International Journal of Information and Computation Technology.
ISSN 0974-2239 Volume 3, Number 9 (2013), pp. 953-962

http://www. irphouse.com /ijict.htm

Detection of Facial Landmarks of North Eastern Indian People

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Abstract

In this paper we worked on the automatic detection of the facial landmarks which includes left eye corners, right eye corners, left eyebrows, right eyebrows, lip corners, nostrils. In this paper, a procedure of automatic facial landmarks detection is presented. It consists of two modules: In first, a morphological opening operation is used to estimate the background. Then create a more uniform background by subtract the background image form original image. In the second module, the facial landmarks had been detected using a corner detector called Fast corner detector. In this case Fast corner detector technique is applied for detecting the facial landmarks, because corner detectors have been widely used as feature point detectors because Comers correspond to image locations with a high information content, and they can be matched between images. The Fast corner detector works on the corner response function (CRF), which is computed as a minimum change of intensity over all possible direction. The Fast corner detector is significantly faster to compute than other algorithms. Experiments have been done over the North-Eastern Face images, which is created by Biometric Laboratory of Computer Science and Engineering Department of Tripura University. In our Experiment we used 105 front images with different expression like Neutral, Anger, Surprise, Sad, Laughter, Fear, and Disgust. We found out the average mean error rate was 0.9619 of all images of different expression of Outer eye corners, Inner eye corners, Mouth corners, Outer eyebrows, Inner eyebrows, Nostrils.

Keywords: Facial landmarks detection, Morphological opening operation, Fast corner detection, Corner response function, North-Eastern Indian face images.

1. Introduction

Face recognition is one of the most active and widely used techniques because of its reliability and accuracy in the process of recognizing and verifying a person's identity. The need is becoming important since people are getting aware of security and privacy. Infact, a person's face can change very much during short periods of time (from one day to another) and because of long periods of time (a difference of months or years). One problem of face recognition is the fact that different faces could seem very similar; therefore, a discrimination task is needed. On the other hand, when we analyse the same face, many characteristics may have changed. These changes might be because of changes in the different parameters. The parameters are: illumination, variability in facial expressions, the presence of accessories (glasses, beards, etc); poses, age, finally background. Face recognition has already established its acceptance as a biometric method for identification and authentication based on human faces[1].The main objective of our project is to detect the face and its landmarks is an essential requirement for Face and Facial Expression Analysis to develop an automatic face recognition system. The landmarks are used to aligning the faces, which has a significant effect on the subsequent analysis. These include eye and eyebrows corner, centre of irises, the nose tip with two end points, mouth corners and the tip of the chin. Several techniques have been proposed over the decades for detecting landmarks.

2. Previous Work

Different researchers have been proposed many face recognition techniques (FRTs) and most of these have been implemented by localizing the facial features and/or the corresponding facial landmarks, determining the feature localization manually. Some of these techniques for detecting/recognizing landmarks used by the researchers are discussed here. Stefano Arca et.al presented a new face identification technique. The method mainly works on color images and its main characteristics are the scale and pose independency. A Comparison was conducted on standard algorithm and showed that their method behaves slightly worse than the top two method i.e. PCA and LDA but on rotated ones it outperforms all the algorithm [2].W.S.S. Junior et.al. Presented Discriminative Filtering technique on principal components for facial fiducial points detection in human faces. The technique has a closed-form designed which is mainly based on pattern and the statistics of the image set. The experiment was conducted on 11 fiducial points of 505 images from the BioID database. The result showed that their method outperformed a similar classifier based on discriminative filters designed without the PCA step, for all fiducial points and also showed that the performance of the proposed algorithm is in general superior to the one of the SVM classifier [3]. S. Arca et.al. Presented a completely automatic face recognition system to detect the facial fiducial points for face recognition. The method mainly consists of two modules, in the first module the facial fiducial point are localized and the second module the face is characterized applying a bank of Gabor filters in corresponds to the found fiducial points. Comparison in case of percentage of recognition they showed that their method performed as well as other well known approaches such as the Elastic Bunch Graph Matching, the PCA or LDA but their method was completely automatic, robust to head rotations and to scale variations, and being local-based, it can be extended to deal with partial occlusions [4]. R. Saha and D. Bhattacharjee presented an automated face recognition system which mainly used in recording of daily attendance application. Their proposed method mainly consists of three parts firstly SUSAN method which is mainly applied to convert the 2D image into gray scale images, the second part is segmentation algorithm and the third part is eye corner extraction and nose corner extraction algorithm. Firstly all the 2D frontal faces from FRAV3D image database are selected and then applied SUSAN method to convert the image into gray scale images for detection of the edges. Then the method is used to extracted feature points. In this method they considered only different frontal facial expressions. Experimental results show that frontal face images may be easily recognized and this technique can be used for simple face recognition. [5]R. Tiwari et al. implemented a morphological method for face recognition using fiducial points, which was independent of facial expressions. In the proposed method, the fiducial points are fed as inputs to a back propagation neural network for learning and identifying a person. They compared their technique with existing feature extraction techniques like PCA & R-LDA. Their proposed system for face recognition consists of following four phases: pre-processing, segmentation of faces including face detection from scenes, feature extraction from the face region and then, recognition of the face [6].

3. Landmark Detection in Huma Face

An landmarks is a point in an image which has a well-defined position and can be robustly detected. There are many landmarks i.e., outer eyebrows, inner eyebrows, outer eye corners, inner eye corners, eye pupils, nose tip, nose saddles, nostrils, mouth corners, inner lip middles, outer lip middles, and tip of the chin in a face image[7]. The detection of landmarks in images is essential for many tasks in machine vision especially human face recognition. The reason that this approach is so popular is that, feature points provide a sufficient constraint to compute image displacements reliably, and that by processing feature points, the data is reduced by orders of magnitude compared to the original image data, which is particularly important for application that must run in real time.

3.1 Advantages of Identification of Landmarks in Human Face

Detection of a face and its landmarks is an essential requirement for face and facial expression. The landmarks are used to aligning the faces, also called registration, which has a significant effect on the subsequent analysis. These include (most of the time) eye and eyebrows corner, centre of irises, the nose tip with two end-points, mouth corners and the tip of the chin.

3.1.1 Types of features point

One of the most intuitive types of feature point is the corner. Corners are image points that show a strong two-dimensional intensity change, and are therefore well distinguished from the neighbouring points. Several algorithms are available for corner detection such as, Susan (a new approach on Harrish), Harrish, Fastcorner, Moravec, The Wang and Brady, The Trajkovic and Hedley corner detector etc. Among these, the Fast corner detector (developed by M. Trajkovic and M. Headly in 1997) has gained most popularity as compared to other detector[8].In this paper we have proposed Fast corner detection technique for detecting the facial landmarks.

3.2 Properties of Fast Corner Detector

The fast corner detector use a Corner Response Function (CRF) that gives a numerical value for the corner strength at a pixel location based on the image intensity in the local neighbourhoods. The CRF is computed over the image and corners are local maxima of the CRF. A multigrid technique is employed which increases the computational speed of the algorithm and acts to suppress false corners being detected in textured regions of an image. The detailed process of Fast Corner Detector is discussed later. Now in this section we will present how a corner detector is useful in a human face for detecting the landmarks. So let us first discuss what a corner is. A corner can be defined as the intersection of two edges. A corner can also be defined as a point for which there is two dominant and different edge directions in a local neighbourhood of the point [8].

3.3 How a Corner Detector Works

One of the first approaches to find corners was to segment the face image into regions, extracting the boundaries as a chain code, and then identify corners as points where directions change rapidly. Corner detectors may be divided into two classes: (1) ‘curvature based’, and (2) ‘interest operators’, for landmark detectors [8].The second class of corner detectors is the so-called feature point detectors. These operators deviate from the intuitive definition of corners and define corners as points that are sufficiently different from their neighbours, or as points where the local autocorrelation of the image intensity is high.

3.4 Corner response function (CRF)

Now describe how corner response function works: In figure 2 we will consider three representative shapes of USAN which correspond to a point in the uniform area, on the edge and on the corner.

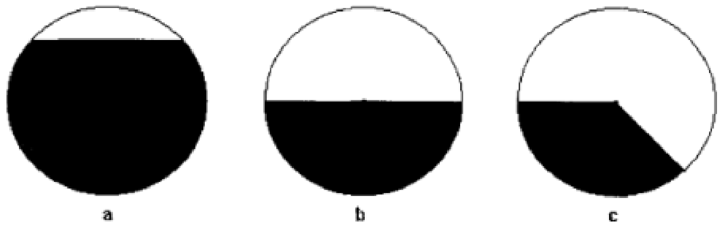

Figure 1: The USAN Shapes.

Here a, b and c are the shapes under USAN stand for 'Univalue Segment Assimilating Nucleus'. Here (a) the nucleus is within the USAN; (b) the nucleus is an edge point; and (c) the nucleus is a corner point. Our main goal is to develop a corner response function (CRF) for distinguishing between a comer point (c) and a point that belongs to an edge or a uniform area (a, b).Now, we will consider an arbitrary line l which containing the nucleus and intersecting the boundary of the circular window at two opposite points *p* and *P*'**,** and the following CRF:

$$R_N = \min((f_p - f_N)^2 + (f_{p'} - f_N)^2), \tag{1}$$

Here, N is the central point and f_p refers to the image intensity at the point ***P*.** Three cases can be occurring.

Case a: The nucleus is within the uniform area. There is at least one line *l*, so that both *p* and P' belong to the USAN. In this case response is low.

Case b: The nucleus is the edge point. There is exactly one line (tangential to the edge), so that both *p* and p' belong to the USAN. In this case CRF is again low.

Case c: The nucleus is a comer point. In case c, for every line *1* at least one of points *P* and *P’* does not belong to the USAN and therefore the CRF is high.

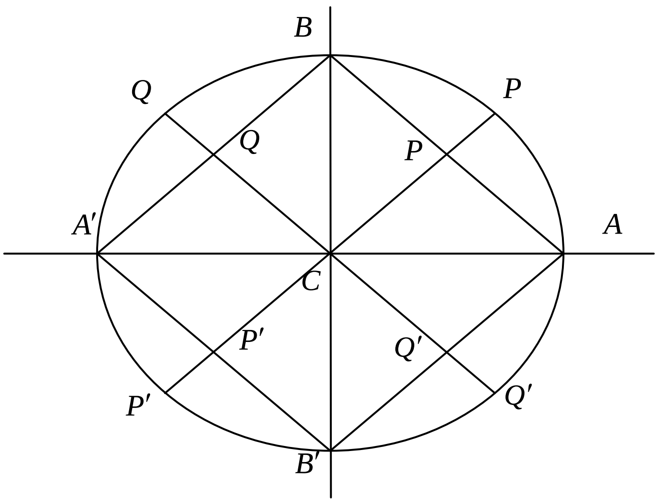

Figure 2: First-order neighbourhoods of nucleus C (ABA'B') showing linear and circular interpixel positions (P, P', Q and Q').

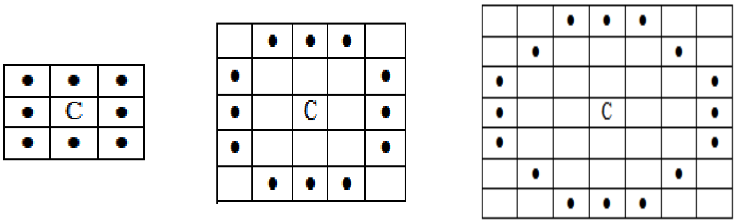

Figure 3: Digital circles of diameter 3, 5 and 7 (S3, S5 and S7).

A discrete approximation of circular window is used for computing the CRF and shown in Fig. 2 and the Eq. (1) becomes,

$$R_N = \min_{P,P' \in S_n} ((f_P - f_N)^2 + (f_{p'} - f_N)^2) \quad (2)$$

Where N is the nucleus and P and P' are opposite with respect to N [8].

3.5 Interpixel approximation

The problem with Eq. (2) is that a strong edge with a direction different to those examined can cause a false corner response. This can be partly resolved by using bigger window (more directions are considered) but then we usually have a worse localization of the corner pixel. To overcome this problem, we use an inter-pixel approximation that can be linear or circular. To show how the inter-pixel approximation is used we will consider the simplest case, a window of diameter three, containing four neighbours only (Fig. 3). The extension to higher order neighbourhoods is First, we compute horizontal (r_A) and vertical (r_B) intensity variation, defined as

$$r_A = (f_A - f_C)^2 + (f_{A'} - f_C)^2 \quad (3)$$

$$r_B = (f_B - f_C)^2 + (f_{B'} - f_C)^2 \quad (4)$$

Then, the CRF is computed as,

$$R = \min(r_A, r_B) \quad (5)$$

If R is less than a given threshold, the nucleus is not a corner point so no further computation is necessary. However, if R is greater than a given threshold, the interpixel approximation is applied to check for diagonal edges [8].

3.6 Multigrid Algorithm for CRF (Corner Response Function)

A multigrid algorithm is used to compute the feature points. The advantages of this approach are:To decrease the computational time; and To improve the quality of the detected corners.The three-step algorithm used to find the corners is presented below.

Step 1: In a low resolution image, compute the simple CRF (Eq. (5)) at every pixel location. Classify pixels with a response higher than a given threshold (T_1) as 'potential corners'.

Step 2: Using the full resolution image, for each potential corner pixel (a)Compute the CRF using Eq. (5). If the response is lower than another threshold (T_2) then the pixel is not a corner, and do not perform (2b), (b)Use the interpixel approximation and compute a new response as explained before. If the response is lower than threshold (T_2) then the pixel is not a corner.

Step 3: Find pixels with a locally maximal CRF and mark them as corners. This step is necessary since in the vicinity of a corner more than one point will have high CRF, and only the largest one is declared to be a corner point-this is called non-maximum suppression (NMS) [8].

4. Experimental Results and Discussions

All the experiments have been done using MATLAB 8.We analyze the performance of our algorithm using North eastern Indian face images which was created by Tripura University biometric laboratory.

4.1 Database:

In this project we used the database of north eastern Indian people Image Which was Created by Tripura Uuniversity biometric laboratory. These images were captured in: Full Illumination, Half Illumination, Left Light on, Right Light on. There are eight different types of expressions (Neutral, Anger, Laughter, Sad, Surprise, Fear, Disgust, Closed Eye) in this database. These images captured in five different Poses (– 0^0, $\pm 25^0$, $\pm 50^0$).

4.2 Performance Results

In our experiment we used 105 frontal images of 15 persons with different expression. Average mean error of our experiment is 0.2716. For performance measurement we used Interocular Distance. It is the distance between left- and right-eye centres. m_e is defined as the normalized mean distance of internal facial feature points to their ground-truth locations. m_e gives a mean error for the entire system i.e.,

$$m_e = \frac{1}{nd_{i0}} \sum_{l=1}^{n} d_l \qquad (6)$$

n=denotes the number of landmarks.

d_l = The Euclidean point-to-point distances for each individual landmark location [9].

In our experiment we used some of the landmarks like outer eye corner, inner eye corner, Inner eyebrow, outer eyebrows nostrils, Inner mouth corner, outer mouth corner. Now in below given table 2 we shows the average error rate of all images of different expression of Outer eye corners, Inner eye corners, Mouth corners, Outer eyebrows, Inner eyebrows, Nostrils. In such a way we find out the performance.

Table2: Accuracy of the landmarking algorithm on north eastern Indian face database.

Land marks	Mean Error Rate	Mean error(% of di0)
Outer eye corners	1.4399	.40
Inner eye corners	.5165	.15
Mouth corners	1.2585	.36
Outer eyebrows	1.277	.36
Inner eyebrows	.55	.16
Nostrils	.73	.20
Mean	0.9619	0.2716

Here we given sample landmarks detected face images of database.

Figure 5: Landmarks detected face images of a person with different expression.

5. Conclusion

In this project we detect a face using its landmarks. It is an essential requirement for Face and Facial Expression Analysis to develop an automatic face recognition system. The landmarks are used to aligning the faces, which has a significant effect on the subsequent analysis. These include eye and eyebrows corner, centre of irises, the nose tip with two end points, mouth corners and the tip of the chin. Experiments have been done over the North-Eastern Face dataset, which is created by Biometric Laboratory of Computer Science and Engineering department of Tripura University.

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