EYE DETECTION IN FRONTAL FACE IMAGES

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Abstract - *Eye Detection is a major phase in face detection or recognition, it is widely used in various applications. With the up trends of systems using face and eye detection in image processing in recent years this domain has gained much more attention in different fields like video conferencing, eye gaze tracking, etc. Eye detection is difficult due to various complications in human faces like eye balls are not just the circular part in face; it also has moles and dots which might be prominent. Aware of these issues, a novel method is proposed for automatic detection of eyes in frontal face images without spectacles. The method is based on the assumption that a full frontal image is available and a series of tests are carried out. The technique used is based on Circular Hough Transform which is applied on a frontal face image and is found to be highly accurate and effective for most of the images. The proposed technique is evaluated for different test cases and found to detect iris more effectively.*

Key Words: eye detection, Circular Hough transform, Eye Pair Distance Test.

1. INTRODUCTION

Eye Detection is one of the very essential steps in many applications, such as face expression analysis, gaze estimation, face detection or recognition, criminal investigation and human interactions. Eye position detection assists eye contour detection. This domain is very helpful in a person's identification by iris matching. Unauthorized access to ATM can be potentially prevented by iris recognition technique enhancing security and personal identification. Eyes are the salient and relatively stable features on the face when compared with other facial features. The position of other facial features can be detected with the help of eye position.

The technique used here to detect the circles is Hough Transform. Hough Transform is a globally accepted method for detecting edges, it is feature extraction technique which stands out in image processing. Hough Transform was basically used for the purpose of identification of lines which was later improved upon in identifying positions of arbitrary shapes which include circles and ellipses.

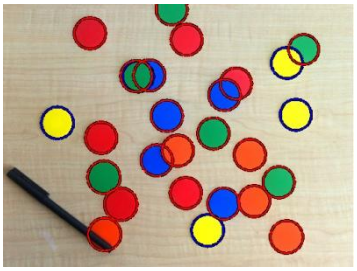

Fig -1: Hough Transform method for circular object Detection

Here Two-stage method with high sensitivity is used to detect circular objects of object polarity darker than its background. Hough Transform is also used to find other structures if their parametric equation is known and gives robust detection even under noise and partial occlusion. In eye detection the eyes are always present horizontally, so the circles which are not present horizontally are removed, Horizontal test is used to implement this.

The eyes are always present on the upper half of the face, so that all the circles which are present on the lower half of the face can be eliminated. Colour can also be one of the main features used for eye detection, the average of dark pixels present inside the detected circles are calculated and the mean of only those circles having least numerical value is considered which lies within the threshold range. The composition of detected iris is mostly black in colour which has a pixel value of 0(zero) in contrast with white having 255 which is why the least value is retained.

Eye pair distance test can be done to see if the circles detected are iris of the eyes. It uses the information about the slope of the line joining the two eyes which is found to be nearly similar in all human beings based on the resolution of the images. The equation of the line y=mx+c where 'm' is the slope is calculated using the distance between the two eyes and width of face for a database of images. The upper and lower threshold are applied and only those pair of circles are retained whose value lies within the threshold. This way only two circles will remain.

2. Related work

Various approaches are available in literature which detect eyes automatically using SVM(Support Vector Machine). In [1], this technique has been used in lot of

areas such as eye pupil movement detection, eye feature extraction, eye state detection, eye gaze detection. The homomorphic filter, extraction of features through the semivariogram and the classification with SVM are executed. Most significant features are extracted through Fisher's stepwise discriminant analysis. Projection gradient and segmentation of the eye candidates is applied to growing region so the eye is extracted.

In [2] the precise localization of parts of a human face such as mouth, nose or eyes is important for image understanding and recognition. Here precise modified Hough transform to detect the eyes and eyelids.

As proposed in [3] the eye centers are first identified using circular Hough transform. Then the histogram of the window eye pair centers are extracted. Predefined conditions are satisfied by the eye pair and using SVM.

The work proposed in [4] first detects face region and then extracts intensity values. From the value iris candidates are extracted. Hough transform, separability filter and template matching are used for efficient eye detection. And, these algorithms can detect the irises only from facial images whose eye patterns are similar to sample eye images used in the eye models.

Eye detection can be inturn used for face detection. In [5]it proposes a method for detecting both iris from gray-scale facial image. It is detected using separability filter

As proposed in [6] the skin color pixel is extracted initially. The same pixels are gathered and the maximum area is extracted with is the candidates face region using region-growing algorithm. Here the darkest region is the eyes and is extracted using Dark-Pixel Filter (DPF)

A novel approach for locating eye centers in face areas under probabilistic frame-work is derived. In [7] after grossly locating a face, the areas where left and right eyes lie in are first found. An appearance based eye detector is used to detect the left and right eye separately, each possible eye pair is normalized and verified.

In [8], the system firstly detect candidates of eye pair and the verification is carried by using SVM to select one eye pair. Then extraction and normalization is applied so that the centre of eye points are detected. Finally face is detected through verification of candidate region using SVM. SVM is efficient since the face detection error rate is significantly reduced by verifying eye pair and face candidate region.

In [9] eye detection on gray intensity face without spectacle uses two methods that is feature based method and template based method. Initially after the location of face is detected feature based method is used where rough regions of eyes are detected on facial image. After the eye regions are found then iris centers will be detected using the template method. Here the database image is in ORL database which has 40 persons image in different expressions.

Simple and efficient eye detection method like RGB, HSV(hue saturation value) and NTSC (National Television System Committee)scales are used in [10]. Basically eye regions are low illuminated, high density and high contrast when compared to other parts of the facial features. Firstly skin is detected using six-sigma technique. HSV is the most efficient space for detecting skin in facial image. Next eye detection where sharp point of reflection which is the light dot is exploited using NTSC format. The morphological techniques are used for boundary detection. Using suitable threshold blobs are plotted. The blob image and skin image is AND operated. At last two candidates which is eye is located.

Another proposed algorithm in [11] is based on neural network approach and is divided in two stages training and detection stage. Here segmentation of eye using HSV, morphological operations and image eye region as proposed in [10] and [12] is applied as input to neural network. If eye matches then detect eye or else eye is not detected.

Eye detection on color images can also be done based on the assumption that they are darker than other part of the facial features as proposed in [9] and [10]. An algorithm has been proposed in [12] use morphological technique to locate eye-analogue segments, and to search small patches in the input image. Here the non-skin regions are used for detecting eye. An ellipse is fit to each eye region using a component analysis. At times the eye brows may be extracted along with the eyes , to discard the eye brows the centre part of an eye region is darker than other parts. A simple histogram analysis is used to extract only eye and discard the eyebrows.

There are two methods described in [13] to detect eyes in a front facial image. It first describes the large flesh colored image and then the estimate the size and separation of the eyes. Here the filters used are based on Gabor Wavelets and then applied to detect eyes in gray level image of frontal face image. A nonlinear filtering method was developed to detect the corners of the eyes in the color image of the frontal face.

As in [1] and [8] SVM based verification is used in [14]. Filtering is used to locate eye pair and later threshold is applied. Binary template is adopted so that the two eyes are in a very rough way and later precise filtering is applied. The eye pair image is the enhanced image which is processed by homomorphic filter and which is extracted

from the facial image.

3. IMPLEMENTATION

3.1 Proposed Approach

Detection of human face and eyes is a striking challenge in human computer interface. Preciseness of iris is much higher compared to the trending techniques like voiceprint ,fingerprint etc. This paper proposes a method that automatically detects the eyes in faces and marks a circular pattern on the iris.

- The method proposed in this paper is a simple step by step procedure which initially makes use of Hough Transform .
- The circles are detected which includes both the eyes and maybe many other locations because of slight curves which can be present anywhere in the face, using Circular Hough Transform.
- Once this is done a series of tests are done to check conditions and remove the unwanted detected circles.
- The first test is Horizontal Test which keeps only pairs of circles which tend to lie along a horizontal axis and the others are removed.
- Horizontal test is followed by the Symmetric Test, which retains pairs of circles present on either sides of the face.
- Next the upper half test is done which removes circles detected in the lower half of the face where there are 0% chances of occurrence of eyes.
- The dark pixel test whose main aim is to calculate the average of dark pixels present inside the circles and keeping only those pairs for which the mean lies above the threshold and there are more of black pixels which is the composition of eye color.
- If not for perfect black eyes, it even holds good for brown eyes. This test removes most all of the unwanted circles but for a few exceptional cases the next and final test is done.
- The last test makes use of information about the relationship between the width of the frontal face image and the distance between the two eyes which is found to be nearly similar to all human beings.
- The equation of the line is $y = mx+c$ where 'm' is the slope and 'c' is the intercept. The value of m and c were estimated as mu=0.468, ml=0.418, cu=15.864, cl=-7.853 where mu, ml are the threshold values of the slope and cu, cl are the threshold values of the intercept.
- Pairs of circles which lie within the thresholds are retained.
- This way the image will be left with only two circles on the face which will be encircling the iris of the two eyes. This method is found to work efficiently in almost all images provided a frontal view of face is fed as input.

3.3 Algorithm –

Step1: A Hough Transform function is used to automatically detect circular objects in the image.
Step 2: Horizontal test is applied, since eyes are present along the axis i.e they lie horizontally. Threshold (distance between two eyes i.e difference between x axis of centres) <=10.
Step 3: Apply Upper half test, where the length of the face is divided into two equal halves and upper half is where the eyes are present.
Step 4: Dark pixel test is applied, since iris are dark, this test calculates the average of dark pixels.

```
radius=constant value
first1=[x-radius : x+radius , y-radius : y+radius]
first=im2bw(first1)
avg=mean(mean(first))
Threshold1=min(avg)
Threshold2=Threshold1+0.1;
```

where,
'first1' is the square boundary whose length is equal to the diameter of the iris
'first' is the binary matrix of first1
'avg'holds the average of the pixel values of matrix first
Step 5: Eye Pair Distance Test, distance between the eyes are found manually.

```
mu=0.468
cu=15.864
ml=0.418
cl=-7.853
y1=(mu*w)+cu
y2=(ml*w)+cl
```

where mu, ml are the threshold values of the slope and cu, cl are the threshold values of the intercept.
If y1<= distance between 2 eyes <=y2
Then the left out pair of circles are eyes.

3.3 Implementation Procedure

The method proposed in this paper is a simple step by step procedure which initially makes use of hough transform. Hough transform is an algorithm or method that detects edges basically and more specifically used in detection of lines and circles in many kind of images. So the basic idea of our proposed approach is to use circular hough transform as the first step to detect circles in the frontal face. Hough Transform is also used to find other structures if their parametric equation is known and gives robust detection even under noise and partial occlusion. The input image is given as shown in fig -2.

Fig -2: Input Image

Once this is done a series of tests are done to check conditions and remove the unwanted detected circles. Image after applying circular hough transform is shown in fig -3.

Fig -3: Image after Hough Transform

The eyes are always present horizontally, so the circles which are not present horizontally are eliminated, Horizontal test is used to implement this which keeps only pairs of circles which tend to lie along a horizontal axes and the others are removed. The resultant image is shown in fig -4.

Fig -4: Image after Horizontal test

Face is structured such that eyes cannot be placed on the same side of the face. Symmetric test is done, which retains the pairs of circles present on either sides of the face, where the frontal face image is divided into equal halves vertically. The output is shown in fig -5

Fig -5: Image after Symmetric test

The eyes are always present on the upper half of the face, so all the circles which are present on the lower half of the face are eliminated. Upper half test will help us in eliminating all the circles which are present on the lower half of the face. The output of this step is given in fig -6.

Initially the size of the image is found, it gives the number of rows and column and then the row value is divide by two and eliminate the circles in the lower half.

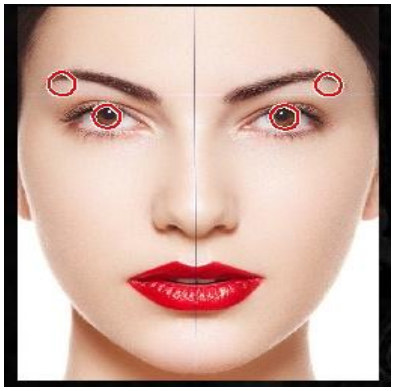

Fig -6: Image after Upper half test

Next is the dark pixel test where the average of dark and white pixels present inside the detected circles are calculated and the mean of only those circles are kept whose mean value is above that of the threshold value and there are more of black pixels which is the composition of the eyes. Those circles are retained as shown in fig -7.

Fig -7: Image after Dark Pixel test

Firstly a list of eye pair distance and width was noted down for the database of images. A graph was plotted with width along x-axis and distance between the eyes along y-axis. Points were found to be linear. The slope and the intercept are estimated. Keeping this as base the test was designed such that only those pair of circles for which the slope and intercepts lied in between the lower and upper threshold were retained and the others were eliminated. This test has been recorded as the most efficient strategy and hence regarded as the final test in the process of detection.

Fig -8: Output Image

The output image contains just two circles which are the detected iris of the eyes as shown in fig -8.

4. CONCLUSIONS

The intent of this project was to detect eyes in the given frontal face image. This is achieved using the technique called Circular Hough transform. Our method detects eyes in a given frontal face image. Four different tests were proposed to detect the eyes. The proposed algorithm is very efficient in detecting eyes. The proposed approach has been tested on various images of database. Experimental results show that this method works well with the faces without spectacles. The proposed method can be used to check whether the eyes are closed in the given frontal image.

Further work lies in this project lies in development of a application used for automatic fitting of contact lenses. The input for the procedure is a cropped frontal face image, the work can be further improved for images without cropping. It can be used to detect other facial features. Improvement can be made on detecting eyes on images with spectacles. It can be further used to detect if the driver is drowsing off while driving.

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