Smart Makeup Mirror: Computer-Augmented Mirror to Aid Makeup Application

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Abstract. In this paper, we present a system that aids people in wearing makeup easily and make the process enjoyable. We call the proposed system the "Smart Makeup Mirror", which is an electronic dressing table that facilitates the process of makeup application. In this system, we place a high-resolution camera above a computer display and have added some functions such as "Automatic zoom to a specific part of the face", "Display the face from various angles", "Simulation of lighting conditions", and "Internet voting on better makeup results" to facilitate the makeup application process. People who use this device for applying makeup will obtain highly satisfactory results, while enjoying the process.

1 Introduction

Most modern women in Japan apply makeup before stepping outdoors. However, many women feel that applying makeup every morning is troublesome. According to a yearly poll of 650 women living in metropolitan areas in Japan and who were in the age group 16-64, in 1999, 51.4% felt that applying makeup was troublesome. This figure increased every year and became 63.5% in 2003. 70% or more of these women who thought that applying makeup was "Troublesome" were in their 30s. From some books and magazines on makeup, it is possible to surmise that many women worried about finding a suitable makeup method or developing their own technique. Further, many women wanted a tool that made applying makeup everyday easy, happy, and satisfying. Moreover, many makeup artists describe that it is important to know your own face in order to apply makeup satisfactorily. If you can know your face, you can notice the makeup that suits you, and show your originality by using a combination of different makeup techniques.

Many researches on make-up focus on makeup simulation. [1] Some of these simulation systems are used at cosmetics counters in the department stores for helping customers to choose cosmetics. However, these systems are not commonly designed for home use.

In this study, we develop a device that facilitates the application of makeup and makes the process enjoyable. The proposed device is termed the "Smart Makeup Mirror". It is an electronic dressing table that facilitates the process of applying makeup. We are certain that people who use this device for the application of makeup will obtain highly satisfactory results.

J.A. Jacko (Ed.): Human-Computer Interaction, Part IV, HCII 2009, LNCS 5613, pp. 495–503, 2009.

2 Smart Makeup Mirror

Figure 1 shows the over view of the proposed system. As part of this system, we place a high-resolution camera (Point Grey Research, Grasshopper, with IEEE-1394b connection, 1624 x 1224 pixels, 30 fps) above the computer display. The camera is trained on the woman, and a mirror image of the woman is shown on the screen; thus, the device functions and assists the woman in applying makeup effectively while looking at her image. There are some researches that use a standard-definition TV camera and display images as a mirror would [2][3]. In the proposed system, we use a high-resolution camera in order to enable practicable makeup application.

In order to realize the functions described later in the paper, we processed the images captured by the camera. We set up a low-resolution camera (Logicool, Qcam Pro for Notebooks, in a 320 x 240 pixel mode, 30 fps) for such image processing. We used OpenCV in the image data processing and FlyCapture for the controlling the high-resolution camera. These cameras are connected to a PC (Gateway GT5092j) with Windows Vista OS.

Moreover, we set up an infra red range sensor and a proximity sensor for performing the following functions. These devices are controlled with a microcomputer, and communicate with the PC program through serial connection.

We developed the following functions to support the makeup application process.

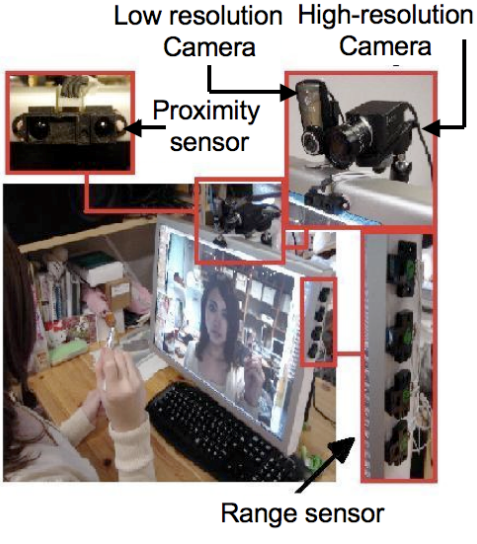

Fig. 1. Overview of Smart Makeup Mirror

3 Makeup Support Function

Using this system, users apply makeup while looking at the computer display where an image of the user's face is captured by the high-resolution camera is displayed. This configuration is slightly different from a realistic mirror because the user's gaze

is not aligned with the image, because the camera takes pictures from the top of the display. The response of the image may be delayed because of computation. Further, the resolution is lower than that of a realistic mirror, and the image may be out of focus where a user moves considerably from the focusing position of the camera. These differences may obstruct the makeup application process. The purpose of this research is to implement an artificial mirror with functions that cannot be achieved by using a realistic mirror in order to compensate for the abovementioned differences.

In order to estimate the influence of the abovementioned differences on the makeup application process, we applied makeup using an early-stage prototype of our electronic mirror. The following observations were made.

- Satisfactory makeup application using the electronic mirror is generally possible.
- However, a function that enables gaze alignment is required.

When a user tries to see an enlarged view of her face and comes considerably close to the camera, the face image gets blurred as the camera does not have an auto-focus mechanism. From the above observations, we conclude that at least two additional functions are required to make the electronic mirror as effective as a realistic mirror in the makeup application process. One is to capture and display the user's face from the front, and the other is to enlarge this image for ease of use. The details of these functions are explained in the following sections.

3.1 Automatic Zoom and Pan

During the makeup application process, we usually bring our face close to the mirror in order to ensure that our makeup is satisfactory and to check the makeup near certain face parts such as the eyes and the mouth. This is a critical part of the makeup application process, is frequently needed, and is often the most troublesome as it requires a strenuous and awkward posture. For this purpose, we developed an automatic zoom function in the proposed system for zooming at a particular at part of the face. When a user brings the makeup tool, with an attached color marker (a small green sticky label), near her eyes, the camera recognizes the marker, zooms in, and switches to an enlarged image of the eye.

In order to detect the color marker, it is not practical to use the high-resolution camera image because the processing time will increase significantly and the response will be unacceptable: moreover, the accuracy of position detection achieved by the high-resolution camera is not required. Therefore, we use an additional low-resolution camera for recognizing markers. This enables users to apply makeup without having to physically approach the display.

3.2 Intuitive Magnification Rate Control

A professional makeup artist recommends having at least one magnifying glass at hand as it aids in carrying out a thorough checkup of the applied makeup [4]. We developed a "magnifying glass function" in order to provide finishing touches to the makeup application process, thereby improving the quality of the applied makeup. The proposed system uses an infrared range sensor to measure the distance between the camera and the face. Further, the magnification rate of the display image can be

increased/decreased by simply and slightly approaching/leaving the display. A similar technique was recently used for a document browser [5].

3.3 Left and Right Reversing Mirror

A professional makeup artist will always recommend checking a person's appearance from the viewpoint of another person standing in front, with the help of a left and right reversing mirror (the reversal mirror) [4]. The impression of the hairstyle: the shape of the eyebrow, eyes, and lips: and the positions of moles are different, when the face is seen in a reversal mirror. Therefore, we added this functionality to the proposed system, enabling the system to as display the image captured by the camera as a left and right reversing mirror would.

3.4 Profile Check

In everyday life, the face is observed not only from the front but also from the side, from the bottom, and in the diagonal direction. Thus, while applying makeup, we must inspect the face from various angles. In the proposed system, the camera captures the image of our face and displays it for several seconds. By looking at that picture, we can inspect the makeup on the face from various angles. As a result, it is possible for us to check our profile and our view from the back, which is not possible to observe in a conventional mirror. When a user captures her face while she is looking at the camera, she can check the gaze-aligned view of her face that a conventional mirror always provides.

3.5 Lighting Mode

It is usual that to apply makeup in a place that is as bright as possible. However, the makeup of a user and hence her appearance may appear different under different lighting sources such as sunlight, fluorescent lamps, and incandescent lamps. This system simulates the lighting conditions depending on the surroundings. (Fig.2) The lighting conditions are makeup mode, office mode, cloudy mode, clear weather mode, red sunset mode, and candle mode. The selected lighting mode is displayed in the title bar of the interface and can be confirmed easily.

3.6 Makeup Log

When we change cosmetics, tools, or the method of makeup, it is difficult to find differences in the face between how our face looked with the old makeup and how it looks with the new makeup. Moreover, it is also difficult to see our own face objectively in a conventional mirror, because we usually hold a good expression in front of the mirror.

The smart makeup mirror allows us to save the image being displayed to a computer file with a particular file name and date. By using this function, we capture an image of our face after applying makeup. This will help us to accurately compare the color, brightness, or texture that suits our face by capturing an image every time in the same environment.

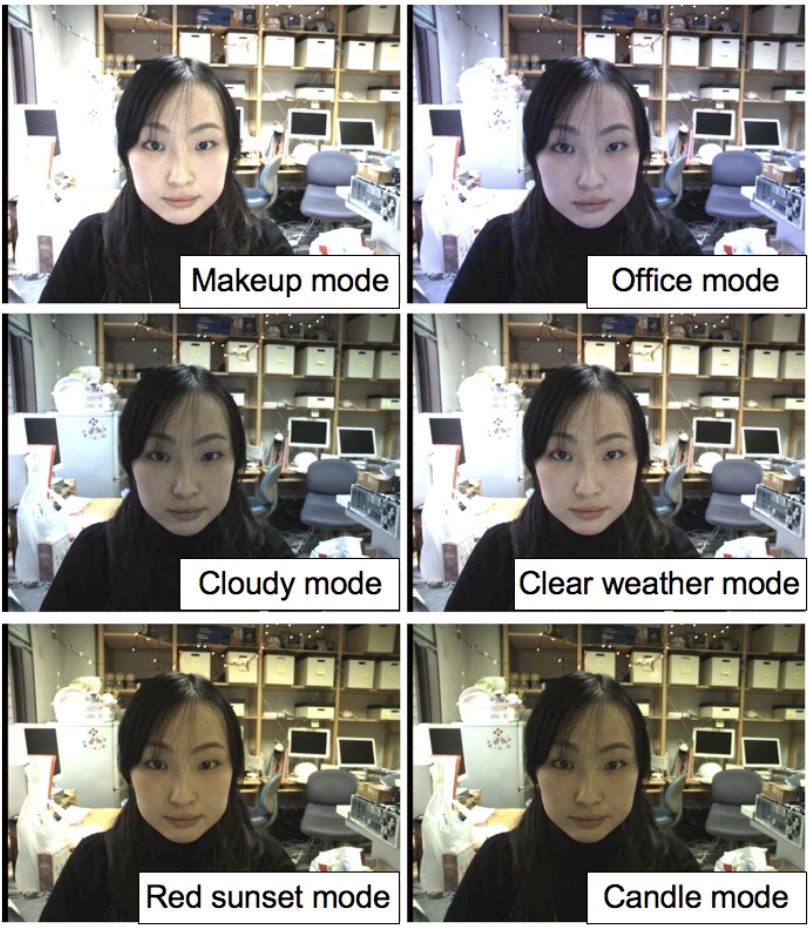

Fig. 2. Differences in the face appearance in different lighting modes

3.7 Noncontact Operation

While applying makeup, our fingers become dirty and it is undesirable to touch anything with the dirty hand. All the operations of the abovementioned functions can be operated without touching any part of the system. Automatic zoom to a specific part of the face and intuitive magnification rate control have already been achieved by noncontact by using a color marker (makeup tool) and the range sensor (position of the body). We attached four proximity sensors to the right of the display. On bringing our hand close to the proximity sensor, we can operate the left and right reversing mirror, profile check, lighting mode, and makeup log functions.

4 Evaluation Test

4.1 Test by the Author

One of the authors (a 23-year-old woman) applied makeup by using this system. Figure 3 shows the steps from "no makeup" to "full makeup and hair arrangement". The author's opinions are listed below:

- It is easy to line the lower eyelid but not the upper eyelid.
- For some makeup activities, the timing of zoom switching and position of color markers need to be adjusted.

After considering these findings, we have improved the timing of zoom switching, and the position of the marker.

Fig. 3. Steps from "no makeup" to :full makeup and hair arrangement."

4.2 Test by Ordinary Women

We have carried out an evaluation test (Fig. 4). Two women (age: 23 and 25 years) participated in the test. They are students in our laboratory and familiar with how to operate a computer. They applied eye shadow, eye liner, eye blowing out, mascara, lipstick, and blush on. The results are given below:

- The two women found the proposed system easier to use than they expected.
- They did not like the fact that they could see spots and dullness more clearly in the electronic mirror than in a conventional mirror.
- They liked the automatic zooming function.
- They occasionally lost sight of the spot where they were applying make up when the system switched to an enlarged image.
- They found the left and right reversing mirror function useful for checking of their appearance.
- They also found the ability to change the lighting mode useful.

- They found it easy to apply makeup to the lower eyelid, but difficult to do so on the upper eyelid.
- They found it difficult to use the eyelash curler because of the motion delay caused by the computation.

Difficulty of applying makeup to the upper eyelid was pointed out by both the author and the two subjects. We will describe the improvement related to this issue in the following section.

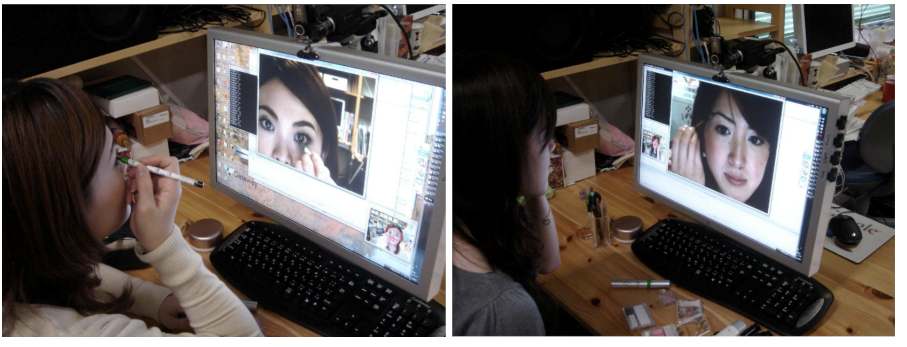

Fig. 4. Evaluation tests by two women

5 Adjusting Position of Display

In order to decrease the difficulty in applying makeup to the upper eyelid, we carefully observed users when they applied makeup to the eyelid. When they applied makeup to the upper eyelid using a mirror, they wanted to see their face from below. For this purpose, they raised their head and lowered their line of vision. (Fig. 5 left) Conversely, when they applied makeup to the lower eyelid, they lowered their head and glanced upward (Fig. 5 right). In the prototype system, the image is displayed at the upper part of the display: therefore, users felt that it was easier to apply makeup to the lower eyelid than to the upper eyelid.

Fig. 5. Application of makeup to upper eyelid (left) and lower eyelid (right)

This problem could be solved by changing the display position of the image according to the makeup activity to the lower and upper eyelids. Thus we have implemented a function that displays a magnified image of the eyes at the upper part of the display when the user applies makeup to the upper eyelid, and displays the magnified image at the lower part of the display when the user applies makeup to the lower eyelid. The user's activity of applying makeup to the upper or lower eyelids is detected by means of computer vision through the low-resolution camera. Thus, users easily apply makeup not only to the lower eyelid but also to the upper eyelid.

6 Internet Voting

By using the makeup log function, a user can capture an image of her face after applying makeup. Therefore, she can accurately compare the color, brightness, or texture that suits her face by capturing an image every time in the same environment. However, it is not sufficient to just find the makeup method suited to the user. Even if a user thinks that the one of the makeup results is suitable for her, other people may not think so. Then, we have developed a web page function that the user's friends can use to judge whether the makeup suits the user (Fig. 6).

Fig. 6. Web page where users' friends can vote

The picture of a face after applying makeup is open to the public on a web page that is password protected. The page shows pictures of a user's face in a favorable order. User's friends who are given the password can change the order of pictures with the arrow buttons on the page. They can arrange better pictures above worse pictures. By using this web page, a user can get useful opinions from her friends in an anonymous manner. This page would provide objective opinions on her makeup.

7 Conclusions and Future Work

We have proposed and implemented an electronic mirror that facilitates the process of applying makeup and makes it enjoyable. During the feasibility test with a female subject (age: 23 years), we have received favorable comments for the system. We carried out the evaluation tests with two women (age: 23 and 25 years). Further, we improved the system on the basis of the result of the tests. Additionally, we developed a web page function that allows friends to vote on a makeup result that suits the user the most.

We are planning to verify the utility of this system by using it for the long term.

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