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Facial Shape Recognition Using Self Organized Feature Map(SOFM)

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Abstract

This study proposed a robust detection algorithm. It detects face more stably with respect to changes in light and rotation for the identification of a face shape. The proposed algorithm uses face shape as input information in a single camera environment and divides only face area through preprocessing process. However, it is not easy to accurately recognize the face area that is sensitive to lighting changes and has a large degree of freedom, and the error range is large. In this paper, we separated the background and face area using the brightness difference of the two images to increase the recognition rate. The brightness difference between the two images means the difference between the images taken under the bright light and the images taken under the dark light. After separating only the face region, the face shape is recognized by using the self-organization feature map (SOFM) algorithm. SOFM first selects the first top neuron through the learning process. Second, the highest neuron is renewed by competing again between the highest neuron and neighboring neurons through the competition process. Third, the final top neuron is selected by repeating the learning process and the competition process. In addition, the competition will go through a three-step learning process to ensure that the top neurons are updated well among neurons. By using these SOFM neural network algorithms, we intend to implement a stable and robust real-time face shape recognition system in face shape recognition.

Keywords: *face detection, face recognition, neural network, normalization, SOFM*

1. Introduction

In this paper, the face shape is used as input information in single camera environment, and only the face shape area is divided using flesh color information [1], and the face shape is recognized by using SOFM (Self Organized Feature Map) neural network [2, 3]. SOFM first selects the first top neuron through the learning process. Second, the highest neuron is renewed by competing again between the highest neuron and neighboring neurons through the competition process. Third, the final top neuron is selected by repeating the learning process and the competition process. In addition, the competition will go through a three-step learning

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process to ensure that the top neurons are updated well among neurons. We will implement a recognition system that is robust against noise and noise in face recognition [4,5,6].

2. Facial shape detection

2.1 Skin Color Filtering

In this paper, we measure the brightness change of the background due to the illumination change, obtain the background image I_t for a certain time T_i considering the time element (t), and then analyze each pixel(x) in the image area R to obtain the pixel $P_{max}(x)$ value when the illumination is brightest and the pixel $P_{min}(x)$ when it is darkest. The difference $D(x)$ of these two pixel values is a threshold of brightness that can be seen as a change in illumination. The background model is constructed using these three elements. The method allows more accurate access and detection of the target area than when using an image with any one specific brightness value. It is like the equation (1-4) if it expresses in the form.

$$BM = \{P_{max}(x) \ , P_{min}(x) \ , \ D(x) \ \}_{x \in R} \tag{1}$$
$$P_{max}(x) = MaxI_t(\mathrm{x}), (1 \ \leq \mathrm{t} \ \leq T_i) \tag{2}$$
$$P_{min}(x) = MinI_t(\mathrm{x}), (1 \ \leq \mathrm{t} \ \leq T_i) \tag{3}$$
$$D(x) = \ P_{max}(x) - \ P_{min}(x) \tag{4}$$
$$B(x) = \{_0^{256 \ if|P_{max}(x) - I(x)|or|P_{min}(x) - I(x)| > D(x)} \ _{otherwise} \}_{x \in R} \tag{5}$$

The equation (5) is a standard to dissect the brightness difference caused by the lighting and to separate only the area with the difference of the movement of the face change, and the noise is removed through the morphology calculation. Figure 1 shows the pre-processing of the image for the face recognition.

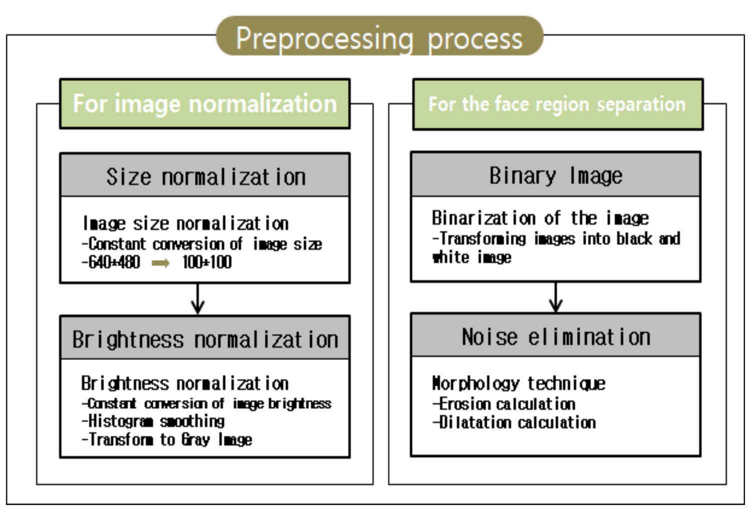

Figure 1. Preprocessing process for input image

2.2 Facial shape detection

In this study, since the color filter is applied and most of the remaining skin color pixels belong to the hand, the number of skin color pixels is separated from the background area by calculating the number of skin color pixels in the abscissa X-axis(labeling). Figure 2 shows the preprocessing of the input face shape.

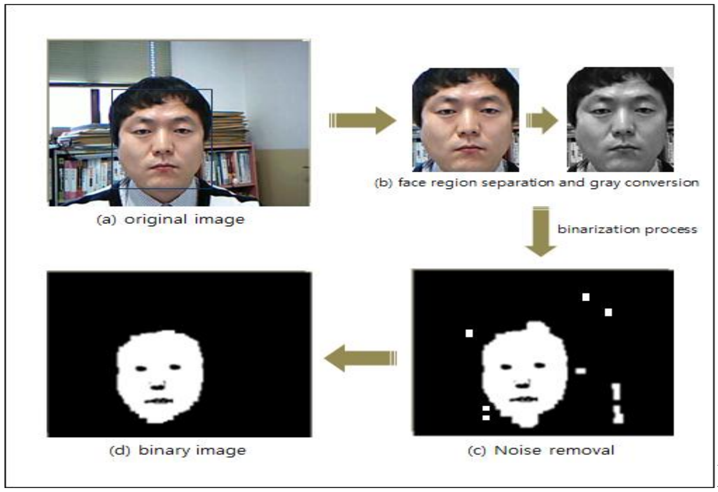

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Figure 2. Extraction of face shape from input video

3. Facial shape recognition

3.1 Neural network algorithm

The SOFM proposed in this paper forms the area map by organizing the two-dimensional feature maps of similar patterns in the competition layer by the objects represented by the feature vectors in the multi-dimensional space in the learning phase, and in the recognition phase, the connection trained in the learning phase. The class is recognized through the position where the response occurs for the unknown feature vector under the weight. Figure 3 shows the system configuration.

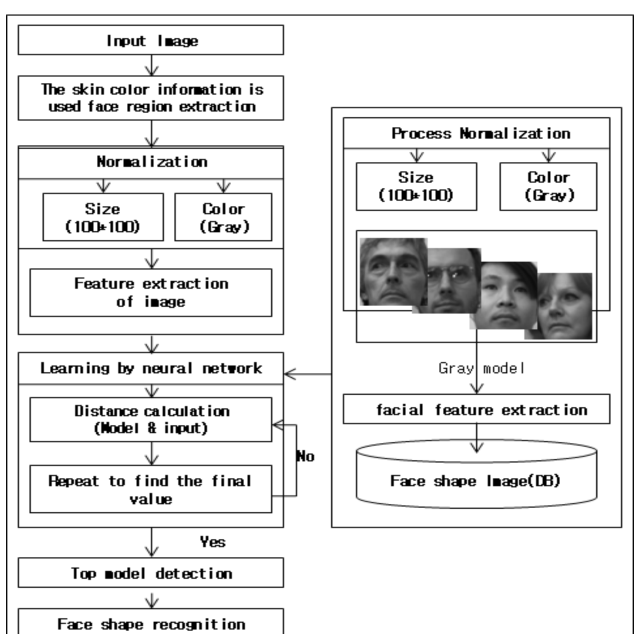

Figure 3. System Configuration

3.2 SOFM process

3.2.1 Competitive process

Each neuron is connected to the N-dimensional feature vector constituting the input space by the connection strength (initialization to 0 to 1 connection strength). Given an input pattern, the neuron with the smallest distance is the winner by calculating the connection strength and distance of all neurons. Figure 4 shows the relationship between the distances of the tubes of models from the input face shape.

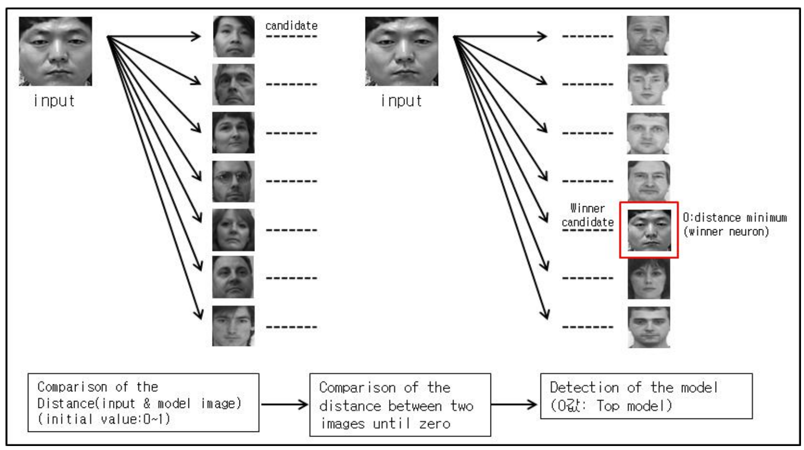

Figure 4. Competition process between input feature vector and model feature vector

3.2.2 Cooperation process

Only the winner with the smallest distance in the competition will be able to output, and only the winner's neighbors will be able to adjust the strength of the connection. Figure 5 shows the neurons adjacent to the winner neurons.

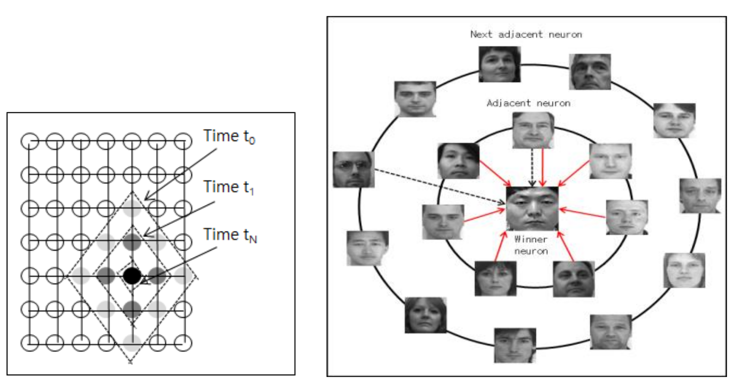

Figure 5. Neurons closest to winner neurons

3.2.3 Adaptation process

The connection strength is updated by adapting the active function to make the winner neurons and their neighbors more sensitive to specific input values. Near neurons adapt more strongly than distant neurons. In Figure 6, the dashed line and the solid line represent it.

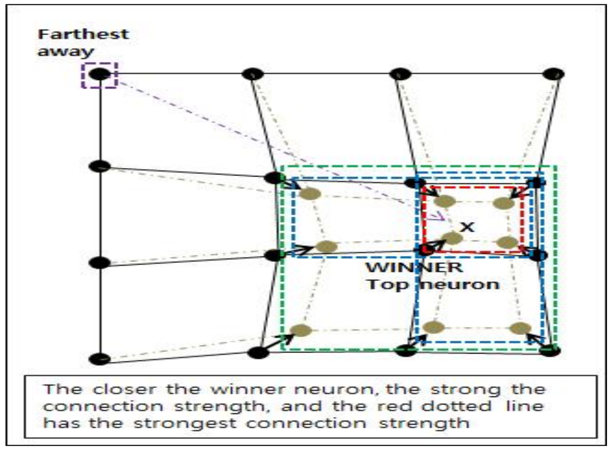

Figure 6. Update of connection strength for winner neurons

3.3 SOFM Learning 3 Steps

Step 1: reset connection strength

Initialize the connection strength between N inputs and M output flow runs to any number of small values. The strength of the connection decreases gradually with $h_{ik}(\mathrm{t})$.

Step 2: Present the input vector and compete

Compute the distance between the input vector and all neurons. The distance between the input and output neurons K is calculated as shown in Eq. (6), and the minimum value among them is selected. Figure 7 shows the distance between the input image and the model image.

$$\mathrm{i}\big(X^{(\in}\big) = \arg\ | \tag{6}$$

$X^{(\in}$ is the i th input vector at time t, W_j is the connection strength between the i th input vector and the j th output neuron at time t.

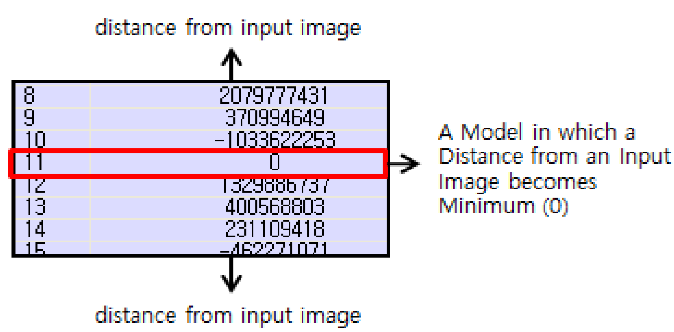

Figure 7. Distance between input image and model image

Step 3: Update the connection strength of the selected neurons and their neurons within their neighbor radius (collaboration and adaptation)

The update of the link strength is updated by equation (7).

$$\mathrm{W}_k = \mathrm{W}_k + \eta(t) \cdot h_{ik} \cdot (X^{(\in} - W_j) \tag{7}$$

$\eta(t) \cdot h_{ik}$ is a gain term with a value between 0 and 1, and gradually decreases with time. The learning rate reduction function is used, as shown in equation (8).

$$\eta(t) = \eta_0 exp\left(-\frac{t}{T_1}\right) \tag{8}$$

η_0 : Early Learning Benefits
t : Number of learning repetitions
T_1 : Learning rate time constant

In this paper, we apply the learning method with different gains according to the distance, as shown in equation (9).

$$\omega_{ij}(t+1) = \omega_{ij}(t) + \eta(t)\mathrm{m}_{ij}(x_i(t) - \omega_{ij}(t) \tag{9}$$

m_{ij} : Learning rate time constant

4. Experiment result

When the input image comes in, the distance between the feature vectors of the image is compared through the competition process, the learning process, and the adaptation process. The model in which the distance is the minimum value (0) is found.

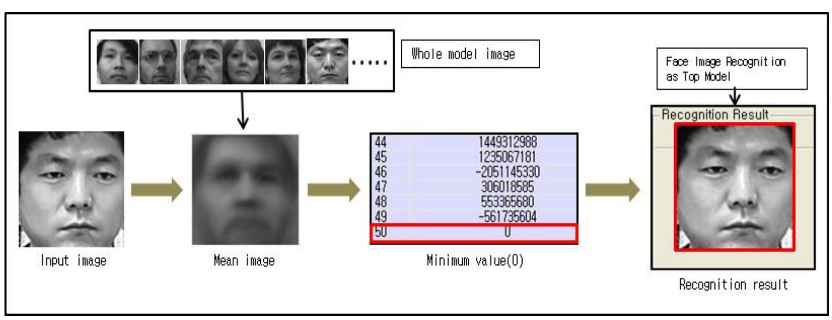

Figure 8. Face shape recognized as top model

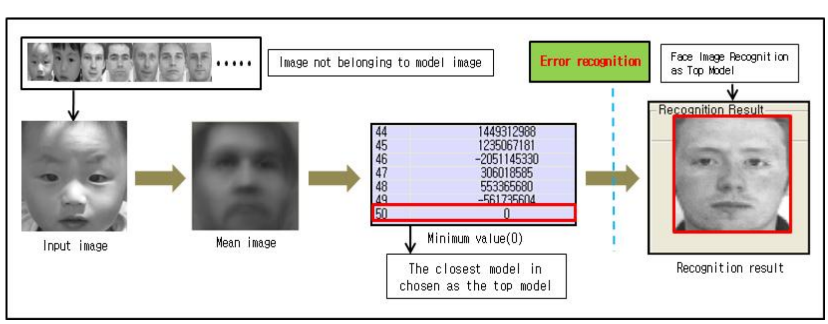

Figure 9. Misidentified face shape as top model

Figure 10. Face shape recognition system using SOFM

When analyzing the face shape recognition results of Table 1, First, in case of PCA, if the face shape of the input image is almost similar, the problem of misrecognition with the same shape often occurs even though it is a different. Second, in the case of SOFM, the strength of connection to winner neurons is strengthened through the learning stage in order to determine the winner neurons by calculating the distance between face shapes and to determine the winner neurons as the top model. Therefore, the problem of misrecognition of different face shapes as the same face shape for face shapes belonging to the model image is greatly improved and shows high recognition rate. However, when it does not belong to the model image, the closest distance is recognized as the best model in the process of comparing the characteristics of the input image with the characteristics of the model image. As a result, there are many improvements in failure rate over other algorithms, but there is still a problem of misrecognition.

Table 1. Performance Evaluation Analysis Table by Recognition Method

Algorithm	Model image classification	Success rate(%)	Failure rate(%)
PCA	Belong to the model	83.7	16.3
	Does not belong to the model	63.5	36.5
SOFM	Belong to the model	90.2	9.8
	Does not belong to the model	73.1	26.9

Table 2 shows the results of real-time recognition performance according to the lighting change for the proposed algorithm. The reason why the recognition rate drops when the lighting is bright and when the lighting is dark is because the detection of the face region in the input image is not performed correctly. In recognition time, the difference between two images was about 0.6~0.7 seconds faster than the simple brightness information.

Table 2. Analysis table for recognition performance evaluation according to lighting changes

Light	Recognition rate(%)	Failure rate(%)	Recognition time(sec)
When bright	86.3	13.7	1.54
Two image difference	90.2	9.8	0.82
When dark	84.7	15.3	1.43

5. Conclusion

This study proposed a robust detection algorithm. It detects face more stably with respect to changes in light and rotation for the identification of a face shape. The proposed algorithm uses face shape as input information in a single camera environment and divides only face area through preprocessing process. Face recognition is very sensitive to illumination changes, so it can be difficult to separate the correct face area. In this paper, we separated the background and face area using the brightness difference of the two images to increase the recognition rate. After separating only the face area, the face shape was recognized using the self-organization feature map (SOFM) algorithm. In this experiment, the model image shows high recognition rate, but when it does not belong, the model adjacent to the top model is selected as the top model, so the recognition rate is 0% because it does not match the model image and the input image. However, the input image belonging to the model image showed good recognition result.

In the future, it is necessary to develop algorithms that can divide elaborately and produce higher recognition results even in complex background and lighting changes. In addition, as the evolution of the times, face recognition should be developed more sensitive recognition algorithms by applying AI techniques such as machine learning and deep learning.

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