Active Appearance Model-Based Facial Expression Recognition Using Face Symmetrical Property in Occluded Face Image

Jaehyun So, Sanghun Han, Hyun-Chool Shin, and Youngjoon Han

***Abstract*—**This paper proposes an Active Appearance Model–based recognition of the facial expression using face symmetrical property in occluded face image. It is very difficult to classify the occluded facial expression due to disappearance of expressional features. Unlike many papers about the recognition of the facial expression, the paper deals with the method that the expression of the occluded face is classified. To solve this problem, we use AAM model with an half of the face features using the symmetrical property of the face. This model uses Principal Component Analysis(PCA) method for the adaptive variation of the facial shape and textures in the pre-processing time. We use an original image and a flipped image of facial expression because the model is about a half of the face. And we have used the Inverse Compositional Alignment (ICA) algorithm to fit a input face into the face model. After the AAM model fitting, the Support Vector Machine (SVM) is applied for the training and classifying of the facial expression. The efficiency of this algorithm was evaluated using Japanese Female Facial Expression(JAFFE) Database.

***Keywords*—**Facial Expression Recognition, Active Appearance Model, Principal Component Analysis, Project-Out Inverse Compositional Alignment, Support Vector Machine

I. Introduction

THE automatic recognition of the facial expression has been studied for a long time because almost people want to know other people's emotion. In order to understanding this information, the human body has many sensor organs like the eye and ear. However, it is very difficult to exactly understand what other people are thinking and feeling. That's why this study is important for communicating in our society. Human is likely to depend on the visual information. So the computer vision similar to human eye using images from CCD camera can provide a solution for the automatic recognition of the facial expression.

Actually, many methods for the recognition of the facial expression have been proposed in computer vision field. gy . Especially, AAM[1] is generally used for robustly finding a face in images, so this method is useful to the recognition of the facial expression. Cheon, Y. and Kim, D. used differential parameters of AAM as the facial feature and K-Nearest Neighbor for classification[2]. And Ashraf and Lucey used the facial shape and texture as the facial feature and SVM for the classification[3]. However these solutions can't recognize an occluded facial expression because these methods are based on features of the whole frontal face. Kotsia and Buciu proved that the occluded facial expression can be recognized using the filtered texture and the shape[4] but they used facial landmarks manually made in each image for the test.

So we propose a new recognition method of the occluded facial expression. We detect faces using VJ method [5] in image, and then fit the AAM model in the facial shape using ICA [6] . This model is made by the database about a half of the face using PCA[7]. After fitting the facial model, we check the fitting result using ROI and some decision rules whether this can be used as the facial feature or not. If the fitting result is good, then we classify the facial expression using the shape points of the model using SVM[8].

In Section 2, our proposed method is described in detail. In Section 3, we provide the experimental result. In Section 4, conclusion is presented.

II. Proposed Facial Expression Recognition

A. The Proposed Method

Our method has various steps like Fig. 1. In first step, the face detection algorithm like a VJ method is applied. The VJ method uses Haar-like feature and Adaboost classifier. But the result rectangle from the face detection cannot express the exact facial region. In step 2, AAM fitting is used for the more exact region of the face. In step 3, some decision rules are applied for the exact model fitting. In step 4, facial models are compared with the base model constructed during pre-processing. In final step, features of the resulting model are extracted, and then SVM classifier is used to classify facial expressions. For these step, AAM models and SVM classifier have to be made in the pre-processing period. The AAM models are made by PCA using the face training database and SVM classifier is trained using facial features after the AAM fitting.

Jaehyun So is with the Electrical Engineering Department of Soongsil University, Seoul, Korea (e-mail: ru2ror@gmail.com).

Sanghun Han is with the Electrical Engineering Department of Soongsil University, Seoul, Korea (e-mail:loup86@naver.com).

Hyun-Chool SHIN is with the Electrical Engineering Department of Soongsil University, Seoul, Korea (shinhc@ssu.ac.kr).

Youngjoon Han is with the Electrical Engineering Department of Soongsil University, Seoul, Korea (e-mail: young@ssu.ac.kr).

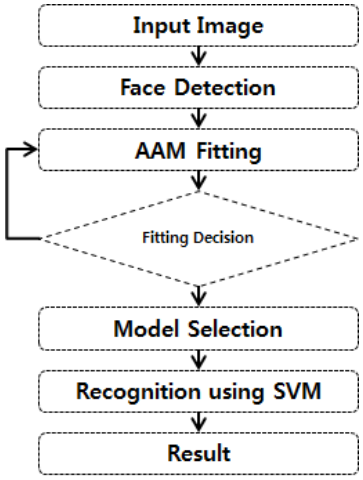

Fig. 1 Flow of the proposed method

B. AAM model about a half the face

The most of papers about the recognition of the facial expression have being used features of the whole face. So, the model fitting and SVM classifying could be failed because of using partial features of the whole face. When the face is occluded, however, our proposed method uses just a half of the face features based on the symmetrical property of the human face as Fig. 2.

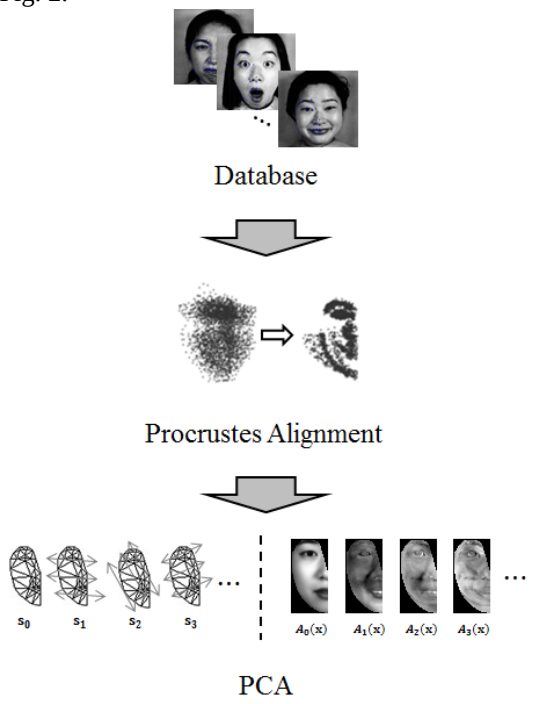

Fig. 2 Calculation of PCA for making the model

As Fig. 2 shows, every landmark is manually made, and then these are aligned by Procrustes method. The number of landmarks is 35. Finally, the shape vectors and texture vectors of the face image are calculated by PCA algorithm. This model can be expressed to Eq. 1. In Eq. 1, S *and* $A(x)$ is the shape model and the texture model.

$$S = S_0 + \sum_{i=1}^{n} P_i S_i$$
$$A(x) = A_0(x) + \sum_{i=1}^{m} \lambda_i A_i(x), \qquad \forall x \in s_0 \tag{1}$$

AAM fitting is calculated using these models. After calculating the current shape of the face image, ICA algorithm is applied using the difference between the base model and the current model. The goal of fitting is that error converges to zero.

$$\sum_{x \in s_0} \left[I(W(x;p)) - A_0(W(x;\Delta p)) \right]^2 \tag{2}$$

In this equation, $I(W(x;p))$ is the warped current face by Piecewise Affine Transformation[9]. Also this equation can be expanded by Taylor series expansion like Eq. 3.

$$\sum_{x \in s_0} \left[I(W(x;p)) - A_0(x) (W(x;0)) - SD\Delta p \right]^2$$
$$, SD = \nabla A_0 \frac{\partial W}{\partial p} \tag{3}$$

This error is used to calculation of the shape parameter using Gauss-Newton Iteration like Eq. 4. In Eq. 4, H is hessian image of SD.

$$\Delta p = H^{-1} \sum_{x \in s_0} \left[SD \right]^T \left[I(W(x;p)) - A_0(x) \right] \tag{4}$$

The model fitting, based on the symmetrical property of the face, is applied for original image, and then the flipped image is gotten as shown in Fig. 3.

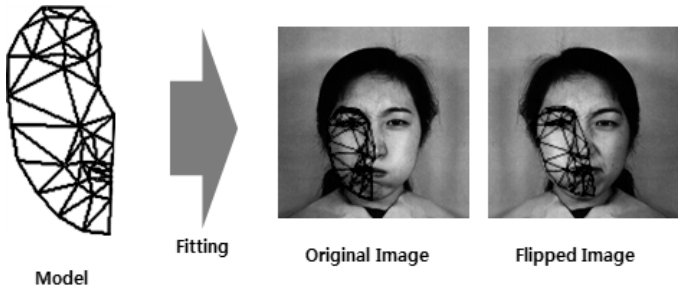

Fig. 3 The model fitting in images.

C. Fitting Decision

The harder AAM fitting is, the worse the recognition rate of the facial expression gets. So we set the ROI for checking the fitting result as shown in Fig. 3 and ROI is calculated by Eq. 5.

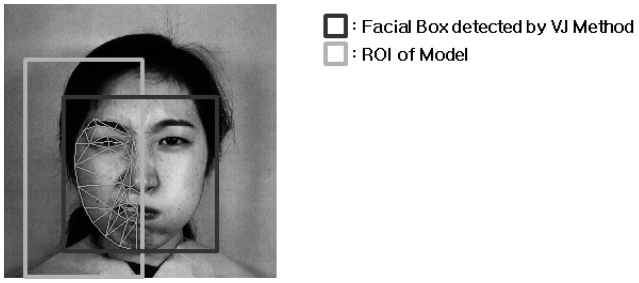

Fig. 4 ROI Setting

$$ROI = Facial\ box \times \frac{7}{5} \quad (5)$$

When the current shape gets out of ROI, fitting process is stopped.

D.Model Selection

Two models were fit in the previous step. But it is very difficult to find out which model has a good feature for the recognition. For solving this problem, the error during ICA fitting are calculated using Eq. (5).

$$\|Error1\|_2^2 - \|Error2\|_2^2 \begin{cases} < 0 : Model\ 1 \\ > 0 : Model\ 2 \end{cases} \quad (5)$$

E. Facial Expression Recognition

If the model is selected, the facial expression can be classified using the features of it. We use points of the shape model as the feature and SVM classifier. The SVM algorithm is a method which finds out a hyper-plane with the maximum margin between features of each class. The calculated hyper-plane can classify the facial expression.

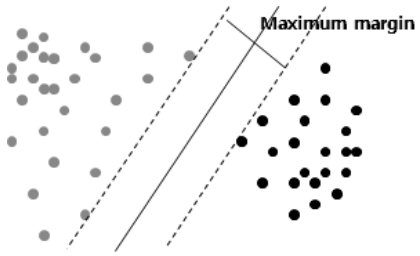

Fig. 5 Calculation of the hyper-plane in SVM

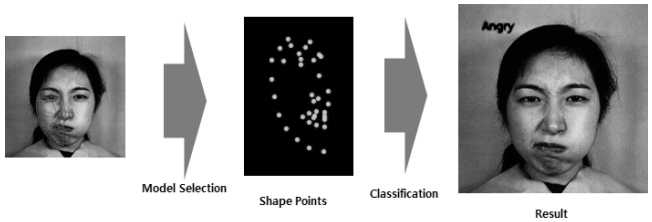

Fig. 6 Facial Expression Recognition

III. EXPERIMENT

We use JAFFE database to evaluate our proposed method algorithm. Many researches have used the database because it has 7 expressions as shown in Fig. 7. We, however, use 5 expressions (neutral, happy, sad, angry and surprise) to get the minimal error. The size of JAFFE images is 640x480. In order to implement our proposed method, OpenCV and LibSVM[10] are used.

Fig. 7 JAFFE Database

76 images of JAFFE for training and other 76 images are used to testing. A half side of the test images is randomly blurred using gaussian kernel for expressing the occlusion.

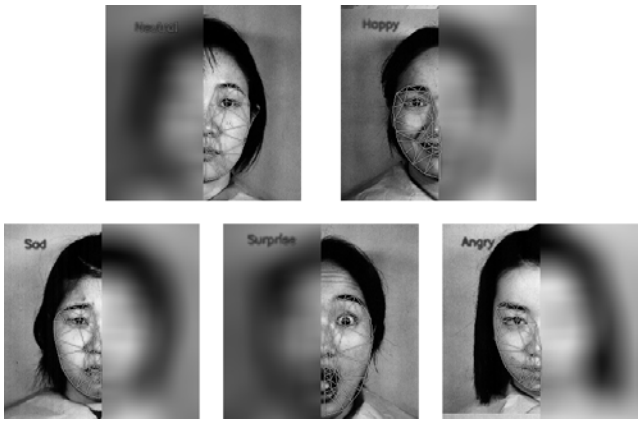

Fig. 8 Testing results

We could check the efficacy of the proposed method using blurred images.

IV. CONCLUSION

The AAM-based recognition method of the facial expression using the symmetrical property was proposed. The method can recognize the 5 facial expressions well when the face is occluded. The AAM model with a half feature of the face image is fit after detecting the face using VJ algorithm. And the SVM algorithm classifies a facial expression into the one of 5 defined expressions using points feature of the shape model. The efficiency of our proposed method is confirmed using the test set of the blurred JAFFE database. But the proposed method

hardly recognizes the expression when the top or bottom part of the face is occluded. We will continuously study about this problem.

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