Feature Points Extraction from Faces

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Abstract

This paper proposes a method to extract the feature points from faces automatically. It provides a feasible way to locate the positions of two eyeballs, near and far corners of eyes, midpoint of nostrils and mouth corners from face image. This approach would help to extract useful features on human face automatically and improve the accuracy of face recognition. The experiments show that the method presented in this paper could locate feature points from faces exactly and quickly.

Keywords: face recognition, feature localization, operator SUSAN, corner point extraction

1   Introduction

Though people are good at face identification, recognizing human face automatically by computer is very difficult. Face recognition has been widely applied in security system, credit-card verification, and criminal identifications, teleconference and so on. Face recognition is influenced by many complications, such as the differences of facial expression, the light directions of imaging, and the variety of posture, size and angle. Even to the same people, the images taken in different surroundings may be unlike. The problem is so complicated that the achievement in the field of automatic face recognition by computer is not as satisfied as the finger prints. Facial feature extraction has become an important issue in automatic recognition of human faces. Detecting the basic feature as eyes, nose and mouth exactly is necessary for most face recognition methods.

Recently, techniques achieved in the researches for detection of facial feature points can be broadly classified as: (i) approaches based on luminance, chrominance, facial geometry and symmetry[1][2], (ii) template matching based approaches[2][3], (iii) PCA-based approaches[1][4][9], and the combination of the above approaches along with curvature analysis of the intensity surface of the face images[5]. Also other facial feature detection approaches exist. Feris et al. present a technique for facial feature localization using a two-level hierarchical wavelet network [6].

In this paper, we propose an approach based on human visual characteristics, using the geometry and symmetry of faces, which can extract the features with properties of scale, translation and rotation invariance and locate the vital feature points on eyes, nose and mouth exactly and quickly. This method needn't normalize the images to same size before processing. It can also help to improve the accuracy of face recognition.

The rest of the paper is organized as follows. In section 2, the feature extracting technique is introduced. In section 3, we describe our method in detail to locate the 9 vital feature points from faces automatically. The experiment results are compared and analyzed in section 4. Finally, section 5 concludes the paper and points out the next research aspects.

2   Face feature extraction technique

In order to perceive and recognize human faces, we must extract the prominent characteristics on the faces. Usually those features like eyes, nose and mouth together with their geometry distribution and the shape of face is applied.

2.1   The feature points on human face

Applying human visual property in the recognition of faces, people can identify face from very far distance, even the details are vague. That means the symmetry characteristic is enough to be recognized. Human face is made up of eyes, nose, mouth and chin etc. There are differences in shape, size and structure of those organs, so the faces are differ in thousands ways, and we can describe them with the shape and structure of the organs so as to recognize them. One common method is to extract the shape of the eyes, nose, mouth and chin, and then distinguish the faces by distance and scale of those organs (as shown in Fig.1). The other method is to use deformable model to describe the shape of the organs on face subtly [7].

We can tell the characteristics of the organs easily by locating the feature points from a face image. If we normalized the characteristics which have the properties of scale, translation and rotation invariance, we can normalize the faces in the database through

pre-treatment, so as to extend the range of database, reduce the storage and recognize the faces more effectively.

Figure 1: Relationship of face features.

Additionally, the selection of face feature points is crucial to the face recognition. We should pick up the feature points which represent the most important characteristics on the face and can be extracted easily. The number of the feature points should take enough information and not be too many. If the database has different postures of each people to be recognized, the property of angle invariance of the geometry characteristic is very important. This paper has presented a method to locate the vital feature points of face, which select 9 feature points that have the property of angle invariance, including 2 eyeballs, 4 near and far corners of eyes, the midpoint of nostrils and 2 mouth corners, as shown in Fig.2. According to these, we can get other feature points extended by them and the characteristics of face organs which are related and useful to face recognition.

Figure 2: The 9 vital feature points on face.

2.2 The approach for feature points extraction

When we extract the face features, it is difficult to integrate the local edge information, and the common edge detection operator may not extract feature contour validly [9]. This paper takes account of the human visual property which makes use of the edge and corner points to locate the vital feature points of face. The corner points on face such as those for the eyes and mouth are extracted by using corner detection approach.

In this paper, we choose the operator SUSAN (Smallest Univalue Segment Assimilating Nucleus) to extract the edge and corner points of local feature area.

The principle of operator SUSAN is to make a mask on the circle area of one point with the radius of r (we set $r = 4$ in this paper) and then observe every point in the whole image on the consistency of this point with all points contained in the mask area.

$$c(\vec{r}, \vec{r}_0) = \begin{cases} 1 & if \ |I(\vec{r}) - I(\vec{r}_0)| \le t \\ 0 & if \ |I(\vec{r}) - I(\vec{r}_0)| > t \end{cases}$$

$$n(\vec{r}_0) = \sum_{\vec{r}} c(\vec{r}, \vec{r}_0)$$

$$R(\vec{r}_0) = \begin{cases} g - n(\vec{r}_0) & if \ n(\vec{r}_0) < g \\ 0 & otherwise \end{cases}$$

Hereinto, $c(\vec{r}, \vec{r}_0)$ is the measurement of the luminance of two pixels;

t is the threshold of difference between pixels. Beyond it, two pixels will be taken for having different luminance. Commonly it is set to be 27;

$n(\vec{r}_0)$ means the area of USAN. If it is smaller, then the edge intensity is bigger;

g is the geometry threshold, which means the max value of the USAN area. Beyond it, that pixel is not on the edge. Commonly it is set to be $\frac{3}{4} \times n(\vec{r}_0)_{max}$.

According to the properties of operator SUSAN, it can be used not only to detect the edge, but also to extract the corner point. Therefore, comparing with the operator such as Sobel, Canny, and so on, it is more appropriate to extract the features of eyes and mouth on the face, especially to locate the corner points of eyes and mouth automatically. It also can get good achievements on images with various qualities by adjusting the parameters r, t and g of operator SUSAN.

3 Locating the feature points from face automatically

When locating the feature points, we should set the searching area of the points firstly. In this paper, they are called the feature areas for the local areas of eyes, nose and mouth. Then we process the areas and locate feature points in them individually.

3.1 Locating the face-area

Firstly, we locate the general area of face from the whole image. According the a priori knowledge of human faces, the face-area can be matched by the normalized face model as shown in Fig.3.

The matching of face model is based on the relativity of luminance and the distributing of the whole luminance pattern of face images. Before matching the face model, we calculate the symmetry and the distributing of luminance and grads of local area, then

get rid of the images which have no face obviously. It can accelerate the matching of face model by using a priori knowledge of luminance and grads. In fact, the sub-image and model used to match is relatively small, about one quarter of the original image, so as to make it robust to the change of scale and rotation of the image and accelerate the matching of face model.

Figure 3: Model image of human face.

3.2   Locating the eyeballs and the corners of eyes

Then we begin to search the two eyeballs, viz. the centres of eyes, in face-area. (In this paper, it needn't to be very exact. It will be OK just within the range of the irises.) To detect the eyes is very important in face feature extraction. Common method to locate eyes is based on the property of valley points of luminance in eye-areas. In this paper, we combine the valley point searching with directional projection and the symmetry of two eyeballs to locate eyes. In a general way we can improve the accuracy of location by using the relationship between two eyes.

Firstly, we need to locate the sensitivity area of two eyes. The centres of eyes are located by searching the valley points in the local luminance image. Projecting the grads image in the top left and top right areas of face, and then normalizing the histogram got by directional integral projection, we can locate the probable position of the eyes in **y** direction based on the valley point in horizontal integral projection image. Then let the **x** coordinates to change in a large scope, so we can find the valley point in **x** direction of this area. The detected points are regarded as centres of two eyes. The locating of two eyeballs is shown in Fig.4.

(a)   Horizontal integral projection.

1	2	3
4	5	6
7	8	9

(b)   Searching the valley point.

Figure 4: Locating the eyeballs.

After getting the positions of two eyeballs, we obtain eye-areas around the two irises. (In this paper, the face images are cropped to 336*480 large, and the eye-areas are set to be the rectangle of 80*40.) We use the auto-adapted thresholds to get binary images of eye-areas, as shown in Fig.5 (a), and then detect the edge and corner points combined with operator SUSAN to locate the near and far corners in eye-areas.
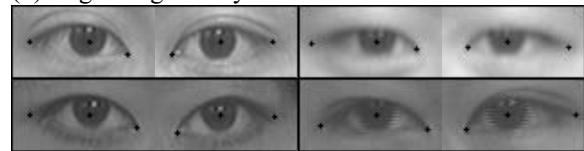
The Fig.5 (b) shows the edge images of eye-areas processed with the above method. Then extracting the corner points from the black edge curves in those images, we can get the accurate positions of the near and far corner points of eyes. The results are shown in Fig.5 (c).

(a) Eye-areas
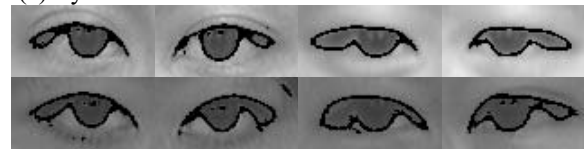
(b) Edge images of eye-areas

(c)   Locating the irises and the corners of eyes

Figure 5: Locating the corners of eyes.

3.3   Locating feature point of nose-area

We define the feature point in nose-area to be the midpoint of two nostrils in this paper. The nose is less important than eyes for face recognition, but the midpoint of two nostrils is relatively stable, and we can use it as the datum mark of normalization to do the pre-treatment of face images.

With reference to the two eyeballs, the nose-area, as shown in Fig.6, is defined by using integral projection of luminance. Firstly, we choose the strip region of two eyeballs width to get integral projection curve in **y** direction. Then we search along the projection curve down from the **y** coordinates of eyeballs and find the first valley point to be the **y** coordinates of nostrils. Through adjusting the Δ value between peak and valley points, we can eliminate the big burrs on the curve caused by scars on face or wearing glasses etc.

Secondly, we choose the region of the two **x** coordinates of eyeballs width, up and down δ pixels from the **y** coordinates of nostrils height, to get integral projection curve in **x** direction.(In this paper, we choose the δ = [**y** coordinates of nostrils – **y** coordinates of eyeballs]*0.06.) Then we search along the projection curve from the midpoint of two **x** coordinates of eyeballs to left and right individually, and find two first valley points to be the x coordinates of the left and right nostrils. By getting the accurate

position of the midpoint of two nostrils, we can define the region of nose area easily.

Figure 6: Processing to nose-area.

3.4 Locating the mouth corners

Mouth has almost the same importance as eyes for face recognition. The shape and size of mouth change greatly because of the variety of face expression. And the whiskers could interfere with mouth-area to be recognized. So it has great significance for face recognition to extract the mouth feature points exactly. Since the corners of mouth have little alteration effected by expression and it can be located easily, so we define the two mouth corners as the feature points of mouth-area.

As we have got the positions of midpoint of nostrils and two eyeballs on the face already, we use the same method to locate the mouth corners. Along the horizontal integral projection curve of luminance in mouth area, we search the first valley point from the **y** coordinates of nostrils and set it to be the **y** coordinates of mouth, remembering to eliminate the burrs on the curve caused by beard or scars through adjusting the Δ value between peak and valley points. Then we can define the mouth region and use operator SUSAN to get the edge image of mouth. Finally the two corner points of mouth are extracted as shown in Fig.7.

Figure 7: Locating the mouth corners.

4 Experiment results

The experiments in this paper is based on the face database established by our lab of Tsinghua University in China, including 270 people each provided 7 face images. It is made up of the front image, the images rotated with little and big angles on left and right sides, and the images with variety of light and expressions. The image size is normalized to 336*480 and the face area is over 50% in each image.

Experiment result on front faces is shown in Fig.8 (a). The locating accuracy of the 9 vital feature points of whole 270 people is average over 95%, as shown with Table 1. In the mean time, we test this method on the images collected from real-time dynamic video, also getting very good results and almost reaching the request of practical uses, as shown in Fig.8 (b).

Table 1: Table of feature point localization accuracy.

Feature Point	Accuracy
Left Eyeball	99.63%
Right Eyeball	100%
Near Corner of Left Eye	98.52%
Far Corner of Left Eye	97.41%
Near Corner of Right Eye	95.93%
Far Corner of Right Eye	97.41%
Midpoint of Nostrils	98.15%
Left Mouth Corner	84.81%
Right Mouth Corner	84.44%
Average	95.14%

Notes: A feature point was counted as accurately detected if it was localized to within 5 pixels of the point marked by hand.

(a) Images in the database of our lab

(b) Images collected by real-time dynamic video

Figure 8: The results of feature points locating.

We also get good results of more than 80% accuracy on the little angle(<15°) left and right rotation faces,

as shown in Fig.9, but not very satisfied on the large-angle left and right rotation faces, as shown in Fig.10.

Figure 9: The results of feature points locating on the little angle rotation faces.

Figure 10: The results of feature points locating on the large-angle rotation faces.

Moreover, for the images in good conditions, this method is relatively robust to the light, expression and wearing glasses, except to the strong sidelight. It will take about 265ms to detect all the feature points in an original face image. Comparing with those presented in the literatures ago [5][8], the approach proposed in this paper is a feasible and fast method with good accuracy to extract the vital feature points from faces.

Furthermore, according to the researches presented above, we propose to normalize the face images in pre-treatment of plane rotations and size-adjusting, using the two far corners of eyes instead of two eyeballs as horizontal datum mark and the distance from the midpoint of two irises to the midpoint of nostrils as vertical datum mark, to normalize the faces into standard. This will be helpful on feature extraction and recognition of human faces.

5   Conclusion

It is well known that it's very difficult to detect the features exactly on each face images due to the complication of human face structure and the diversity of face features and shooting angle. This paper proposes a useful approach to extract the feature points from faces automatically. Experiment results show that the locating of the feature points is exact and fast, and it would help to increase the accuracy of face recognition.

Though we set the scale of face images to be fixed on 336*480, it doesn't mean any restriction for the size of images. The approach presented in this paper can automatically locate the feature points with high accuracy as for most front face images of luminance, even for some small angle left and right rotation face images, but it is still limited in the application of large angle rotation with reducing of the accuracy and is partly impacted by strong sidelight. So we should do more researches on feature points detecting and go on study to improve the robustness.

6   References

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