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Real Time Face Recognition using Steerable Filters and Template Matching

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Abstract: In this paper a technique of Face Recognition is discussed**.** Face detection in the image is an important research branch of face recognition. For the purpose of recognising the faces in images efficiently, a face recognition method based on face-template is proposed. According to the character of density of the feature organs such as eye, ear, nose, mouth, part of cheek in the face images, the frontal full face-template is constructed. And the frontal half face template is constructed directly based on density symmetry of face-template. Template formation required to figure out the region containing facial components. This is done using steerable filters. Eyes usually contain both dark and bright pixels in the luma component. Gray scale morphological operations like dilation and erosion are performed on the image to emphasize brighter and darker pixels in the luma component around eye regions. We further notice that the mouth has a relatively lower response in the C_r/C_b feature but a high response in C_r^2. Therefore, the difference between C_r^2 and C_r/C_b can emphasize the mouth regions. The region containing the eye and mouth region is taken as templates. The face detection experiments in the frame images from the surveillance video were carried on using the method of colour segmentation and face is recognised according to comparability between template and detected face. The theory analysis shows that the average face-template can reduce the chanciness of local density of the template effectively and the half face-template can reduce the symmetry redundancy of density in the face-template and increase the speed of face detection. The experimental result indicates that the half face-template can adapt to side face images in a large angle, which improves the correctness of side face recognition substantially.

Keywords: Template matching, Face Detection, Face Recognition, Steerable Filters, Comparability.

I. INTRODUCTION

Advanced and multimedia technologies have developed the era of intellectual methods of interaction between humans and machines, where other input devices like keyboard, mouse and monitor play no roles anymore. In recent days, the cost decreasing and performance increasing of computation has developed computer vision systems through our daily life. Human identification and face recognition with applications through surveillance and data security has fascinated a lot of attention. Face analysis has been carried out by many researchers in past few decades in terms of detection, recognition and tracking [1], [2], [3], [4], [5]. A human face provides a variety of different communicative functions such as identification, the perception of emotional expression, and lip-reading. For these reasons, many applications in robotics and computer vision fields require tracking and recognizing a human face. Face recognition from video has received much interest in recent times. This is likely due to heightened security and the availability of inexpensive surveillance cameras. Also, face recognition from video may produce better overall accuracy since a video will have many frames of a subject's face instead of just a few examples. Among the person identification methods, face recognition and speaker identification are known to be the most natural ones, since the face and voice modalities are the modalities we use to identify people in our everyday lives. Although other methods, such as fingerprint identification, can provide better performance, they are not appropriate for natural smart interactions due to their intrusive nature.

The paper incorporates Face Recognition through template matching. A database for the purpose will be sustained that will include the templates constructed by us. For instance, we are preparing a face recognition system for 5 persons, and then 10 templates will be constructed. Two templates will be formulated for each person, a half face template and a full face template respectively. These templates will further be used in the face recognition process. The preserved face-template is ransacked on the image frames that are the part of the video from surveillance cameras and the similarity between template and frame image is calculated. The image frame which is similar to the template is reckoned among the recognised image frame, if the value of the similarity function in some position is less than the threshold value given. Face template can either be searched directly on image frame or on a processed image frame containing only the face of the person by subtracting the background. The algorithm is summarised in the figure 1.

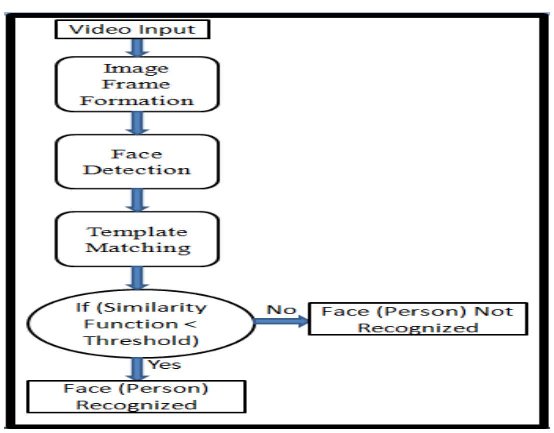

Figure 1: Face Recognition Algorithm

The face recognition method based on template matching chooses full face feature as the matched template, with which the burden of computing of face search is relatively large. However, most human faces are symmetry obviously. So we can choose half of the full face-template that is choosing the left half face or the right half face as the template of face matching which can reduce the burden of computing of face search. Moreover, half face template is useful in recognising the face when the person is standing in front of the camera at an angle of 30º or 45º.

II. TEMPLATE FORMATION METHOD

The quality of the template immediately influences the recognition. So, full face templates are constructed to recognize the frontal faces and half face templates are designed to easily recognize the inclined faces.

According to the character of density of the feature organs such as eye, ear, nose, mouth, part of cheek in the face images, the obverse average full face-template is constructed. And the obverse average half face-template is constructed directly based on density symmetry of face-template.

In the paper we only consider the frontal faces while designing the templates. It generally can be viewed as a structural object with facial components- two eyes, a nose and a mouth. Since facial components are dark region on a face, we can use steerable filter [6] to detect them. If the face image is sampled in the situation that the distance between the face and the camera is fixed, the size of face is unchanged.

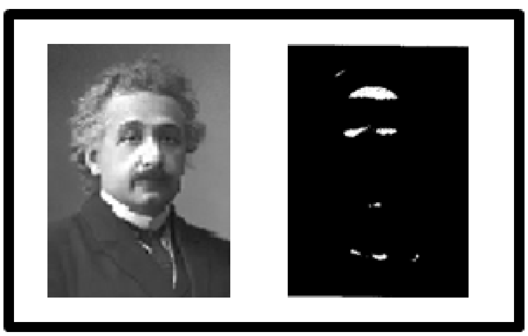

Figure 2: Facial Components Detection using Steerable Filters [6].

Among the various facial features, eyes and mouth are the most suitable features for recognition and estimation of 3D head pose [7]. Another approach that can be used to locate eyes, mouth and face boundary is based on measurements derived from the color components of an image. The full face template includes the located area. As human face is symmetrical, i.e., left and right part of human face is similar, so half face template can be formulated by dividing the full face template vertically in two equal halves.

Eyes usually contain both dark and bright pixels in the luma component. Gray scale morphological operations like dilation and erosion [8] are performed on the image to emphasize brighter and darker pixels in the luma component around eye regions. These operations have been used to construct feature vectors for a complete face at multiple scales for frontal face authentication [9]. In our eye detection algorithm, the gray scale dilation and erosion using a hemispheric structuring element at an estimated scale are applied independently to construct Eye Plot in the luma. In addition, an analysis of the chrominance components indicated that high C_b and low C_r values are found around the eyes. The Eye Plot in the chroma is constructed from C_b, the inverse of C_r, and the ratio C_b/C_r. The two resulting eye plots are combined by a multiplication operation. The resultant eye plot brightens both the eyes and suppresses other facial areas, as can be seen in Figure 3(c). Eye candidates are selected by using

a. A pyramid decomposition of the enhanced eye plots for coarse localizations
b. Binary morphological closing and an iterative thresholding for fine localizations.

The mouth region contains more reddish component compared to the blue component than other facial regions. Hence, the chrominance component C_r is greater than C_b, near the mouth areas. We further notice that the mouth has a relatively lower response in the C_r/C_b feature but a high response in C_r^2. Therefore, the difference between C_r^2 and C_r/C_b can emphasize the mouth regions. Figure 3(d) shows the mouth plots of the subjects in Figure 3(a).

The eyes and mouth candidates are verified by checking

a. Luma variations of eye and mouth blobs;
b. Geometry an orientation constraints of eyes-mouth triangles;
c. The presence of a face boundary around eyes-mouth triangles.

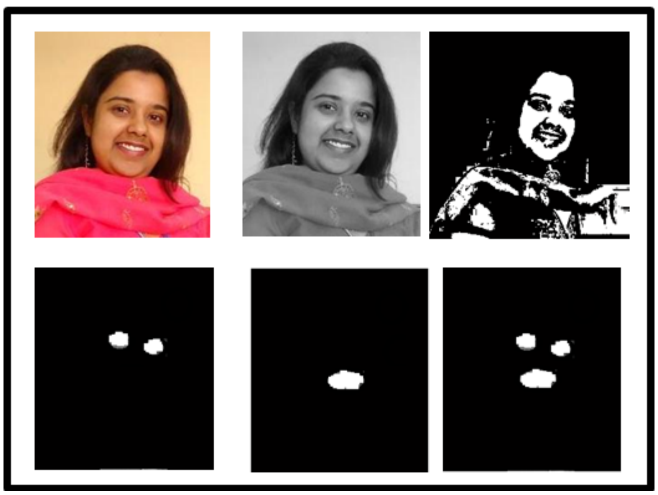

Figure 3: (a) Original Image, (b) Gray scale image, (c) Processed Image, (d) Eye plot, (e) Mouth Plot, (f) Eye/Mouth Plot

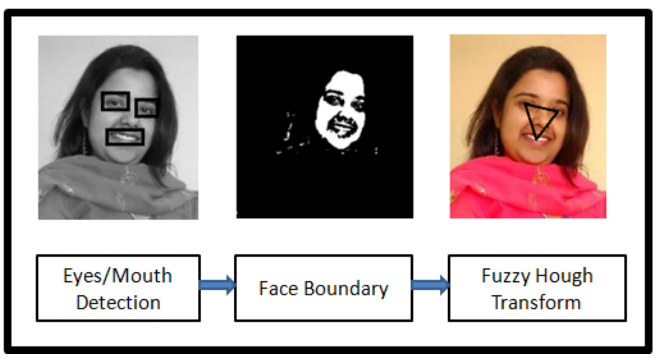

Figure 4: Face Boundary and Eyes & Mouth Triangle

Based on the locations of eyes and mouth candidates, our algorithm first constructs a face boundary plot from the luma, and then utilizes a Hough transform to extract the best-fitting ellipse. The fitted ellipse is associated with a quality measurement for computing eyes and mouth triangle weights. Figure *4* shows the boundary plot which is constructed from both the magnitude and the orientation components of the luma gradient within the regions having positive orientations of the gradient orientations. The Hough transform is useful for the detection of parametric shapes; its efficiency depends on the dimensionality of the accumulator. An ellipse in a plane has five parameters: an orientation angle, two coordinates of the centre, and lengths of major and minor axes. Since we know the locations of eyes and mouth, the orientation of the ellipse can be estimated from the direction of a vector that starts from midpoint between eyes to the mouth. The location of the ellipse centre is estimated from the face boundary. Hence, we only require a two-dimensional accumulator for an ellipse in a plane. The ellipse with the highest vote is selected.

Each eye-mouth triangle candidate is associated with a weight that is computed from its eye/mouth plots, ellipse vote and face orientation that favours upright faces and symmetric facial geometry.

A. Full Face Template:

In the situation that the distance between the face and the camera is fixed and the angle of airscapes is 15°, 100 face images are sampled at the angle of obverse, left side 30° and 45°. For each angle, there are 40 images, and the number of the face image with and without cap are both 20. The sampled images are shown as figure 5.

Figure 5: Face Images at angle of observe, 30º and 45º respectively

In the image, the obverse face includes the feature organs like eye, ear, nose, mouth, part of cheek and so on, as is shown in figure 6-(a). The character of distribution of these images can be the basis for detecting the existence of face. So the eyes, ears, noses, mouths and part of cheek were selected as the main area of constructing the full face-template, whose model is shown in figure 6-(b).

Figure 6: (A) Facial Components, (B) Full Face Template

20 face images were sampled manually. The size of each image is 25 × 30 pixels. As a comparison experiment, template must not only match the obverse images, but also the side ones. So the half face templates are also formulated. The obverse full face-template constructed is shown in figure 6-(b).

B. Half Face Template:

The frontal full face-template may be considered as combination of the almost symmetrical left and right face template. So the frontal full face-template can be divided vertically into the left face template and the right one at the axis centre of symmetry. The construction of half face-template is shown as figure 7. Moreover, the half face-template can be constructed based on the full face-template, which can reduce the symmetry redundancy of density in the full face-template.

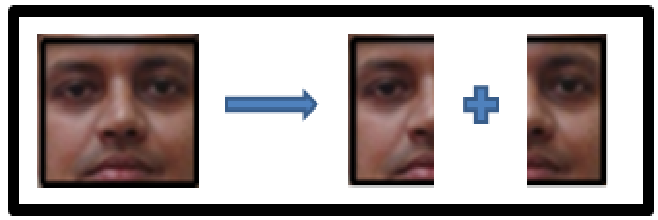

Figure 7: Construction of Half Face Template

The density of the left face and the right one are symmetrical in the perfect face-template, in other words, they are comparability pairs. In the practice, there is a little difference between the left face and the right one in the face images, and the distribution of density of them is not a fully symmetrical scene, so the comparability is decreased. Taking the left face for example, the left face can be detected at first, when searching the face image with the half face template examine whether there exists face image, as is shown in figure 8. The solid line frame in the figure is the left face detected.

Figure 8: Detected location of Half Face

III. FACE RECOGNITION ALGORITHM

The face recognition algorithm includes two steps namely, Face Detection and Template Matching. The frame taken for consideration includes background objects along with the human face. So, there is a need to detect the face in the whole frame. Then the template is scanned over the detected face and if the two are similar then the person is declared to be recognized. Frontal faces can easily be recognized using full face template, but be the frame contains face at some angle of inclination then half face template is used for the process of recognition.

A. Face Detection:

Detection of the face and subtraction of the background in the frame can be done using a variety of face detection techniques discussed by various researchers. The technique used by us for detecting the face is discussed by us in the paper [10]. Moreover, we directly tested the template matching algorithm on the frame image. We received positive results but the search engine took more time to ransack the whole frame image.

B. Template Matching:

In the experiment, the half faces in the images were detected with the template matching method. Its fundamental principle can be described as follows. The selected average half face-template is ransacked on the detecting image and the similarity between them is calculated. The half face image which is similar to the template is reckoned among the detecting image, if the value of the similarity function in some position is greater than the threshold value given.

The similarity is the statistical value of local areas in the image. The similarity value of some different sub-image image might be equal to another, despite all that they are different sub-images. In the experiment, the similarity function value in the half face-template matched position should be stood out and the value in the non-matched position should be bated. The method adopted is described as follows.

Suppose the length of the half face-template T is Y and the width is Z. The length of the full face-template is $2Y$ and the width is Z. Of the detecting image, the length is L and the width is W. The sub-image corresponding to the position (m,n) in the image where the template is set on is $P^{(m,n)}$.Then the similarity between the template and the sub-image $S(m,n)$ can be expressed with the formula (1) [11].

$$S(m,n) = \sum_{y=1}^{Y}\sum_{z=1}^{Z}[P^{(m,n)}(y,z) - T(i,j)]^2 \quad -(1)$$

For the function above, the rule of determining whether there exists the half face is that given a threshold value th, if $S(m,n)=th$, the half face-template T is similar to the sub-image $P^{(m,n)}$ and if $S(m,n)=0$, the half face-template T is identical with the sub-image $P^{(m,n)}$ completely.

Assuming that the $C(T)$ represents time cost of face detection based on half face template and the $C(F)$ represents that based on full face one, the calculating method of the $C(T)$ and $C(F)$ can be described as formulas (2) and (3).

$$C(T) = Y * Z * (L - Y) * (W - Z) \quad -(2)$$
$$C(F) = 2Y * Z * (L - 2Y) * (W - Z) \quad -(3)$$

The ratio of $C(T)$ to $C(F)$ can be shown in formula

$$\frac{C(T)}{C(F)} = \frac{Y * Z * (L - Y) * (W - Z)}{2Y * Z * (L - 2Y) * (W - Z)} = \frac{L - Y}{2L - 4Y} \quad -(4)$$

When the value of L is much greater than that of Y, the result of (4) approximates to 1/2, that is to say, the time cost of detecting faces in images with the half face template is about half of that with the full face one. Therefore, about half time of the processing is saved.

IV. RESULT

Figure 9: Image for Template Formation

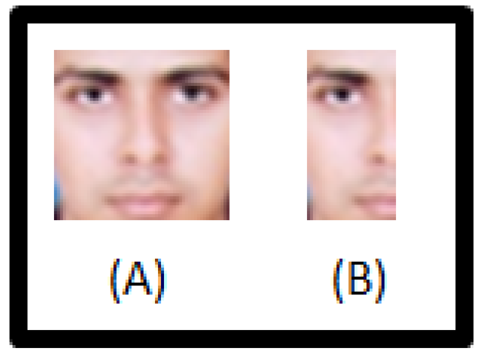

Figure 10: (A) Full Face Template, (B) Half Face Template

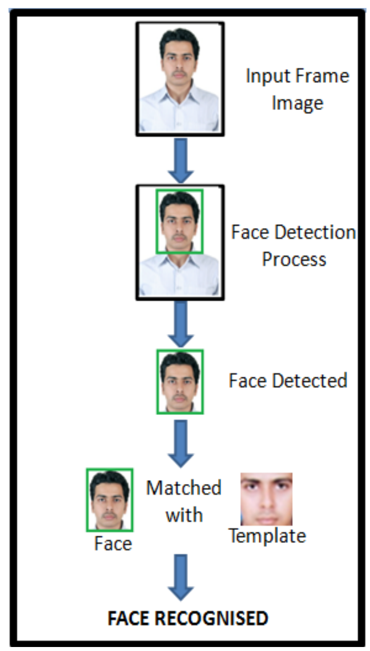

Figure 11: Face Recognition Process

V. CONCLUSION

In this paper, we gave an algorithm of the face recognition technique. We first explained the formation of the template containing the facial components of human face. We explained the construction of half and full face template. Full face template is used to recognise the frontal faces. Whereas, half face template is used mainly to recognise the inclined faces. The vital thing which should be kept in mind is that the distance between face and camera is kept fixed. The frame image taken from the video contains background along with the human face, so a technique of face detection is used to subtract the background. Then, template is ransacked on the detected face to get the final results.

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