

IMPROVED ACTIVE SHAPE MODEL FOR FACIAL FEATURE LOCALIZATION

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ABSTRACT

For face representation, the illumination effect is an important factor, in order to reduce illumination factor, we propose a facial feature location method based on improved active shape model (IASM) to reduce the drawback of intensity contrast and to enhance edge information. First, the face images are preprocessed by the proposed illumination normalization method using Gabor wavelets. Then, the location of facial features can fit more efficient and fast by the Gabor kernels reduction and the proposed feature-based weighted warping method. Based on our method, it not only obtains the better face alignment but also overcomes the active shape model (ASM) method which caused the failure for aligned target. Experimental results show that this approach can achieve in JAFFE face database with seven type facial expressions and Yale face database_B with varied illumination conditions.

1. INTRODUCTION

Automatic face recognition and expression analysis were a very progressed in the last few years, making its uses practical in experimental or commercial software systems. Zhang and Gao [1] proposed a practical face recognition system which includes various poses and expressions with varying illuminations. If these effects are also considered, the overall recognition rates can be further improved and robust.

Generally, pattern recognition problem relies upon the inherent features within the pattern. In the past, there are many approaches about this problem to copy with the effects of illumination variations on facial localization and face recognition, such as the literature [2, 3]. For facial feature extraction, many techniques, such as Fourier transformation, wavelet transformation, and Gabor filtering, are usually adopted to extract the efficient facial features. The 2D Gabor filtering is very popular for computer vision and image processing and many other application areas. It is well-known that the Gabor filters are robust against the local distortions, preventing the control points from sticking into local minimum during optimization.

Face image data are usually denoted high-dimensional format to hold the important attributes, hence they become very hard to analyze and process. Due to this, the mechanism of reducing the face data dimension is necessary

and thus can obtain fast and good recognition result. In order to reduce the dimension and improve the computational complexity, in this paper, an efficient representation method which is insensitive the varying illumination is proposed for facial feature localization.

The rest of the paper is organized as follows. Section 2 describes our proposed method. Results and performance evaluation are presented in Sections 3. Finally, we discuss the conclusions.

2. OUR APPROACH

First, we use the 2D Gabor filter to extract the features for a given face image, and based on the characteristics of Gabor filter, we can obtain high-dimensional space of features. Some of these features caused the invalid classification. Hence, the feature selection is a crucial step in our approach. In order to solve this problem, we use the Gabor kernels reduction to improve and obtain the available feature. Next, using weighted warping procedure, it can correct the unstable feature in the local graph warping for face images and obtain the pattern change information that will yield the advantage of face mapping. Finally, in order to efficiently improve the convergence performance and accurately locate feature points in ASM process, we propose an improved ASM method to capture the features and locate the frontal face image. Details of the procedures are described as follows.

2.1 2D Gabor feature extraction

It is known that the 2D Gabor filter [4] has local optimum ability under the spatial domain and frequency domain based on multi-frequencies and multi-orientations characteristics. Hence, in our approach, we use the 2D Gabor filter to modulate the orientations and frequencies for face feature extraction. The Gabor filter is expressed as

$$\varphi_{\mu,\nu}(z) = \frac{\|k_{\mu,\nu}\|^2}{\sigma^2} e^{\left(\frac{\|k_{\mu,\nu}\|^2 \|z\|^2}{2\sigma^2}\right)} \left(e^{(ik_{\mu,\nu}z)} - e^{\left(\frac{\sigma^2}{2}\right)} \right), \quad (1)$$

where μ and ν denote the orientation and scale of the Gabor where kernels, $z = (x, y)$ [4, 5]. The wave vector $k_{\mu,\nu}$ is defined as

$$k_{\mu, \nu} = k_{\nu} \cdot e^{i\phi_{\mu}} \quad (2)$$

where $k_{\nu} = \frac{k_{\max}}{f^{\nu}}$ and $\phi_{\mu} = \frac{\pi\mu}{8}$. $k_{\max}$ is the maximum frequency, and f is the spacing factor between kernels in frequency domain.

The term $k = 2^{\frac{s}{2}}(2^{-\pi})$ is represented each scale value is Gabor wavelet transform. The term $-e^{\left(\frac{\sigma^2}{2}\right)}$ is represented the deduction illumination noise [3].

Generally, Gabor filter is used to eight orientations, $\mu \in \{0, 1, \dots, 7\}$ and five different scales, $\nu \in \{0, 1, \dots, 4\}$ [5] as the transform parameters. Thus, it needs 5×8 filters to extract feature data.

2.2 Gabor kernels reduction

Because evaluating all 5×8 filters to convolve the facial image is quite time consuming. Hence, in order to reduce the computational complexity and improve the performance, we use Phase-Sensitive Similarity Function [6, 7] to match kernels [8] and choose high frequency components to represent feature diversity in the database.

Owing to 2D Gabor filter has the characteristic of angle symmetry, here, we chose the orientation in the range [90, 180] and three smaller scales to cover more high frequency signal. Based on this viewpoint, for the parameters in Gabor filter, the last four orientations $\mu = (4, 5, 6, 7)$ and the first three scales $\nu = (0, 1, 2)$ are selected to use in our experiments.

2.3 Local feature-based weighted warping (LFBWW)

According to Beier-Neely algorithm [8] shown in Fig. 1, variables μ means a fraction region, and ν is a interval length $\overline{PQ}$. The corresponding formulas are briefly as follows. The line segment $\overline{PQ}$ will be mapping the line segment $\overline{P'Q'}$ given feature point X , the mapping position X' in the destination image from X is determined by the following formulas.

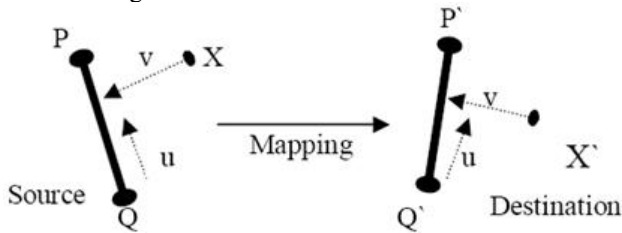


Fig. 1. Plot of single line pair.

$$u = \frac{(\overline{XP}) \times (\overline{QP})}{\|\overline{QP}\|^2}, v = \frac{(\overline{XP}) \times (\overline{QP})^\perp}{\|\overline{QP}\|^2} \quad (3)$$

$$X' = P' + u(\overline{Q'P'}) + v(\overline{Q'P'})^\perp, \quad (4)$$

where $(\overline{Q'P'})^\perp$ is a vector with the same length and perpendicular to $\overline{PQ}$.

A weighting of the coordinate transformation for each line segment is presented in order to more than one pair of line segments. The weight (ω_i) for the line i and line length is expressed as

$$\omega_i = \left[\frac{\text{length}^p}{(a + \text{dist})} \right]^b. \quad (5)$$

Parameter of a , p , and b are the constants to control the warp that adjusts the smoothness of warping, falloff of strength with distance and rewarding longer lines respectively [10]. The final mapping position of X is computed by

$$X' = \frac{\sum \omega_i X'_i}{\sum \omega_i}. \quad (6)$$

We use the Beier-Neely algorithm to decide and detect the local feature-based weighted warping (LFBWW) for face images. Based on the above calculated, we can obtain good warping information due to warping integrating ability superior to affine transformation.

Hence, active integrating reliable features can be verified and simultaneously save time-consuming computation by means of this LFBWW to mapping X in destination.

2.4 Dimension reduction in IASM algorithm

Based on invariant feature and template matching characteristics, ASM [11] will use the principal component analysis (PCA) to process the high-dimensional data. Then the fast iterative computation can be completed which obtained the convergence by using manual landmark points. Based on the above, we also adopt this viewpoint to apply to our IASM in order to reduce the dimension and computational time. For s as shape vector matrix, each s corresponds to the eigenvalue (λ_s).

$$\left(\sum_{i=1}^t \lambda_i / \sum_{i=1}^s \lambda_i \right) \geq \alpha. \quad (7)$$

According to [12], the parameter α in Eq. (7) is as a dimension reduction adjustment factor which mainly can effectively reduce the dimension. Hence, for sorted eigenvalues, the first t eigenvectors satisfying the Eq. (7) are selected, and the variable α is set 0.95.

2.5 IASM 2D profile extension

For mapping of feature point location by means of ASM, it is a key technique and more sensitive. In order to solve the given profile line on strongest edge which will cause the matching error, such as shown in Fig. 2(a), it shows the mapping error in 1D profile searching. We extend it to 2D operation shown in Fig. 2(b) which can effectively decrease the location error. Figure 2(b) shows that the current feature point positioned in the center of the square with the size of m , so that the error of location can be decreased.

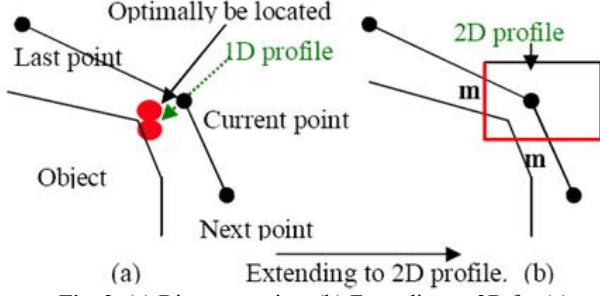


Fig. 2. (a) Direct mapping. (b) Extending to 2D for (a).

3. RESULTS

In our experiments, we use two common database JAFFE face database [13] and Yale face database-B [14]. The former database contains 213 images of 7 facial expressions (6 basic facial expressions + 1 neutral) posed by 10 Japanese female models, the latter database contains 5760 single light source images of 10 subjects, each seen under 576 viewing conditions (9 poses $\times$ 64 illumination conditions).

For system performance evaluation, we adopt the average localization error (E) to measure, and it is expressed as [7, 12]

$$E = \frac{1}{n \times m} \sum_{i=1}^n \sum_{j=1}^m |p(i, j) - p'(i, j)|, \quad (8)$$

where n and m denote the number of the test images and the number of the landmark in each image, respectively. $p(i, j)$ is the manually-labeled position of the j th feature point on the i th image, $p'(i, j)$ is the feature point position localized by the ASM process. Based on Eq. (8), the average localization error of the proposed IASM method was computed and compared with that of ASM method. Additionally, we use an improved factor (I) to measure the improvement percentage of the proposed IASM method over ASM. When I is positive, the proposed IASM method is superior to ASM.

$$I = \frac{E_{\text{ASM}} - E_{\text{proposed-IASM}}}{E_{\text{ASM}}} \times 100\%. \quad (9)$$

In order to estimate the performance for our proposed IASM method, we utilize manually labeled two eyes method and Viola-Jones face detector [7, 15] to verify our system

performance. According to two evaluation methods for two databases, Tables 1 and 2 show the experimental results for JAFFE database and YALE_B database, respectively. From Tables 1 and 2, it is clear that our proposed IASM method presents the lower location error and good improved performance than the ASM method.

Figure 3 shows the results corresponding to the different face expressions under against illumination. Figure 4 shows the comparison results with the ASM method and our proposed IASM method. For Fig. 3, we can obtain the good facial location under the different expression variations using the predefined special mesh. This special mesh is very appropriate to represent the expression shape and to work expression recognition. For Fig. 4, it is obvious that the result obtained by our proposed IASM method can achieve a good fitting than the ASM method.

In addition, under the insufficient illumination case, such as Fig. 5, we can also obtain a better facial location. That is, this approach is robust to the illumination factor in facial location and can achieve the good performance. In contract with the ASM method, it is not suitable as preprocessing step for face detection. In our experiments, there is about 37.5% information missing in face detection process.

Table 1. Performance with JAFFE database.

Evaluation method	ASM	Proposed IASM	Improved factor
Manually labeled	3.72	2.13	42.74%
Viola-Jones face detector	11.63	5.33	54.14%

Table 2. Performance with YALE_B database.

Evaluation method	ASM	Proposed IASM	Improved factor
Manually labeled	5.56	4.07	26.79%
Viola-Jones face detector	30.44	10.98	63.92%

4. CONCLUSIONS

In this paper, we have presented an efficient facial location using a constrained Gabor features algorithm. It can be robust to face with illumination-biased situation. However, According to the results, the performance of our approach is superior to the ASM algorithm, and the improved performance for our proposed method can achieve 54.14% and 63.92% corresponding to JAFFE database and YALE_B database, respectively.

5. ACKNOWLEDGEMENTS

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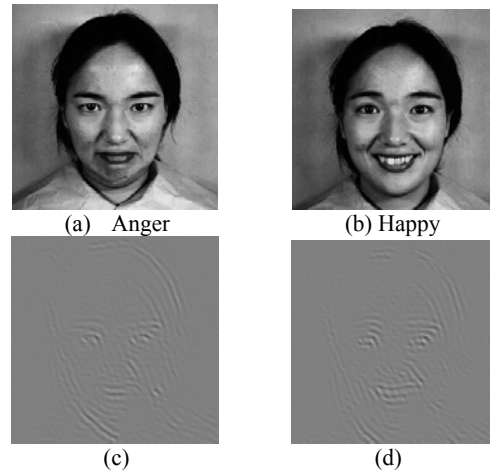


Fig. 3. (a) and (b) JAFFE face database. (c) and (d) Real part of the Gabor filter corresponding to (a) and (b), respectively.

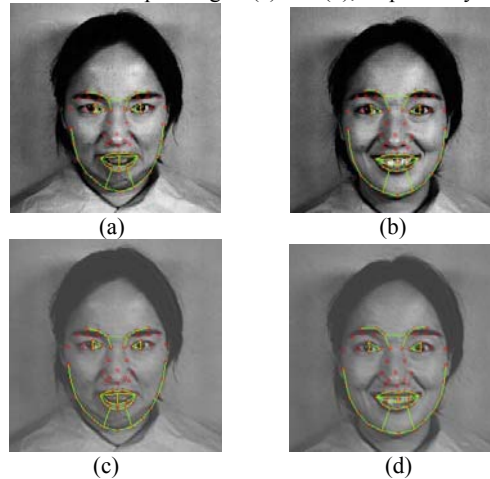


Fig. 4. Comparison result with the ASM method and our proposed IASM method. (a) and (b) Results of using the AMS method. (c) and (d) Results of merged Fig.3 (a) and (c), Fig. 3(b) and (d) by using the proposed IASM method, respectively.

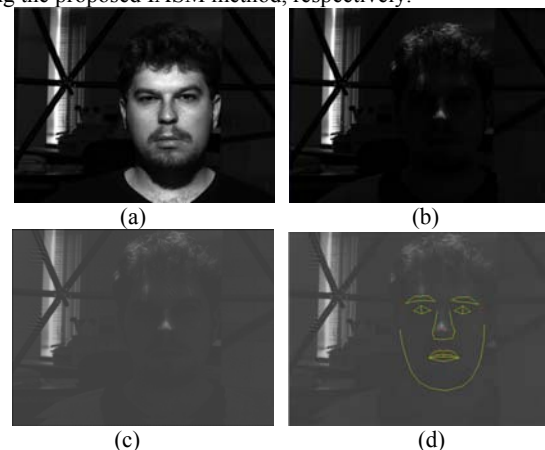


Fig. 5. (a) YALE_B database. (b) Low illumination for (a). (c) Result of the proposed method for (b). (d) Face fitted.