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A New approach for the eye detection of any living object with the help of Harris Corner Detector

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Abstract: In the present study, the well known Harris corner detector algorithm has been utilized along with morphological dilation operation for the detection of eyes of human being and the cat. The dilation operation has been found to extract features by feeling hole and broken area from the image background. Harris corner detection has been then applies to find the intermediate distance between the two corners of the eyes and distance has been compared with the predetermined distance between the two corners of the eyes. Eye detection would be confirmed incase the measured distance come within such end feasible range of the predetermined one. The present method has been found yield satisfactory results for both the human being and the cat.

Keywords: Eye detection, Harris corner detection, Morphological dilation operation.

I. INTRODUCTION

Eye detection is a well known problem for any living object especially for human beings. Eyes serve has an important parameter for human Harris detection. The mental condition and the emotion can be recognized from the appearance of the eyes. The eye expression has been found to be extremely important to gauze the nature and feelings of the animals who can not speak. Eyes are also invariant composed to other facial parameters during the time of either the recognition of the human face or human facial expression. A good numbered of research works have already been carried out in the fields of face recognition and facial expression recognition [1-8]. Several research works has also been carried out by various researchers in the field of human eye detection. Feng and Yeun developed a variance projection function to locate landmarks of the human eye which are then used to guide the detection of the eye position and shape [9]. Huang and Wechsler perform the task of eye detection by using optimal wavelet packets for eye representation and radial basis functions for subsequent classification of facial areas into eye and non-eye regions [10]. Bhoi and Mohanty described template based method for eye detection where correlation of eye template with various overlapping regions of the face image is found out [11].

The region with maximum correlation with the template refers to eye region. Sirohey and Rosenfeld used Filters on Gabor wavelets to detect eyes in gray level images [12]. Zhou and Geng propose a hybrid projection function to locate the eyes [13]. By combining an integral projection function, which considers mean of intensity, and a variance projection function, which considers the variance of intensity, the hybrid function better captures the vertical variation in intensity of the eyes. Yuille, Hallinan and Cohen first proposed using deformable templates in locating human eye [14]. The disadvantage of the deformable templates is that the processing time is lengthy. Lam and Yan introduced the concept of eye corners to improve the deformable template approach [15]. A study on combined corner or edge detector based on the local auto-correlation function has been made by Harris and Stephens [16].They had obtained a good consistency of image filtering on natural images. Recently Malik, Dahiya, and Sainarayanan has utilized Harris corner detector corner eye detection technique [17]. Lak and Yazdi and proposed a new strategy based on filters combination approach for eyes localization in which filters are used to find and highlight corners of region with local maximum intensity [18]. Despite of above mention either numerous research works in the related fields by various researchers, no study on the eye detection using Harris corner detector has been found in the available published and on line literature.

In the present study image morphological operator viz.dilation has been applied to create a unique background outside the face under test (for both the human and the cat).Dilation operation augments to fill the holes and broken areas from the image and subsequent extraction of image features. It removes all the light objects and less prominent attributes from the background to enable the following eye detection in more comfortable and easier way. Harris corner detector, a less sensitive algorithm to scaling effect and illumination level of the image, has been applied to measure the distance the two eyes and the distance has been compared with a predetermined distance between the eyes obtained by using the Data Cursor operator of the starting window of MATLAB. The eye could be detected only when the distance obtained from the Harris Corner detection algorithm falls within feasible and considerable range of the predetermined distance. The method has been applied on a human face (two authors of the images) and on the image of the cat and found to be yield acceptable and satisfactory results for both the cases.

II. MATHEMATICAL BASIC AND FORMULAE

A. Background Creation:

It may be happen in some cases of face images that some background light is present. This problem may create another problem in the corner detection process as the corner detection method will detect the corners from the whole input image i.e. from both the ace region as well as the background of the face region also. Therefore, to overcome the possibility of getting unwanted corner from the background, it becomes necessary to first generate a unique background before applying corner detector. One of morphological operation called 'dilation' has been applied for creation unique background.

In a morphological operation, the value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbours. The most basic morphological operations are dilation and erosion. In this paper, we have applied dilation operation to generate the images with unique background. Dilation is one type of operation that grows or thickens objects in an image [19]. In this operation the value of the output pixel is the maximum value of all the pixels in the input pixel's neighbourhood. For e.g. in a binary image, if any of the pixels is set to the value 1, the output pixel is also set to 1. In our work we have applied dilation operation on gray scale images. Mathematically, dilation is defined in terms of set operation. The dilation of A by B, denoted $A \oplus B$, is defined as,

$$A \oplus B = \{z \mid (\hat{B})_Z \cap A \neq \varnothing\} \tag{1}$$

Where, Ø is the empty set, z is pixel element, A is object and B is the structuring element in (1). 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.

The image samples of human face (one of the authors) and a cat has shown in Figure 1 reveal the fact about how 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. In this figure, corner detector has been applied on the same image, but the only difference is that, the algorithm has been applied directly on the grayscale image in case of (a) and in case of (b) the algorithm has been applied dilation operation on the gray scale image.

B. Corner Detection:

A corner is defined as the intersection of two edges. A corner can also be defined as points for which there are two dominant and different edge directions in a local neighbourhood of the point [20]. An interest point can be a corner but it can also be, for example, an isolated point of local intensity maximum or minimum, line endings, or a point on a curve where the curvature is locally maximal. The main advantages of a corner detector is its ability to detect the same corner in multiple similar images, under conditions of different lighting, translation, rotation and other transforms.

The Corner Detection block finds corners in an image using the Harris corner detection, minimum eigenvalue, or local intensity comparison method. The block finds the corners in the image based on the pixels that have the largest corner metric values. A simple approach to corner detection in images is using correlation, but this gets computationally very expensive and suboptimal. Harris Corner Detector is one of the promising tools to analyze the corner points. It is based on the autocorrelation of image intensity values or image gradient values. The gradient covariance matrix *M* is given by,

$$M = \begin{pmatrix} A & C \\ C & B \end{pmatrix} \tag{2}$$

Where A, B and C in (2) are as follows,

$$A = (I_X)^2 \otimes w \tag{3}$$

$$B = (I_y)^2 \otimes w \tag{4}$$

$$C = (I_X I_y)^2 \otimes w \tag{5}$$

The I_X and I_y are the gradients of the input image, I in the X and Y direction, respectively in (3), (4) and (5). The symbol $\otimes$ denotes a convolution operation in (3), (4) and (5). The coefficients have been used for separable smoothing filter parameter to define a vector of filter coefficients. The block multiplies this vector of coefficients by its transpose to create a matrix of filter coefficients *w*.

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

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

The variable k corresponds to the sensitivity factor in (6). We can specify its value using the Sensitivity factor (0< k <0.25) parameter. The value of k has to be determined empirically, and in this literature we have used the value 0.04. The smaller the value of k, the more likely it is that the algorithm can detect sharp corners. On the basis of R the pixels are classified as follows:

$R > 0$: Corner pixel, R ~ 0: pixel in flat region, R < 0: Edge pixel.

III. EXPERIMENTAL PROCEDURE AND RESULTS

The complete system and implementation steps are described with a block diagram shown in Figure 2. Firstly, we have applied a morphological operator called dilation operator which ensures that no corners will be detected in the background of the input face image or minimizes the corners in the background. Harris corner detector has been used to detect the corners after applying morphological operator. After corner detection, we have done manual analysis to find out the possible range of distances between the detected eye corners and used it as the predefined distance. Then, we have searched for the eye corners by measuring the distances between the detected corners and comparing them with the predefined distance. Lastly, the eye region was extracted and stored in the eye database after the separation of the eye corners from the other corners and stored in the eye database.

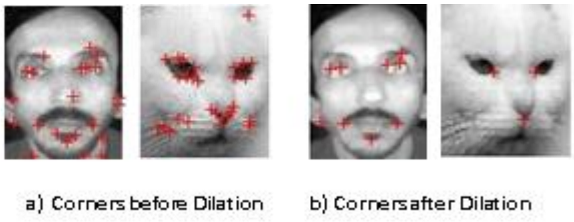


Figure 1. Corner Detected Images Before and after Dilation.

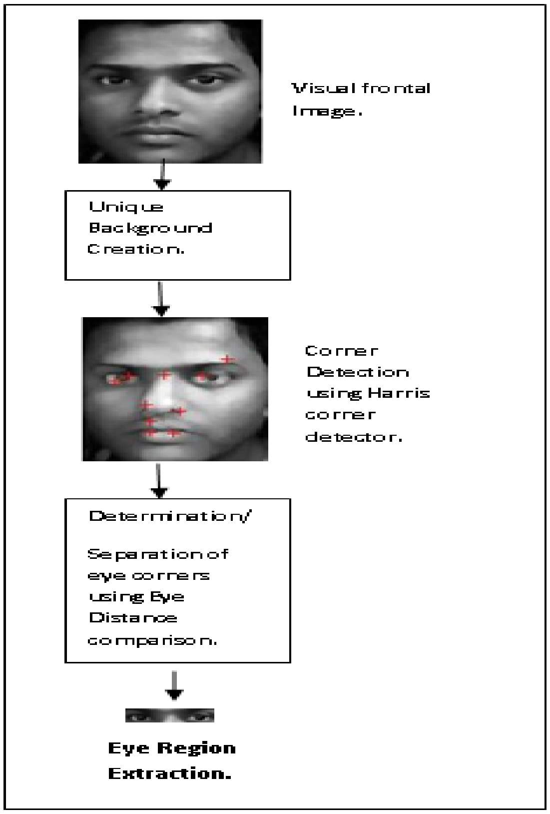


Figure 2. Block Diagram of System.

There are 10 different visual face images obtained from real life. The face images of two authors and family members of one authors has been taken at different times for experiment. There are five different real life face images of cat also has been taken for our experimentation [21]. The size of each image has been resized by 92×112 pixels, with 256 grey levels per pixel.

After the corners have been detected, our first task is to find out the eye corners; so that we can extract the eyes from the face image. For finding out the eye corners, we first need to find out the lower and upper limits of the distance between the right and left eye corners. For this purpose, manual distance calculation has been done over 10 different real life images. We have used the 'data cursor' operator of MATLAB, which gives the (x, y) coordinate values of the eye corner pixel, on selection of the pixel. After getting the coordinate values of the two eye corners, the row and column distances have been measured. If we consider the coordinates of the two eye corners as (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 real life images are shown in Table I. From the table it can be seen that the maximum and minimum values for R_d is 5 (R_{dmax}) and 0 (R_{dmin}) respectively and for C_d it's 38 (C_{dmax}) and 29 (C_{dmin}) respectively. 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 I.

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

Table I. Manually calculated row and column distance of the eye corners

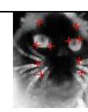
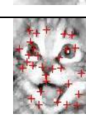
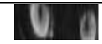
Image No	*Corner detected Images*	*Pixel coordinate*				*Distance by coordinate (pixel)*	
		Left eye		*Right eye*			
		c_2	r_2	c_1	r_1	$\lvert c_2 - c_1 \rvert$	$\lvert r_2 - r_1 \rvert$
1		60	46	24	46	36	0
2		54	45	22	47	32	2
3		72	53	35	49	37	4
4		61	46	23	46	38	0
5		48	31	18	35	30	4
6		68	52	39	52	29	0
7		56	33	27	34	29	1
8		63	49	25	48	38	1
9		65	35	28	40	37	5
10		64	38	27	37	37	1

Table II. Results of Extracted Eye Regions

Image No	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
Extracted Eye Region										

IV. CONCLUSION

The proposed method based on image morphological operator and harris corner detector for the detection of human and animal eyes is simple. It has been found to yield higher rate of eye detection. The method can be utilized to detect human lips, nose as well as pair of canine teeth.

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