Extracting Facial Features with Partial Feature Templates

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Xinguang Song†, Chil-Woo Lee‡, Gang Xu† and Saburo Tsuji†
† Department of System Engineering, Osaka University
‡ Laboratories of Image Information Science and Technology

1 Introduction

Feature extraction is a frequent and fundamental problem in pattern recognition. Particularly, it is a key point in constructing a face recognition system or a facial expression analysis system. However, it is a difficult task because facial features vary with different illumination conditions, face styles and facial expressions.

Some methods and algorithms have been developed to extract facial features. Methods using image features are introduced in [1][2][3]. Since these features can not be used to express facial organ positions directly, further process with constraints of geometric model is necessary for facial organ extraction. The method of [4] can figure out the exact facial organ shapes, but the final results depend heavily upon the initial position guesses, which is difficult to use when the face position is unknown.

2 Partial Feature Template (PFT)

Although facial organ features differ from person to person in general, two facts should be noticed: (i) the deformation of a partial organ feature is less than that of the whole organ; (ii) in matching process, edge image is usually less sensitive to lighting conditions than gray-scale image.

Considering these two factors, we developed a method of extracting facial features with PFT matching. The PFT (Fig.1) is made in such a way that it has a size of 32 × 32 pixels, possesses the generalized shape of partial organ features such as the corners of brows, eyes and mouth. It is composed of five parts: upper and lower horizontal edge parts (UHE, LHE), vertical edge part(VEP), non-edge part (NP) and irrelevant part(IP).

The matching process starts from edge points in the PFT. UHE and LHE parts are matched first with

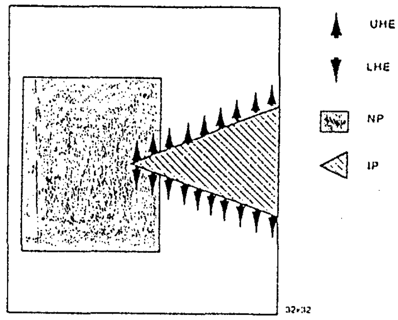

Figure 1: The Structure of PFT

$$R_{edgepart} = \sum_{i=1}^{3} \beta_i \times (M_i - W_i),$$

where $\beta_i = N_m/N_t \times 100\%, W_i = \sum_{k=1}^{N_m} d_{ik}$

$$d_{ik} = \begin{cases} \|p_{ik} - p_{ik-1}\| & p_{ik} \text{ and } p_{ik-1} \text{ are both edges.} \\ \text{PFT size}/2 & \text{otherwise.} \end{cases}$$

M_i is a constant, N_m and N_t are the matched and the total relevant edge point numbers.

The matching regions for VEP and NP parts are determined dynamically by UHE and LHE matching results. The result for NP part is got with: $R_{non-edgepart} = N_{nm}/N_{nt} \times 100\%$, where N_{nm} and N_{nt} is the matched and the total non-edge point number in the matching window. IP is the place where nothing is done because (i) it is meaningless to count this part into the final result since only edges are the interesting features; (ii) it is an unstable place in such case of eye balls and lips, so the matching result can be improved by ignoring this part. The final PFT matching result is the combination of edge and non-edge parts: $R = R_{edgepart} + kR_{non-edgepart}$.

The predefined search range for horizontal edges of PFT allows partial organ features to have certain shape deformation, size and direction variations.

As it is difficult to describe precisely what the partial organ feature shapes should be, the correct position of each facial feature is not guaranteed by that of the best matching result, so it is necessary to keep some best k results as candidate positions for correct matching. (See Fig.2).

3 Global Facial Model(GFM)

The GFM is a model which expresses the geometric relations among partial organ features. It is established by picking out the correct feature positions manually from images. Because we use relative lengths r_{m_i} and relative angles $\Delta\theta_{m_j}$ of vectors connecting each point and their centroid, GFM is invariant to translation, rotation and scale variation of face.

The process to pick organ positions is done in two steps: (1) establishing temporary model GFM′ with any set of candidate data, then getting r_{p_i} and $\Delta\theta_{p_j}$; (2) evaluating the candidate data set with the following function and choosing the set which is the most similar to GFM.

$$E = \sum_{j=1}^{N_m} (\Delta^2_{mp(j)} + \Delta^2_{\theta_{mp(j)}} + \Delta^2_{pp(j)}),$$

where $\Delta_{mp(j)}$ and $\Delta_{\theta_{mp(j)}}$ express the vector lengths and angle differences between GFM and GFM′. $\Delta_{pp(j)}$ is a term of evaluating the symmetry of these vectors. The result is shown in Fig.3.

4 Experiments and Summary

A method of extracting facial organs using PFT matching and the global facial constraints expressed by GFM is introduced. The whole processing procedure starts with inputing a full face image, then the image is smoothed with Gaussian function. After getting the edge image with Sobel operator, shrinking and expanding processes are employed to remove short and thin edges. PFT matching gives the best k results, here we use 10, as candidates which are selected with GFM. In the experiment, we got correct positions of organ features with success rate of over 80% even in the case of 50% size change and 20 degree rotation of faces.

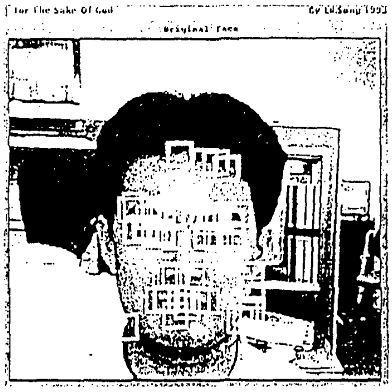

Figure 2: PFT Matching Result

Figure 3: GFM Matching Result

References

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