An Effective Method of Eye Detection Using Segmentation and Projection

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Abstract- *Face detection and eye detection has long been the subject of interest in practical implementation of image processing and vision. Moreover the exact pupil detection of eye is the cream of research as the basic step of retinal identification. In this paper we present a new method of accurate eye-band detection. The previous approaches in this field failed to work on tilted or inclined facial images. But this approach not only works on tilted faces, but also determines the pupil in the eye exactly*.

Keywords - Segmentation, Threshold, Masking, Projection, Pupil diameter.

I. INTRODUCTION

The previous approaches in this field used cue colors [20] and pixel edge detection [19], which was difficult in computation. Some also used geometrical approaches [11, 12, 13] which had the limitation of unconstraint background. The projection based approaches failed to work on inclined faces [17].So we present a projection based method which works on mixed background and tilted faces. The approach we give here can be organized into steps as:

(a) Refining the image (b) Obtaining facial mask (c) Determining co-ordinates if the pupil (d) Localizing the pupil

II. PROCEDURAL DETAILS

A. Refining the image:

Step1) The true color image is first converted into gray scale image by standard conversion function. [1]

Step2) The gray scale image is normalized [10] by the following function:

$$I1(m,n)=\begin{cases}\mu_1+\sqrt{\dfrac{\sigma_1^{\,2}\cdot(I(m,n)-\mu)^2}{\sigma^2}}, & \text{for } I(m,n)>\mu\\[2ex] \mu_1-\sqrt{\dfrac{\sigma_1^{\,2}\cdot(I(m,n)-\mu)^2}{\sigma^2}}, & \text{for } I(m,n)<\mu\end{cases}$$

where,

I(m,n) is a inputted image. μ & σ^2 are respectively mean and variance of the inputted image. μ_1 & σ_1^2 are respectively the desired mean and variance of the destination image. I1(m,n) is the destination image.

Step3) The hence received normalized image is stretched [11] to use the full pixel range between 0 and 255 to improve the contrast. This is done by using gray stretching as

$$I1(m,n)=\begin{cases}0(black) & ,I(m,n)<I_{min}\\ 255(white) & ,I(m,n)>I_{max}\\ \dfrac{(I(m,n)-I_{min})\cdot(R1)}{R}, & I \in R\end{cases}$$

Where,I(m, n) is the inputted normalized image.

I1(m, n) is the output stretched image.

I_{min} & I_{max} are the minimum and maximum pixel values respectively.

R= (I_{max} - I_{min})and R1= (255-0) or the range we want to specify.

Inputted image

Gray image

Normalized image

Stretched image

Step4) Next the grey normalized and stretched image is transformed into a binary image by determining an appropriate threshold[2], and converting the pixel values less than the threshold into black(0) and those higher than the threshold into white(255).

B. Obtaining facial mask

Step1) This binary image is segmented into blocks of appropriate size, which depends on the size and type of image.[3]

Step2) Now an appropriate threshold is determined for each block by counting the number of black and white pixels in that block. [4]

Step3) Now if the number of white or black pixels is less than the threshold then those pixels (black or white) are removed totally. Performing the operation on each block we obtain the face mask (the image without the eyes, nose and lips).

Step4) Applying the face mask on the refined image obtained from method (b.1) we extract the face region. Thus we obtain a binary image consisting of just the eyes, the nose and the lips.

Binary image

Face mask

C. Determining co-ordinates if the pupil

Step1)Now as we are to work with maxima instead of minima so we complement the image i.e. we transform the white into black and black into white. This is done by subtracting the pixels from white (255).

Extracted facial region

Complementary image

Step2) Now the orientation of the complementary facial region (i.e. the inclination) is studied and accordingly a line is drawn which approximately divides the facial region into two halves viz. left and right.

Step3) Now the left region (RL) is formed by removing (converting into white) the pixels having co-ordinates on the other half of the line. Similarly the right region (RR) is formed by removing the pixels having co-ordinates less than that of the line.

Left facial region

Right facial region

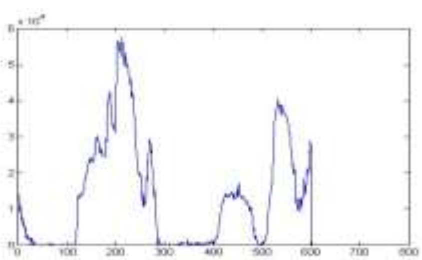
Step4) The pixels of the left region are summed up through each row and thus are horizontally projected.[5] Now this projection (HHL) when studied forms an approximate bell-shaped curve. So this curve is smoothened using an appropriate Gaussian mask.[6] Now the peak of this smoothened curve is taken as the Y co-ordinate (IL) of the pupil of the left eye. [7]

Step5) Similarly the Y co-ordinate (IR) of the pupil of the right eye is found out.

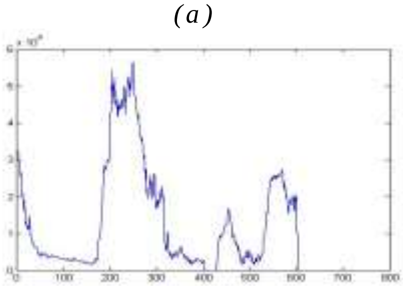
Step6) Assuming an approximate radius (WL) for the left eye, a similar vertical projection is taken (by summing up through each column) of the strip (IL-WL) to (IL+WL).[8]

Step7) We see that the graph obtained is plateau shaped. Thus the average of the maximums is taken and the value thus obtained is the X co-ordinate (JL) of the pupil of the left eye.

Step8) Similarly the X co-ordinate (JR) of the pupil of the right eye is found out.

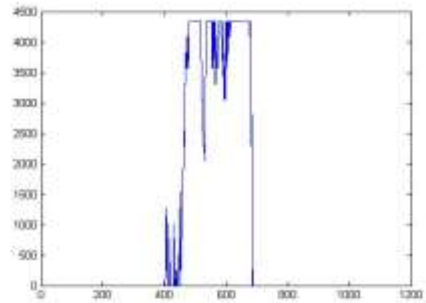


(a)

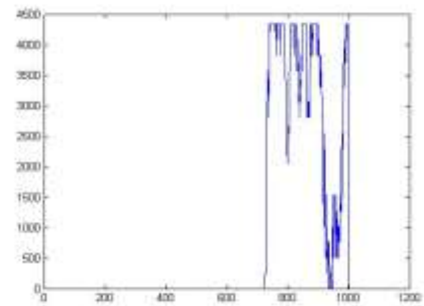


(b)

Graph of Horizontal projection (by summing up pixels through rows) of the Left eye region (a) and Right eye region (b).



(a)

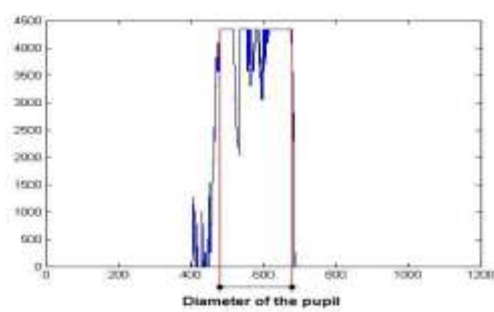


(b)

Plateau shaped graph of Vertical projection (by summing up pixels through columns) of the Left eye region (a) and Right eye region (b).

D. Localizing the pupil

Step1) Now if the vertical projection (HVL) be studied a part of the graph is found out to be uniformly parallel to the Y axis. The range of co-ordinates of this part is the diameter of the pupil.



Determination of diameter of the pupil

Step2) Obtaining the centers of the left and right pupil resp.(IL,JL) (IR,JR) & obtaining the diameter of the pupil, we can draw a circle to locate the exact pupil region in the image.[9]

Output image in which the exact pupils are located.

III. EXPERIMENTAL RESULTS

We have implemented the method using Matlab7.1 on multiple images and we have received quite satisfactory results. However a few outputs are shown here. The images taken were in jpg format. The pupil is marked by red spots in the output image.

(a)

(b)

Inputted images

(a)

(b)

Output images

III. V. CONCLUSION

The approach we have presented here is better than the conventional methods applied in this field. Though there are certain limitations of this approach like:

1.The image must have a uniform background.

2.The image must be large enough for segmentation.

3.The image must contain the whole face without spectacles.

4.The face of the image should be bright enough to be differentiated from the background.

Yet the process has some unique advantages:

1.It works very well in tilted faces

2.It not only detects the eye but also locates the pupil and its diameter.

3.As it is a matrix based approach and not geometrical texture oriented it is faster in computation.

4.The false detection rate of this process is quite low and negligible.

The future research in this process can be done by improvising the segmentation and threshold determining functions. Improvement can also be done in smoothing the projection curve through Gaussian mask.

REFERENCES

[1] R.C. Gonzalez, “Digital Image Processing”, second edition.

[2] Jana Kosecka, “Thresholding”, CS682.

[3] J.Shi, “Normalized Cuts and Image Segmentation”,IEEE transactions.

[4] P.C.Henden, “A comparison of thresholding methods”, NTNU

[5] C.A.Alonzo, “Photon-efficient gray-level image projection by The generalized phase contrast method”,New Journal of Physics9

[6] “Area/mask processing methods”, Trucco,Chapt3

[7] “Image processing through Matlab”, Matlab help.

[8] J.H.Debes,"First high-contrast imaging using Gaussian aperature pupil mask"572:L165-L168.

[9] "Circle drawing and clipping",CS 430/536.

[10] "Digital Image Processing and analysis",D.D.Majumder & B.Chanda.

[11] T.S.Nedzamba, "Statistical approaches to image based eye- detection and tracking", Tshwane University of Technology2002, 2006.

[12] S.Asteriadis, "A novel eye detection algorithm utilizing edge- related geometrical information", Aristotle University of Thessaloniki.

[13] Q.Wang, "Eye detection in facial images with unconstrained background",JPRR 1 (2006) 55-62.

[14] http://www.faqs.org/patents/

[15] http://www.bnet.com/

[16] K.Peng"A robust algorithm for eye detection on gray intensity face without spectacles", JCS&T Vol.5 No.3

[17] Zhi-Hua Zhou, "Projection functions of eye detection"

[18] "A hybrid method for eyes detection in facial images", ISSN 2070-3740.

[19] A.Hajdu, "An eye detection algorithm using pixel to edge information"

[20] R.T.Kumar, "Eye detection using color cues and projection functions"

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