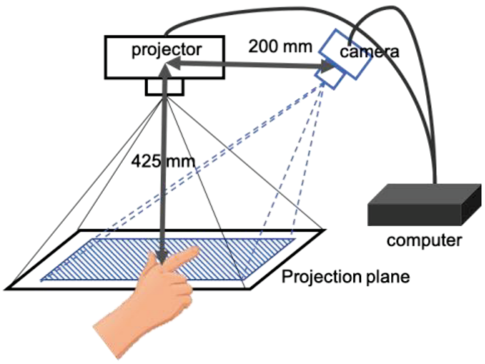


Figure 2. Schematic of the mechanism setting. The camera's FOV need cover the projection surface.

2.2 Proposed Method

(1) Calibration

As the same with stereo camera architecture, two cameras can use the epipolar geometry to estimate the transform information. Instead, our system replaces one of the cameras by a projector. The principle is the same, the difference is only in the camera is receiving light and the projector is releasing light.

In order to obtain the fundamental matrix between the camera coordinates and the projector coordinates, we use the method of the eight point algorithm, was introduced by HC Longuet-Higgins [9]. in this method, as long as the eight pairs of feature points on the stereoscopic image are acquired. Although we didn't get camera and projector internal and external parameters, there is enough important information to calculate fundamental matrix F [10].

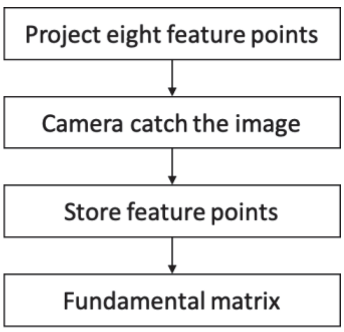


Figure 3. flow chart of calibration

Fig. 3 shows our calibration flow chart. First, we put the hand on the projection plane, and then the projector will project an image of the feature points whose coordinates are already known. Then, we'll know the pixel position of the eight feature points in the camera perspective. With these corresponding feature points, we can estimate the fundamental matrix.

(2) Pattern Projection

If people want to obtain information on the position of the nail at the projector perspective, there are currently many methods of 3D reconstruction been developed. In most applications, non-contact measurement systems are used, and non-contact method also are divided into active sensors and passive sensors [11]. In order to reduce costs and avoid the inconvenience of measurement, we use the fringe projection method in active sensors. The principle of this method is to code each pixel of the stereoscopic image by projecting multiple stripes or patterns.

The encoding sequence of proposed method is shown in Fig 5. In addition, we use the technique of line shift [6] to solve the ambiguity problem which is shown on the highest level of pattern. Finally, we decided project two single pixel line patterns to replace the highest layer pattern (shown in Fig. 6).

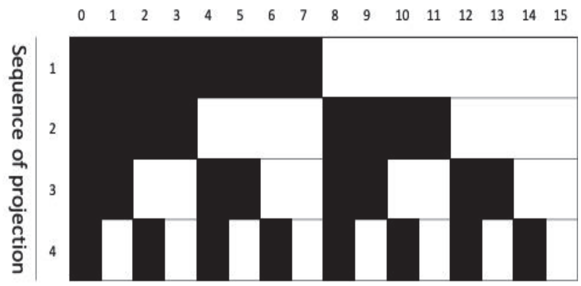


Figure 5. Sequence of binary-coded pattern

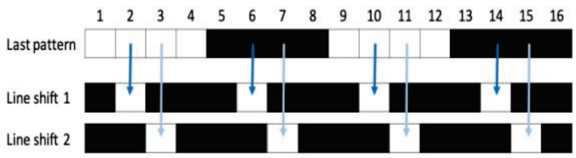


Figure 6. we choose the middle set of pixels to implement line shift for avoiding edge problem.

The flow chart of our method is shown in Fig. 7. First of all, we will project the pre-generated sequence of binary stripe patterns on the projection plane, and then store the binary images that are observed by the camera. Since it is only necessary to map the nail area, the pixel of the nail position is stored by color segmentation. Then, the epipolar line of the pixel of each nail area is calculated, so the right pixel position of the projector perspective can be found on the line, this step allows us to save the sequence of patterns in the horizontal direction. Finally, we only need to decode each layer pattern, then we can find the pixel with the same encoding on epipolar line, store this point, and generate a projection image after all points are processed. Users can modify the projection image which will achieve more changes (e.g. monochrome or various patterns).

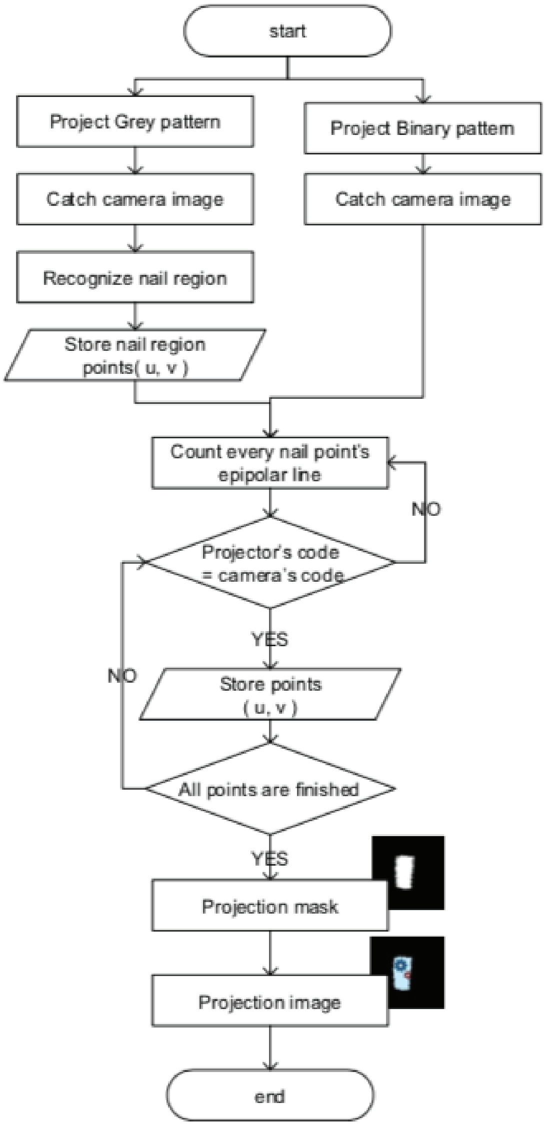


Figure 7. flow chart of our method

3 RESULTS AND DISCUSSION

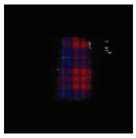
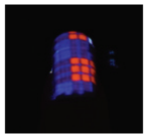
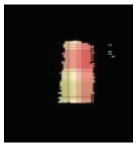
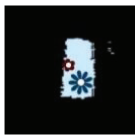
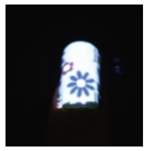
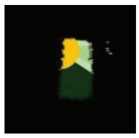
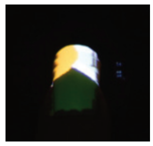
According to the proposed method mentioned in section 2, the calculation of the first set of patterns can be used to obtain a mask for projection shown in Fig. 8(a). From this result, it would be noticed that some points in the nail area are missing after calculation, so we shift the whole set of patterns to the right by 2 pixels to get a new set of coded pattern. Then, the nail pixels in the camera image are decoded through the second set of patterns. The projection mask calculated by the two sets of patterns is shown in Fig. 8(b). It can be seen that the result is better.

(a) (b)

Figure 8. (a) The result mask of counting the first set of stripe patterns. (b) the result mask of counting the first and second set of stripe patterns.

Then we try to change the color and pattern of the projection image, as shown in table 1.

Table 1. the result of projection mask in reality

	projection image	reality
Texture_1		
Texture_2		
Texture_3		
Texture_4		

Some potential shortcomings of the current system and challenges have also been identified as a result of our work developing these applications, and there are two major limitations in this study that could be addressed in future research:

(1) the placement of the hand can only remain frozen when the user is using.

(2) the finger is limited to place on the right half of the projection plane

In the first limitation, our method can only encode and decode objects in a static scene, so after the user places their hand on our plane, then let us project the pattern to get the data, the hand can no longer move. The second, if the finger is placed at the left half of the projection plane, the camera will be able to see the larger dead sector of the nail area which cannot be successfully projected.

Finally, in our point of view, for practical in the case of nail make up is much close to the reality. Two main issues are to be addressed：(1) the expansion of the projection range by applying multi-camera and using a faster encoding to adapt for moving hand, refer [12] use of one-shot pattern projection to obtain 3D dense information. (2) Improve the color rendering of light projection on the nail and propose a range of applications in the color space.

4 CONCLUSIONS

The main purpose of this paper is to present the AR system for nail make-up. At present, most AR nail make-up system on the market is through the display, but we believe that people actually have different feelings about watching the screen and reality, so we try to project the pattern of nail make-up directly by projector. Our basic approach involves using binary code to obtain nail's position in projector perspective and optimize the result by line shift method. We have shown in this paper how possible ways to use computer vision in applications based on camera-projector system.

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