Research on how to present images showing uneven foundation application that do not cause unfavorable impressions to the viewer

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Foundation is expected to have a covering effect that hides skin imperfections such as pores and uneven coloring when it is applied evenly. However, since the foundation itself is close to the skin color, people cannot tell easily where they have applied it. Therefore, we proposed a system to detect and visualize uneven foundation application, and have succeeded in binary classification of bare skin and foundation skin. Here, visualizing the unevenness of foundation on the face may create a negative impression for users. Therefore, we studied a method to visualize the uneven application of foundation on the face, taking into consideration factors other than ease of understanding. As a result, we found that the most positive evaluation was a method that made it relatively easy to recognize where foundation had been applied unevenly and gives the impression of "bright, warm, active and radiant".

CCS CONCEPTS • Human-centered computing • Visualization • Visualization design and evaluation methods

Additional Keywords and Phrases: Foundation, Makeup, Visualization, Unevenness

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1 INTRODUCTION

The face is a part of the body that easily shows personal features such as age, gender, and emotions [1]. For this reason, people apply makeup as a means of making their facial impressions more ideal [2]. According to an Internet survey [3] conducted by Pola Cosmetics Corporation in 2019, approximately 80% of women aged 15-64 wear makeup. In addition, the demand for cosmetics is increasing not only among women but also among men, and the number of brands selling cosmetics for men is also on the rise. Against this background, the size of the global cosmetics market was valued at USD 254.08 billion in 2021 and is anticipated to register a Compound Annual Growth Rate of 5.3% from 2022 to 2028 [4].

In general, one can learn about cosmetics through special features in magazines and advice from beauty advisors when buying cosmetics. In recent years, celebrities and influencers have been releasing makeup videos on video distribution sites such as YouTube and social networking services such as Instagram, providing more and more opportunities to learn about makeup casually. According to a 2014 survey [5] by ASMARQ, the average score in self-evaluations of makeup skills is low, at about 51 out of 100 points, and few people are satisfied with how they apply their makeup. This is thought to be due to the difficulty of learning how to select cosmetics that match the individual's physical constitution and preferences and the difficulty in acquiring the skills to apply makeup to one's face, by using existing learning methods.

Makeup involves various processes depending on its purpose. In base makeup, foundation, primer, and concealer are mainly used to hide blemishes and pores, while highlighting and shading are used when giving the face a three-dimensional appearance. If the foundation is not applied properly, it is difficult to hide blemishes, pores, and other skin imperfections. In addition, foundations often contain sunscreen ingredients, so uneven application may result in sunburn on parts of the skin. However, applying multiple layers of foundation tends to cause the makeup to fall off from the layered areas, so it is necessary to apply an appropriate amount of foundation. To solve these problems, we have been working on a makeup support system that eliminates uneven application by visualizing the state of foundation application in real time and making it easier to check where and how much foundation has been applied. We proposed a machine-learning method for classifying foundation-applied skin images and bare-skin images captured by a smartphone camera [6]. However, in the study, the method of visualizing unevenness of makeup was not considered.

General research on visualization has focused on the ease of viewing and understanding of the data. However, visualization of uneven foundation application requires users to view many uneven spots on their faces. Therefore, the visualization of an uneven foundation, which is a negative aspect of foundation, must also take into consideration factors other than ease of understanding. The objective of our study is to find a method which users do not feel uncomfortable when they are presented with uneven makeup on their own faces, and that allows them to easily correct the uneven makeup. In this paper, we examine appropriate methods for visualizing uneven makeup application in a way that makes its location easy to check and less uncomfortable. We examined various methods of presenting uneven foundation applications to reduce discomfort in visualization.

The contributions of this study are as follows:

- We clarified the importance of considering the user's impression when visualizing uneven foundation application.
- We clarified a method that helps users to eliminate unevenness of foundation application by themselves when visualizing the unevenness of foundation application.

2 RELATED RESEARCH

Makeup is one of the ways to make one's face look its best. However, it is difficult to learn how to apply makeup that suits individual needs, since different people have different preferences, ideal finishes, and skin tones. There has been a lot of research on simulation and support for improving makeup techniques, such as systems that apply makeup to a simulation created from a photograph of the user’s face [7]-[9] and systems that suggest makeup methods that suit the user's face [10]. Kamitake et al. [11] proposed a system that takes a user’s facial image as input and simulates the user's desired look and suggests products that achieve it. Moreover, there have been studies on systems [12] that suggest the best foundation color for the face color in the image.

However, because the skin consists of two layers, the epidermis, and the dermis, and the calculation of light reflection is complex, simulations using still images as input may be affected by lighting conditions and other factors. Tsumura et al. [13] created a face model that closely resembles the user's skin texture and simulated makeup. Huang et al. [14] combined

the Kubelka-Munk model [15][16] with a screen-space skin rendering approach to account for the optical properties of the skin, applying different makeup materials and styles to simulate makeup in real-time.

Research related to the detection of uneven application includes studies on a system that measures the amount and distribution of foundation by using optical filters that emphasize the difference in the wavelength characteristics of reflections between bare skin and skin with foundation on it [17]. This system exploits the fact that skin with foundation on it absorbs light more efficiently [18] than bare skin does. However, it requires an optical filter which spectral transmission characteristics have been optimized through experiments, making it difficult for general users to use. In their study, only a heatmap was used to visualize the unevenness of the coating, and a detailed impression survey of the visualization was not carried out.

3 IMPRESSION EVALUATION EXPERIMENT

To investigate the impression people have of visualizations of uneven foundation applications to a face, face photos were painted with multiple round patterns that resembled unevenly applied faces, and an impression evaluation experiment was conducted on these photos. Since visualization on one's own face and those on someone else's face may give different impressions, we used two types of face photos: one of the participant's face and one of a woman created by an AI. Nineteen female undergraduate and graduate students participated in the experiment.

3.1 Creation of image with visualization dataset

We first captured images of participants' faces with primer and foundation applied using a smartphone. At this time, we used an LED light to illuminate the area where the image was taken so that the brightness would be the same as when applying makeup at a washbasin or similar location. Next, facial images of a young woman were generated by a web service [19]. We duplicated these images and processed them. There were 12 types of processing (Table 1), and three patterns of position of the uneven parts to be visualized for each type. It should be noted that, in this survey, these points were not real uneven makeup applications, but were randomly applied by the author using a software program called Processing. For the heat map-based Methods 1 to 4, the colors indicate the amount of foundation applied, with red, yellow, green, and blue indicating thicker foundation in that order. In Methods 5 to 8 and 9 to 12, which present the unevenness of the foundation by enclosing it and by filling it in with color, respectively, an area where foundation is not applied is indicated by a circle. The circles are colored in red, blue, yellow, and green. Unlike the color definitions in Methods 1 to 4, these methods only indicate that colored areas are unevenly coated places.

3.2 Experimental procedure

First, in Experiment 1, to investigate the difference in impressions between the processing of one's own face and that of another person, we asked participants to evaluate 72 images, of which half were of the face of the participant and the other half those of a woman (hereinafter referred to as "another") created by the AI. The respondents were asked to evaluate their impressions of 13 adjective pairs in seven levels, for example, with a -3 rating as "completely cold," a -2 rating as "very cold," a -1 rating as "a little cold," a 0 rating as "neither," a +1 rating as "a little warm," a +2 rating as "very warm" and a +3 rating as "completely warm" (Fig. 1). In the experiment, the order in which the images were presented and the order of the impression evaluation pairs were randomized to account for order effects. We selected those adjective pairs with high scores for personality and artistic expression from the frequently used adjective pair scale compiled by Inoue and colleagues [20] and added some adjective pairs related to makeup after discussions among the authors. Here, we were aiming to create a system that visualizes unevenness of makeup, but we assumed that some people might feel

unpleasantness when seeing their own faces with visualized uneven foundation applied. Therefore, in order to examine a visualization method that gives as positive an impression as possible, we asked the users to rate their impressions as "favorable", "bright or dark", "warm or cold" and so on.

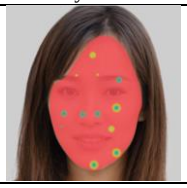
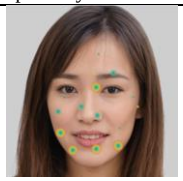
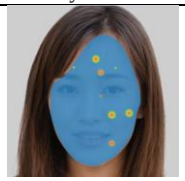
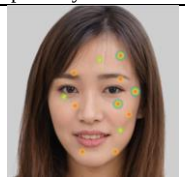
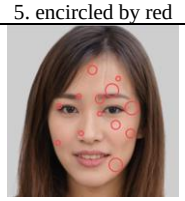
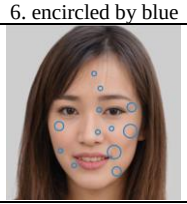
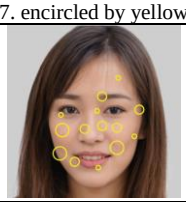
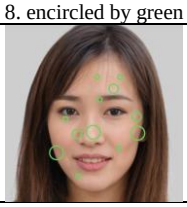
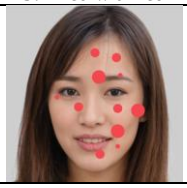
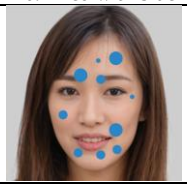
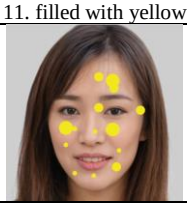
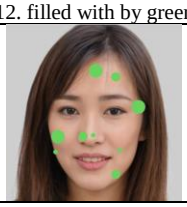
In Experiment 2, we asked the participants to compare two out of 36 photographs of their faces in terms of whether the presentation method was favorable or unfavorable to them and whether the unevenness of application was easy or difficult to recognize in order to investigate the ease of recognizing of unevenness when using different processing methods (Fig. 2). As in Experiment 1, the order in which the images were presented and the order of the impression evaluation pairs were randomized to account for the order effect.

In these experiments, it was necessary to continue looking at many images in which multiple circles appeared due to the nature of the processing. In addition, since the subjects were not accustomed to seeing their processed faces, they may have felt a strong sense of discomfort. Therefore, we recommended that the participants take breaks as necessary during the experiment, after obtaining their consent in advance. In addition, if the subject felt uncomfortable, he or she could leave the experiment at any time. Finally, a brief post-experiment questionnaire was administered. The questionnaire consisted of two questions: one asking for the areas of interest during the evaluation and one asking for impressions of the experiment.

Figure 1: Experimental system (Experiment 1)

Figure 2: Experimental system (Experiment 2)

Table1: Visualization Methods

1. entirely red heat map	2. partially red heat map	3. entirely blue heat map	4. partially blue heat map
			
5. encircled by red	6. encircled by blue	7. encircled by yellow	8. encircled by green
			
9. filled with red	10. filled with blue	11. filled with yellow	12. filled with by green
			

3.3 Experimental result

Experiment 1 was an impression evaluation experiment that used adjective pairs on face images processed to point out the foundation, to investigate the difference between the impression of visualizing uneven foundation application on one's own face and that on the face of another person. The score for the most positive evaluation was +3, and the score for the most negative evaluation was -3. Table 2 shows the averages of the results for each method.

From the table, we can see that the participants had more negative impressions when the unevenness was visualized on their face images than when on the images of other people's faces.

In Experiment 2, we asked the participants to compare two out of 36 photographs of their faces in terms of whether they preferred or did not prefer the presentation method and whether they found it easy or difficult to see the unevenness of the foundation makeup. Based on the results, to investigate the trend of the methods selected as “preferred” and “easy to understand,” we ranked the methods by PageRank (Tables 3-6). PageRank was calculated by placing a valid link from the one rated as “not preferred” or “not easy to understand” to the one rated as “preferred” or “easy to understand” for a given two-party relationship.

The figures show that the preferred presentation methods were “fill,” “encircle”, and “heat map,” in that order. Of the four “heat map” methods, Methods 3 and 4, in which the colors change in the order of blue, green, yellow, and red from the outside, were rated higher than Methods 1 and 2, in which the colors change in the order of red, yellow, green, and blue from the outside (Table 4). In terms of ease of understanding, they were evaluated in the same order.

4 DISCUSSION

The evaluation of the impression of the unevenly coated face images (Table 2) revealed that the subjects had more negative impressions of the visualization of their own faces than of others' faces. In conventional visualization studies, something, for example thermography, is visualized on the face of the experimental collaborator and not the collaborators themselves but researchers evaluate the visualization result. However, the results of the present study indicate that it is necessary to consider the impression that the person receives from the visualization of uneven foundation on their own face. In the following subsections, we will discuss appropriate methods for visualizing uneven makeup application in a way that makes its location easy to check and less uncomfortable.

4.1 Conditions Affecting the Likability and Understandability of the Technique: visualization methods

Tables 3 to 6 show that the method of presenting the unevenly coated areas as areas filled in with color was rated highest in terms of both likability and understandability. On the other hand, the heat map was judged to be the most difficult to understand and the least preferred.

The reason why the participants did not like the heatmap may have been because, unlike the other methods that used a single color for visualization, the heatmap used multiple colors, which made them feel there was a larger gap between their visualized face and their face as they imagined to it appear. In fact, in the free description of the post-experiment questionnaire, we obtained opinions such as “I felt uncomfortable with the ones in which the entire face was blue or red because it was hard to see the face itself,” and “I felt uncomfortable with the ones in which the entire face was processed with a solid color.” “The method that received the lowest evaluation among the four types of heatmaps was the one that pointed out the amount of foundation applied in stages based on the amount of foundation thickly applied to the entire face (Method 1 in Table 1). In this method, the entire face was colored red color, which made it difficult to determine the position of the eyes and nose. In fact, in the post-experiment questionnaire, there were comments such as, “It was difficult to see where the unevenness was located on the face.”

On the other hand, the presentation where the uneven part was filled in with color was more highly evaluated than the presentation with the unevenly coated part encircled with color. The reason for this may be that the former had a wider area covered with color than the latter, making it easier to confirm the location of the unevenness. As one respondent commented in the questionnaire, “I noticed that the brighter the cheeks are, the better the impression was,” it may be effective to emphasize the color to the extent that it does not impair the recognizability of the position.

These results indicate that the method that makes the parts of the face visible and the position of the unevenness on the face easy to recognize tends to be preferred.

Here, while the methods that present unevenness by enclosing (Methods 5 to 8) and filling in (Methods 9 to 12) only point out unevenness for all colors, the colors in the heatmaps (Methods 1 to 4) indicate the amount of foundation applied in stages. In the heatmaps (Methods 1-4), the colors indicate the amount of foundation applied in stages, with red, yellow, green, and blue indicating thicker foundation in that order. Therefore, we expected that the heatmap method would be the easiest to understand, but in fact, it was the lowest rated. This may have been because we did not provide sufficient information about what the colors indicated in the experiment and that the heatmaps generated in the experiment were different from those used in general studies. On the other hand, since the visualization of uneven application is a means with which to identify uneven locations and to rework the foundation there, it may be sufficient to roughly indicate the locations of uneven application rather than to point out the distribution of thickness as in a heatmap. Therefore, in addition to the 12 methods proposed in this experiment, we plan to investigate other visualization methods, such as unique stamps that can be displayed on the face by using photo processing applications.

4.2 Conditions Affecting the Likability and Understandability of the Technique: color pattern

Tables 4-6 show that the evaluation of each method differs depending on the color and other conditions, and that green, yellow, blue, and red have the highest evaluations, in that order, among the fill and encircle methods. The red and blue were also mentioned in the questionnaire as “I had a slightly negative impression of blue” and “I found red circles and gradient circles (especially those with a red center) difficult to look at.” This suggests that circles depicted on the face may have evoked negative feelings for due to their resemblance to disease symptoms, such as rashes and bruises. We speculate that the color used to visualize uneven foundation application should be one that does not evoke negative symptoms associated with the face.

4.3 Influence on impression evaluation depends on the area of interest

The post-experiment questionnaire revealed that 12 participants focused on the entire face, five on the processed parts, and two on other parts of the face when evaluating the images. If the respondents paid attention to different parts of the face, they may have had different impressions of the face. Therefore, we conducted a comparative analysis by classifying the subjects into two groups according to the different areas of focus: 14 subjects in the entire face group and five subjects in the processed face group. The other two subjects were included in the group that focused on the entire face because they had focused on the entire face in Experiment 1.

As a result, the evaluation scores of one's own face were lower than those for others' faces, regardless of the part of the face focused on, indicating a tendency to receive a negative impression from one’s own face. However, for the heatmap covering the entire face, those who focused on the processed part of the face were more likely to have a negative impression than those who focused on the entire face. In addition, the average evaluation of other people's face images was lower for those who focused on the processed parts rather than on the entire face, and the average evaluation of the face images was lower for those who focused on the entire face rather than on the processed parts. Furthermore, the difference between the

evaluations of their own and others' face images was smaller for those who focused on the processed parts, while the difference was larger for those who focused on the entire face.

These results suggest that people who focused on the processed parts were able to evaluate their images more objectively than those who looked at the entire face, but their negative impression may have been emphasized when the range of irregularities was large. Therefore, when presenting an undesirable object such as an image of one's own face unevenly coated with makeup, it is possible to soften the negative impression by drawing more attention to the processed part, but the effect of the range, size, and amount of unevenness to be presented must also be taken into consideration. The threshold value should be considered in the future.

Table 2: Average for each method of impression evaluation

	heat map				encircle				fill			
	entirely red	partially red	entirely blue	partially blue	red	blue	yellow	green	red	blue	yellow	green
participant's face	0.027	0.166	-0.045	-0.383	0.050	0.031	-0.497	0.231	-0.123	0.045	-0.329	0.206
another one's face	0.053	0.321	0.174	-0.483	0.181	0.249	-0.260	0.587	0.170	0.504	-0.233	0.660

Table 3: PageRank of favorability and understandability of methods

	favorable or not	understandability	average of favorability scores	average of understandability scores
1. entirely red heatmap	0.032	0.031	0.037	0.034
2. partially red heatmap	0.035	0.032		
3. entirely blue heatmap	0.039	0.035		
4. partially blue heatmap	0.042	0.037		
5. encircled by red	0.044	0.042	0.050	0.050
6. encircled by blue	0.047	0.047		
7. encircled by yellow	0.049	0.050		
8. encircled by green	0.059	0.060		
9. filled with red	0.084	0.087	0.614	0.166
10. filled with blue	0.123	0.117		
11. filled with yellow	0.138	0.164		
12. filled with green	0.310	0.298		

Table 4: PageRank of "fill" method

	filled with red	filled with blue	filled with yellow	filled with green
favorable or not	0.084	0.123	0.138	0.310
understandability	0.087	0.117	0.164	0.298

Table 5: PageRank of "encircle" method

	encircled by red	encircled by blue	encircled by yellow	encircled by green
favorable or not	0.044	0.047	0.049	0.059
understandability	0.042	0.047	0.050	0.060

Table 6: PageRank of "heat map" method

	entirely red heat map	partially red heat map	entirely blue heat map	partially blue heat map
favorable or not	0.032	0.035	0.039	0.042
understandability	0.031	0.032	0.035	0.037

4.4 Impression adjective pairs that positively influenced the evaluation

Table 2 shows that the method of presenting unevenly coated areas by filling them in with color (Methods 5 to 8) was evaluated more negatively than the method of presenting images by encircling unevenly coated areas (Methods 9 to 12). However, the fill-in method was positively evaluated in terms of the likability of the aforementioned methods. Comparing the two methods in terms of color, “blight - dark,” “warm - cold,” “active - passive,” and “radiant - subdued” pairs tended to receive more positive evaluations when the filled-in method was used than when the encircling method was used. From this result, it can be inferred that a method that enhances impressions of the face such as bright, warm, active, and radiant, is a suitable one for visualizing foundation.

4.5 Summary

From the above, we conclude that, when presenting an uneven foundation application, it is desirable to visualize the positions of uneven application in a color that is relatively easy to recognize and gives a flashy impression. In addition, it was suggested that drawing attention to the processed part of the face may soften the negative impression of an undesirable object visualized on one's face.

5 CONCLUSION

To investigate an appropriate method for visualizing uneven foundation application, we processed two types of face image, one of the participants and one generated by the AI. Twelve different processing combinations (three visualization methods × four color patterns) were examined by a survey, and an impression evaluation experiment was carried out on the desirability and understandability of methods for visualizing foundation application.

It was found that the impression of one's own face image was more negative than that of images of other people’s faces. Therefore, when visualizing the uneven application of foundation, it is necessary to consider the impression that the person whose face is visualized receives from the visualization.

In addition, it was found that the received impression varied depending on whether the entire face or the processed part of the face was the focus of the evaluation. This suggests that people who focused on the processed parts were able to evaluate their images more objectively than those who looked at the entire face, but at the same time, the negative impression may have been emphasized when the area of the image was large. Therefore, when presenting an undesirable image such as an unevenly coated area, it is possible to soften the negative impression by drawing more attention to the processed part. On the other hand, it is necessary to take into account the effects of the range, size, and amount of unevenness to be presented, so we plan to investigate threshold values for these effects in the future.

As a result of the evaluation of the likability and understandability of the proposed method, it became clear that the method tended to be preferred when the locations of the irregularities were relatively easy to identify. In addition, the method that received the highest evaluation tended to be preferred in the impression evaluation items of “bright – dark,” “warm - cold,” “active - passive,” and “radiant - subdued.” Although some people may not want to view images that highlight places where they have unevenly applied foundation, we believe that appropriate visualization can reduce users' discomfort and give them a more positive impression. Therefore, we would like to investigate positive visualization methods in the future when we create a system for visualizing coating irregularities.

In the experiment, the generated heatmaps were different from those used in previous studies, which may have had an impact on the results. In addition, since the experiment was conducted by placing coating irregularities randomly on the face, the visualizations were not necessarily the actual coating irregularities. Therefore, we plan to improve the proposed method and conduct experiments that visualize the actual unevenness of the coating.

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