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EXTRACTION OF EYE REGION OF HUMAN FACE BASED ON CORNER DETECTION AND DILATION OPERATION

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ABSTRACT

This research paper has been mainly focused on human eye detection using morphological dilation operator and Harris corner detection method. At first a unique background is generated for input image using dilation (morphological) operation. In this paper, dilation operation has been used twice for accurate detection of corners in the human face images so that the corner detection algorithm doesn't detect any corners in the background and also used to remove light objects from the background. After that, Harris corner detector has been applied to detect the interest points on human face. Then, the intermediate distance in two interest corner points are measured and compared with the predetermined distance between the two corners of an eye. The measured obtained distances those come within a considerable range of the predetermined distance, ensures the detection of eye. After eye detection, both the left and right eyes are extracted separately and store them in the Eye Database. ORL Face Database has been used for this whole work. The proposed technique is found 87.5% of average correct detection rate of eye extraction from proposed database compared to previous work.

KEYWORDS

eye detection, corner, dilation, morphological, data cursor.

1. INTRODUCTION

Human face detection and recognition has been largely tested for long years. It has been used in wide application field ranging from the commercial to the security one. For recognizing a human face, fiducial point estimation may be one of the essential work. Fiducial point may be defined a mark or one of several marks, visible in the field of view of an optical instrument, used as a reference or for measurement. Several fiducial points has been found in human faces. Eyes are the most prominent features of human face. For that, eyes are one of the most important fiducial points. The main important reasons for selection of eye detection on human faces are as follows:

- Eyes are the most crucial source of information of human beings. The shape, size and color of the eyes provide hints in recognizing individuals; The eye movement may reveal "interest", or "attention" of a person, and it may contribute to recognize his/her emotional state.
- Human faces contain two eyes which have a very similar appearance. So, human can be searched simultaneously with the same method.
- The eye appearance is not too much dependent on face changes. Eyes are not affected by the presence of facial hair (beards or mustaches) and are almost unaltered by small in-depth rotations of the face, while the nose appearances greatly changes on human faces.
- The eye localization is very important to identify and manage all the other facial features of interest.

There are several approaches developed by different researchers to detect eyes from human face. Chris Harris et al. present Image edge filtering for 3D interpretation of image sequences using feature tracking algorithms. A

combined corner and edge detection based method on the local auto-correlation function is also used for eye localization (Harris and Stephen, 1988). G.C. Feng et al. present the variance function which is used to detect eye location & shape. It is completely a new approach (Feng, 1998). Liu wen yu et al. proposed the morphological skeleton which is implemented by fast corner detection algorithm. This technique is completely different from chain code based corner detection algorithm (Malik et al., 2011). Mohammadreza Ramezanpour et al. proposed a new algorithm. Firstly the face region is extracted from the image by skin-color information. Secondly horizontal projection in image is used to obtain the eye region (Ramezanpour et al., 2009). Jyoti Malik et al. are used Harris Corner Detector for extract palm print features. Cui Xu et al, proposed a eye corner detection method based on schematic features which are abstracted from the structures and appearance and characteristics of the canthus. In this proposed method after detecting the face the eye window is extracted from the face (Xu et al., 2008). Paola campadelli et al. introduced an algorithm for automatic detection and description of facial features in 2D color images of either frontal or rotated (Campadelli and Lanzarotti, 2002). Waldir S. S. Junior et al. presents the discriminative filtering technique performs pattern recognition using a two-dimensional filter. It has a closed-form design, based on the pattern and the statistics of the image set. Here, they investigate the use of discriminative filtering for detecting fiducial points in human faces (Junior et al., 2010). Stefano Arca et al. present a method of automatic face detection system on color images after having localized the face and the facial features, it determines facial fiducial points, and characterizes them applying a bank of Gabor filters which extract the peculiar texture around them, they didn't use rotated images (Arca et al.,).

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In this paper, we have focused to detect human eye using Harris corner detector after creation unique background by morphological operator (double operation dilation and erosion). This paper is organized as follows: system overview has been given in Section 2, which includes the description of unique background creation and proposed corner detection technique. Section 3 shows the distance analysis and experimental results using ORL Face Database. Finally, the conclusion and future work is given in section 4.

2. PROPOSED SYSTEM

The whole system and implementation steps are described with a system diagram shown in Figure 1. At first, the morphological dilation operator have been applied twice times which ensures that no corners will be detected in the background of the input face images. After that, Harris corner detector has been applied to detect the corners on the images. After detection of corners, we have done manual analysis to find out the possible range of distances between the detected eye corners and used it as predefined distance. Then, the eye corners have been searched through measuring the distances between the detected corners and comparing them with predefined distance. After separation of the eye corners from other corners, the eye region was extracted and stored in the eye database.

Figure 1: Block Diagram of the System:

2.1 Creation of Unique Background

It may happen in some cases that some background light is present in human face images. In some cases, presence of background light may create problem in the corner detection process as the corner detection method will detect the corners from the full input image from both the face region and background of the face also. This is essential to generate a unique background before starting the detection of corners for eradicates the possibility of getting any unwanted corner from the background. The 'dilation' morphological operation has been applied for this in this work.

Morphology is a broad set of image processing operations that apply a structuring element to an input image, creating an output image of the same size. The most basic morphological operations are dilation and erosion. We have applied dilation operation twice compared to previous work to generate images with unique background. Dilation is an operation that grows or thickens objects in an image (Gonzalez et al., 2006). In this operation, the value of the output pixel is the maximum value of all pixels in the input pixel's neighbourhood. In a binary image, if any of the pixels is set to the value 1, the output pixel is also set to 1. In this work, the dilation operation have been applied on gray scale images. In mathematically, dilation is defined in terms of set operation. The dilation of A by B , denoted $A \oplus B$, is defined as:

$$A \oplus B = \{z \mid (\hat{B})_z \cap A \neq \emptyset\} \quad (1)$$

where, $\emptyset$ is the empty set and B is the structuring element. In words, the dilation of A by B is the set consisting of all the structuring element origin locations where the reflected and translated B overlaps at least some portion of A (Gonzalez et al., 2006).

The image samples shown in Figure 2 reveal the fact about how application of dilation operation has generated the unique background; as a result of which it has been possible to restrict the corner detection algorithm from detecting any corner in the background.

The dilation operation has been used twice to create the unique background for detection few numbers of corners compared to previous work. In this figure, corner detection algorithm has been applied on the same image, but the only difference is that, the algorithm has been applied directly on the gray scale image in case of (a) and in case of (b) the algorithm has been applied after applying dilation operation on the gray scale image.

2.2 Applying Harris Corner Detection

A Corner is defined a intersection of two edges. A corner or interest point can also be defined as points for which there are two dominant and different edge directions in a local neighbourhood of the point (Corner detectionar). An interest point or corner can also be an isolated point of local intensity maximum or minimum, line endings, or a point on a curve where curvature is locally maximal. The main advantages of a corner detector is its ability to detect the same corner in multiple same images under conditions of different lighting, translation, rotation and other transformation.

The corner block detection has been found in corners in an image using the Harris corner detection method. The block finds the corners in image based on the pixels that have largest corner metric values (Malik et al., 2011).

Harris Corner Detector is one of the promising tools to analyze the corner points clearly. Actually, it is based on the autocorrelation of image intensity values or image gradient values. The gradient covariance matrix is given by

$$M = \begin{pmatrix} A & C \\ C & B \end{pmatrix} \quad (2)$$

Where,

$$A = (I_x)^2 \otimes w \quad (3)$$

$$B = (I_y)^2 \otimes w \quad (4)$$

$$C = (I_x I_y)^2 \otimes w \quad (5)$$

Where, I_x and I_y are the gradients of the input image, I in the X and Y direction, respectively. The symbol $\otimes$ denotes a convolution operation. The above coefficients have been used for separable smoothing filter parameter to define a vector of filter coefficients of an image. The block of corners multiplies this vector of coefficients by its transpose to create a matrix of filter coefficients, w.

The Harris corner detection method avoids explicit computation of the eigenvalues of the sum of squared differences matrix by solving for the following corner metric matrix, R:

$$R = AB - C^2 - k(A + B)^2 \quad (6)$$

Here, k defines to the sensitivity factor. The value of k is specify using the Sensitivity factor ($0 < k < 0.25$) parameter. The value of k has to be determined empirically, and in this literature the value 0.04 is used. The more likely it is that the algorithm can detect sharp corners in smaller value of k. The pixels are classified as follows on the basis of R:

$R > 0$: Corner pixel, $R \sim 0$: pixel in flat region, $R < 0$: Edge pixel

Figure 2: (a) Corner detection before dilation, and (b) corner detection after dilation;

3. EXPERIMENTAL RESULTS AND DISCUSSION

3.1 Creation of Unique Background

There are 40 distinct subjects with 10 different visual images in each subject. In some subjects, the images were taken at different times, varying the lighting, facial expressions such as open and closed eyes, smiling and

not smiling and facial details with glasses and no glasses (Dep. Computer Science and Technology). The whole images were taken in an upright, frontal position (with tolerance for some side movement) against a dark homogeneous background with the subjects. The size of each input image is 92×112 pixels with 256 grey levels per pixel used in experimental work.

3.2 Unique Background

The first task is to find out the eye corners from detected face region; so that we can extract the eyes from the face image. For finding out the eye corners, the lower and upper limits of the distance between the right and left eye corners have been found. For this, manual distance has been calculated over 10 images of 10 different classes. The 'data cursor' operator is one operator in MATLAB which have been used for the (x, y) coordinate values of eye corner pixel on selection of the pixel (Ebisawa, 1998).

An example of the process is shown in Figure 3. After getting the coordinate values of the two eye corners, the row and column distances have been measured. If we the coordinates of the two eye corners are (r_1, c_1) and (r_2, c_2) , then the row distance (R_d) will be $|r_2 - r_1|$ and the column distance (C_d) will be $|c_2 - c_1|$.

All these coordinate values, along with R_d and C_d measured for the 10 different images of 10 different classes are shown in Table. 1. In Table. 1, it can be seen that the maximum and minimum values for R_d is 2 (R_{dmax}) and 0 (R_{dmin}) respectively and for C_d it's 38 (C_{dmax}) and 26 (C_{dmin}) respectively (Bagci et al., 2004). These two values of C_d have been used as the limits or as the distance range for eye distance. All these pixel coordinates, row wise distances and column wise distances are shown in Table 1.

Figure 3: The x and y coordinate values of eye corners.

As per Table 1, we now know the possible range of the column distance between the two eye corners. For automatic determination of the eye corners, we have used the maximum row distance as the range for selecting the corners which fall within a horizontal region of the height of R_{dmax} .

Then the column wise distance is measured between each of the two corners of that region. If any of the distances come within the range of C_d , (i.e. from C_{dmin} to C_{dmax}) then we consider those two corners as the eye corners (Tan et al., 2002).

Testing images have been chosen from the same 10 classes which were used for training i.e., for manual distance calculation. But, we have selected only the frontal and straight images available in each of those 10 classes except the training images and so, the number of images per each class is different.

Total 40 images have been chosen for testing purpose. Experimental results have been shown in Table 2 (Majumder et al., 2012; Chiang et al., 2003). Results show that eye detection was successful for 35 images, which implies that eye detection rate is 87.5%.

Table 1: Manually calculated row and column distances of the eye corners.

Class	Training image	Pixel coordinate				Distance by coordinate (pixel)	
		Left eye		Right eye		$ c_2 - c_1 $	$ r_2 - r_1 $
1		62	54	26	53	38	1
2		65	56	30	55	35	1
3		64	53	29	53	35	0
4		61	57	29	57	32	0
5		65	54	28	53	37	1
6		62	47	25	46	37	1
7		56	58	30	59	26	1
8		66	64	31	64	35	0
9		68	39	32	40	36	1
10		67	53	32	53	35	0

Table 2: Testing Results

Class	No. of testing images	Eyes detected properly	Eye detected, but with other parts	Not detected	Total no. of testing images	Total no. of detected eyes	Proper eye detection (%)
1	4	4	-	-	40	35	87.5
2	3	2	-	1			
3	1	1	-	-			
4	4	4	-	-			
5	6	5	1	-			
6	4	4	-	-			
7	4	3	1	-			
8	5	4	-	1			
9	4	3	-	1			
10	5	5	-	-			

After detection of the eye corners from all other detected corners, eye region is extracted from the face image and stored in the Eye Database. Some sample images of the extracted eyes along with the eye corner distance have been shown in Table 3.

Table 3: Extracted Eye

Class	1	2	3	4	5	6	7	8	10
Extracted eye region
Eye corner distance	36	26	31	29	33	35	33	25	34

4. CONCLUSION

In this paper, the dilation operation has been used twice for extraction of human eye compared to previous work. Also Harris corner detection method is used after applying of dilation operation. The proposed method has been performed on 40 no. of images of 10 different classes of ORL Face Database. The correct detection rate of eye detection and eye extraction are found 87.5% detection rate. In future, the work will be done for extraction of eye automatically using different technique.

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