Abstract—The study presents a robust technique for the extraction of eyes from human faces with different poses. Image registration has been applied on different pose images with respect of still image for alignment the pixel position of images. Harris corner detector is applied on a morphological pre-processed registered human faces. The eye dimension thus found is compared with a predetermined dimension of the same obtained through ‘data cursor’ operator prevailing in Matlab toolbox. The proposed technique is found 93% of average correct detection rate of eye extraction from registered human face of OTCBVS benchmark database.

Key words: Image registration, extraction, data cursor, corner.

I. INTRODUCTION

Eye detection and eye extraction are well known problem to play an important role in systems such as face detection and face recognition, gaze tracking, and iris recognition, etc. for any living object especially for human beings. Human eyes are the most prominent features of human face image. Face alignment involves spatially scaling and rotating a face image to match with face images in the database. In most face recognition methods, eye positions are manually given. But for a real time application of face detection and recognition, manually detecting eye positions is apparently not realistic. Automatic eye extraction and detection is needed to fully recognize the human face recognition.

Various research works have also been carried out by various researchers in the field of human eye detection and extraction. Lak and Yazdi has developed 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 [1]. Saber and Tekaip used geometrical structure of facial images to estimate the location of eyes [2]. Huang and Wechsler represent a technique for eye detection from human face using optimal wavelet packets and radial basis functions (RBFs) [3]. Sirohey and Rosenfeld proposed filters on Gabor wavelets to detect the two eyes in gray scale human face images [4]. Lam and Yan developed a new technique of eye corners to overcome some difficulties of previous deformable template [5]. Bhoi and Mohanty described template based method for eye detection where correlation of two eye template of the face image is taken out [6]. This is followed by polynomial curve fitting to boundary points. Zhou and Geng introduced a method for eye location based on hybrid projection function [7]. Those regions which are maximum correlation with the template indicate to eye region. Vezhnevets and Degtiareva estimates approximate eyelid contours based on facial features (eye corners, iris border points), Iris center, radius and upper eyelid are then detected where by filtering the resulted image, the outliers are removed [8]. He combined an integral projection function which is considers mean of intensity, a variance projection function, and the variance of intensity for getting better results. Feng and Yeun developed a variance projection function to locate landmarks of the human eye depending position and shape [9]. Yuille, Hallinan and Cohen represent an eye detection technique with the help of deformable templates [10]. Real-time eye detection using infrared images are utilized to capture the physiological properties of eyes [11-12]. Besides above several proposed technique by many researchers, very few works have been done in the area of eye extraction and eye detection from color human faces with different poses of angles using corner. There are different types of corner detection algorithm in image processing area. A paper on combined corner or edge detector based on the local auto-correlation function has been made by Harris and Stephens [13]. They had obtained a good consistency of image filtering on natural images. But, no study has been developed on eye localization and eye extraction with the help of image registration process on images with different alignment. Image alignment is very important to take all images in a straight position respect to one
image. In this study, eye extraction of human face has been introduced with the help of modified image registration process based on corner detection method.

This paper is organized as follows: in the first section, we have introduced our proposed eye detection method and previous works on eye detection by various researchers. In the second section, we describe system overview in detail. In the third section, the experimental result has been described on OTCBVS benchmark database Face database. Finally, fourth section gives the conclusion.

II. PROPOSED SYSTEM

The whole system and steps of implementing has been described using system diagram shown in Fig. 1. Input color images have been used for whole performance. In this section pre-processing steps, image registration, morphological, Harris corner detection method and extraction of eye area have been discussed.

A. Preprocessing

In pre-processing step, firstly input color images have been converted into gray scale images for further post processing work. The input original color image is usually in the Red-Green-Blue (RGB) color space. For image processing, RGB color space is not optimal image because of intensity information of RGB image is diffused across all three color dimensions. For this reason, the input color image is converted into grayscale image for apply image registration technique and also subsequent stages to extract the eye.

B. Image Registration

Image registration is the process of overlaying two or more images of the same scene taken at different times, from different viewpoints, and/or by different sensors. It aligns two images such as the reference and sensed images. The present differences between images are introduced due to different imaging conditions. Image registration is a crucial step in all image analysis tasks in which the final information is gained from the combination of various data sources like in image fusion, change detection, and multichannel image restoration. Image registration has been applied on gray scale images for alignment all other images with respect to reference image. After alignment through registration process, all images have been resized in same format and cropped the human face area.

Then all images are collected for processing by morphological operation.

C. Morphological Operation

After image registration, morphological dilation operation is applied for taking dilated images. Less no of corners can be found in dilated images to extract eye map from the registered images. 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. 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,

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

(1)
Where, $\emptyset$ 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 $A$.

**D. Harris 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. 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,

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

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

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

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

$$C = (I_xI_y)^2 \otimes w$$

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 $R$,

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

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,
- $R < 0$: Edge pixel,
- $R \approx 0$: pixel in flat region.

**E. Eye Extraction**

After the corners have been detected, the first task is to find out the eye corners; so that we can extract the eyes from the dilated face images. 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. 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 $|c_2 - c_1|$.

**III. EXPERIMENTAL RESULTS AND DISCUSSIONS**

The whole work of proposed method has been simulated using MATLAB R2013a in a machine. The configurations of machine are 2.20 GHz Intel (R) Core (TM) i3-2328M Processor and 2.00GB of Memory. The performance of the proposed method has been analyzed using OTCBVS database which is a standard benchmark thermal and visual face images for face recognition technologies.

**A. OTCBVS Database**

Total 2014 thermal images of 17 different classes and total number visual images among 18 different classes are 2345 images in OTCBVS dataset. All the experiments were performed on the face database which is Object Tracking and Classification Beyond Visible Spectrum (OTCBVS) benchmark database, which contains a set of thermal and visual face images. Total size of the dataset: 1.83 GB, Image dimension: 320 x 240 pixels (visible and thermal), 4228 pairs of thermal and visible images,
176-250 images/person, 11 images per rotation (poses for each expression and each illumination), 30 individuals with different expression, pose, and illumination. Expressions: surprise, laughter, anger with varying poses. Illumination: Lon (left light on), Ron (right light on), 2on (both lights on), dark (dark room), off (left and right lights off) with varying poses.

B. Results

The experimental results have been illustrated in this section. The proposed technique has been applied on images of OTCBVS dataset. The average runtime of eye extraction from registered image is 3.3 seconds in a proposed machine configuration. At first, the input color image has been converted into gray scale image for post processing steps. In above dataset, there are face images with different angle. For alignment of images with respect to one reference image, image registration is applied. After image registration, obtained images have been resized and cropped around the face area.

Then, morphological dilation operation has been applied on cropped registered image. After morphological operation, Harris corner detector is applied on those obtained image to detect the corners on those images. Less no’s of corners can be seen on dilated images so that manual distance between two corners of eyes can be measured accurately. Manual distance can be calculated using “data cursor” presents in Matlab 2013a simulator. After getting manual distance between two eye corners, final eye map is extracted. The proposed technique is found 93% of average detection rate through eye extraction on proposed dataset. The output of the extraction of human eye on proposed dataset has been shown in Fig. 2

IV. CONCLUSION

In this paper, a new modified image registration method based on corner detection has been described to detect the human eyes. It contains mainly four stages such as applying image registration, resizing and cropping, morphological operation and Harris corner detection methods on original input images to extract the human eyes from human faces. A good no of results have been found on proposed dataset compared to other.
REFERENCES


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