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Modification Method for Facial Skin Temperature Image Considering Facial Artery Structure

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Abstract

We proposed a new method to modify facial skin temperature image considering facial artery structure. The proposed modification method facilitates more attention to blood flow information on the thermal face image. The method was adapted to an originally collected dataset to evaluate its performance. The dataset consisted of thermal face images under good or poor subjective health conditions. The result of the evaluation of the discriminant performance indicates that valuable information for health conditions estimation could be extracted from thermal face images by using the proposed modification method.

1. Introduction

Facial skin temperature image has been used for evaluating human physiological and psychological states because facial skin temperature reflects the location of increased or decreased blood flow in a windless, non-sweating situation. Based on this information, many studies have estimated various human states such as stress, emotions, and drowsiness. These studies extract features for estimation by defining arbitrary rectangular regions[1] or by applying machine learning methods such as a Convolutional neural network[2]. However, given that the information on the blood flow is used for estimation, modifying the thermal face image considering facial artery structure before feature extraction could be useful in obtaining more valuable information from the thermal face image. The purpose of this study is to propose a new method to modify the thermal face image considering facial artery structure.

2. Materials and Methods

2.1 Modification of Thermal Face Image

To modify the thermal face image based on facial artery structure, facial artery structure image was defined by the results of anatomical studies[3]. The defined facial artery structure image is shown in the center of Fig.1. In this study, we modified the thermal face image by multiplying the facial artery structure image as shown in Fig.1.

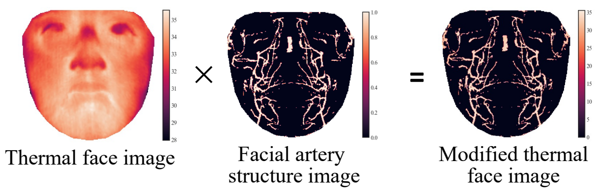

Fig. 1. *Thermal face image, facial artery structure image defined based on anatomy and modified thermal face image considering facial artery structure.*

Heat in blood vessels is transferred to the skin surface by thermal conduction. Considering this property, modification using the facial artery structure image defined in the center of Fig.1 is too sensitive for the thermal face image. Therefore, a Gaussian filter was applied to the facial artery structure image. The equation for the Gaussian filter is Eq.1.

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

In this study, σ was varied to verify what degree of smoothing is appropriate for modification. Examples of facial artery structure images when varying σ are shown in Fig.2. A larger σ value results in a broader Gaussian distribution and thus a stronger smoothing effect.

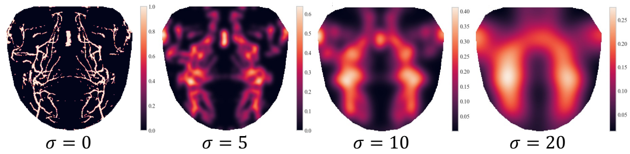

Fig. 2. *Facial artery structure images applied Gaussian filter with each σ. $\sigma = 0$ means the filter was not applied.*

2.2 Dataset for Evaluation

The proposed modification method was evaluated by the performance of separating poor health conditions from good health conditions. For evaluating separation performance, AUC (Area under the ROC Curve) was obtained by descriptive statistics calculated from the modified thermal face images. The dataset for evaluation was collected in the environment shown in Fig.3. The dataset consisted of the answers to a health conditions questionnaire and the corresponding thermal face images, with a total of 258 data. The data were collected from one subject from January 2021 to March 2022. The subject was asked to complete the questionnaire on a tablet immediately after measuring his thermal image. The collected thermal images were classified as good or poor health conditions based on the answers to the questionnaire.

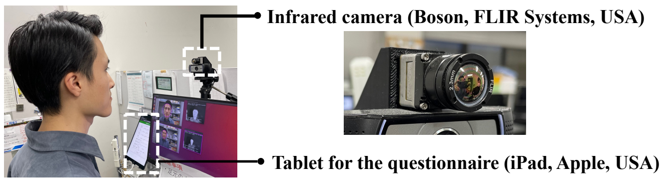

Fig. 3. *Measurement environment. The measurement was conducted at a room temperature range of 25.3–30.9 °C.*

3. Results and Discussions

Figure 4 shows the AUC for each descriptive statistic calculated from the modified thermal face image. X-axis represents the σ of the applied Gaussian filter. The "base" in the x-axis means descriptive statistic was not calculated from the modified image but from the original thermal face image. Discriminant performance was highest when σ was 10, 13, and 14, and AUC was 0.76. The highest AUC, when the thermal face image was not modified, was 0.66. This indicates that valuable information for health conditions estimation could be extracted by modified thermal face image using the facial artery structure image adapting the Gaussian filter with σ around 10.

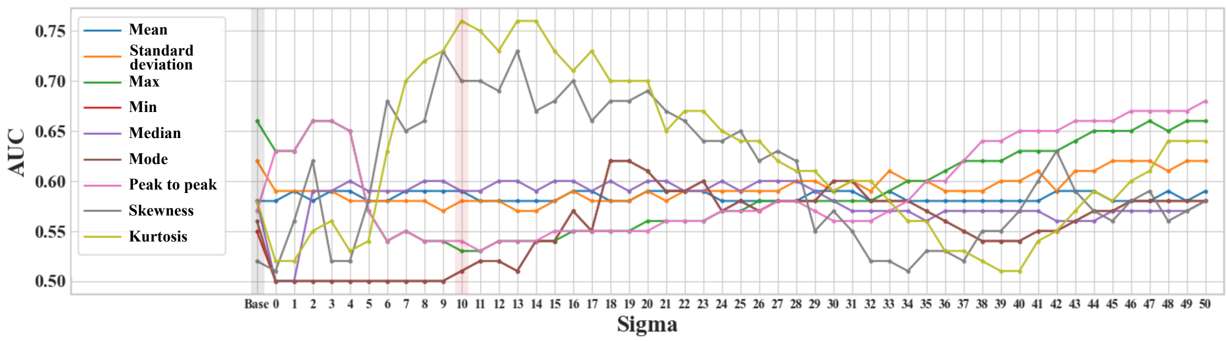

Fig. 4. *Discriminant performance of health conditions for each descriptive statistic calculated from the modified image.*

References

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