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# AUTOMATIC HUMAN EYE LOCALIZATION AND ITS VALIDATION FOR 2D FACIAL IMAGE

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**Abstract-** Eye detection is required in many applications like eye gaze tracking, iris recognition, auto-stereoscopic displays, face detection and face recognition, human-computer interfaces, driver sleepiness detection, security and biology systems. In this paper, template matching method for eye detection is described. The template is correlated with skin region of the face image. The region which gives maximum correlation with template refers to eye region. Verification of detected eye is also done by measurement of Euclidean distance between detected eye and eye template. The method is simple and easy to implement. The effectiveness of the method is verified in both the cases like open eye as well as closed eye through various simulation results.

**Keywords-** Eye detection, Template matching, Cross-correlation, Euclidean distance

## Introduction

Human face image analysis, detection and recognition are the most important research topics in the field of computer vision and pattern classification. Recognition of human faces is an actively developing research field. Various researches on human-computer interaction or other types of application based on eye observation have been done. Apart from it, eye detection is a crucial aspect in many useful applications ranging from face recognition and face detection to human computer interface design, and driver behavior analysis.

In literature, there are many techniques available for automatic eye detection. In [1,3], iris geometrical information is used for determining a region candidate that contains an eye in the whole image, and then the symmetry is used for selecting the pair of eyes. [2] uses physiological properties and appearance of eyes as well as head/ eye motion dynamics. Probabilistic based appearance model is used to represent eye appearance.[4] uses the structure of the eye region as a robust cue to find eye pair candidates in the entire image. Then eye pairs are located by a support vector machine-based eye verifier. This method fails when eyes are closed. In [5] advantages of two existing methods, feature based method and template based method, are combined.[6] uses edge vector to detect eye.[7] uses map of eyes flexible threshold and geometrical tests. In [8] eye candidates are extracted within face regions then, using the anthropological characteristics of human eyes, the pairs of eye regions are selected.[9] uses the geometry and shape based rules on connected regions to detect eye. [10] uses rules derived from the spatial and geometrical relationships of facial components.[11] uses morphological operations which fails when one or both eyes are closed.

Although much effort has been spent, the problem of automatic eye localization is not fully solved because of its complexity. Factors including facial expression, face rotation in plane and depth, occlusion and lighting conditions affect the performance of eye detection algorithms. The method proposed in this paper also involves verification of detected eyes using Euclidean distance between eye template and detected eye.

The rest of the paper is organized as follows. The template based method is described in section II. The implementation and verification results are shown in section III. A conclusion is shown in section IV.

## A Template Matching Approach for Eye Localization

The template matching approach presented here is an enhancement of the approach presented in [12]. Our presented eye detection technique involves three steps namely skin segmentation, eye localization and eye verification. Verification step is added the previously presented method [12]. In our presented approach, the detected eye is verified using Euclidean distance.

### Skin Segmentation

Color Space Selection: Here our input image is 2D front face color image. From front face image skin portion is detached out using the method suggested in [13,14]. The goal is to remove the maximum number of non-face pixels from the images in order to narrow the focus to the remaining predominantly skin-colored regions. For this purpose appropriate color space should be selected from the wide variety of choices such as RGB, HSV, CMYK, YCbCr etc. From these, RGB (red-green-blue), HSV (hue-saturation-value) and YCbCr are widely used [15]. In the RGB model, each of the three components may exhibit substantial variation under different lighting environments. The results of YCbCr and HSV are more robust to lighting variations because in both the color spaces, color classification is done using only pixel chrominance. It is expected that skin segmentation may become more robust to lighting variations if pixel luminance is discarded and it is also verified by results. Here HSV color space is preferred for color classification because of its similarities to the way human tends to perceive color. It decouples the chrominance information from the luminance information. Thus we can only focus on the hue and the saturation component.

Setting Threshold and Binary Image Creation: After choosing the suitable color space, the next step is to separate the skin colored region from the given input image. For this, the best technique is to apply threshold. When these threshold values are applied to the input image, the new binary image is formed in which the portions satisfying the conditions is made white and the remaining portion is made black. [Fig-1] shows result of skin segmentation. This is a binary image created from a RGB input image. The threshold setting is done on the basis of the HSV values.

**Fig. 1-** Skin segmentation **(a)** input image **(b)** image after skin segmentation

### Eye Localization

The three steps involved in eye localization process are discussed as follow.

### Template Creation

For any template based approach, it is very much necessary to obtain a template which is a good representative of the data. In this technique, eye template is created by averaging the intensities of a set of eye images.

Intuitively, it seemed reasonable that the best template to use would be one derived by somehow averaging the some eye images of the dataset that would likely be in the testing images. The good subset of the eyes is found in the training images those are clear, straight, and representative of typical lighting/environmental conditions. It is also important that these images be properly aligned and scaled with respect to one another. To this end, considerable time was spent for manually segmenting, selecting, and aligning eye images. At the end 18 eye images were chosen. These cropped images were first converted into gray scale and then the average was found which gives final template. The eye template T is formally defined as,

$$T(i,j) = \frac{1}{N}\sum_{k=1}^{N} Ek\ (i,j) \qquad (1)$$

Where N is the number of eye images used for eye template creation and Ek is the eye image. Ek(i, j) and T(i, j) represent the pixel values of the pixel of Ek and T respectively. Thus, our final template for eye detection is a result of averaging together the 18 eye images. The actual template used in the matched filtering is of size 40×22 pixels. The template generated and used in the experimentation is shown in [Fig-2].

### Resizing Template

It is observed that the size of the eye is proportional to the size of the front face image. This observation is used for resizing the eye template in the proposed technique. To handle the detection of eyes of various sizes, eye template need to be resized to make it appropriate for the detection of eye in the image.

$$wt^e = \frac{wr^2}{wr^f} wi^f \qquad (2)$$

By keeping the aspect ratio of the eye template same, it is resized to the width obtained in above Equation 2. Where $wi^f$ and $wr^f$ be the widths of the input face image and the reference face image respectively and $wi^e$ and $wr^e$ are the widths of input eye image and the reference eye image respectively.

Localization: To search an eye in the image I, eye template T is moved over the skin area of the image and normalized cross correlation coefficient (NCC) [16] is computed at every pixel. NCC at point (x, y) is defined in Equation (3) as,

$$NCC(x,y) = \frac{\sum_{u,v}\left[I(u,v)-\bar{I}_{x,y}\right]\left[T(u-x,v-y)-\bar{\tau}\right]}{\sqrt{\sum_{u,v}\left[I(u,v)-\bar{I}_{x,y}\right]\sum_{u,v}\left[T(u-x,v-y)-\bar{\tau}\right]}} \qquad (3)$$

where sum is performed over u,v under the window containing T positioned at (x,y). $\bar{I}_{x,y}$ and are the average of brightness values of the portion of the target image under the template and template image respectively. Values of NCC lie between -1.0 and 1.0. Where it is found maximum, a rectangle of template size is drawn around it to show detected eye. Value of NCC closer to 1 indicates a better match.

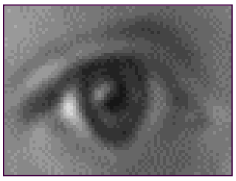

**Fig. 2-** Created template image

### Eye Verification

Here to determine whether a detected eye is a true eye or not, shape based eye verification is performed. To measure the similarity, Euclidean distance between the two sets (one for extracted edges of template and another for extracted edges of detected eye) of mean is used, which is estimated as follows:

$$\text{Distance} = \sqrt{\left(|M^T| - |M^E|\right)^2} \qquad (4)$$

Where MT and ME are mean of extracted edges of eye template and extracted edges of detected eye respectively. Similarity distance between them is calculated using Equation (4). If the value of distance is less than a pre estimated threshold, detection is accepted otherwise it is rejected.

## Experimental Results

### Data Acquisition

In this work CVL (CVL is library for image and data processing using graphics processing units (GPUs)) dataset [20] is used, which contains total 114 persons with 7 images of each. Resolution of each image is 640 x 480. All the Images are in JPEG format captured by Sony Digital Mavica under uniform illumination, and with projection screen in background. Another Indian face database is used which contains images of 40 distinct subjects with eleven different poses for each individual. Resolution of each image is 640 x 480. One dataset is also produced, having images of 50 front faces with dynamic lighting condition with screen resolution of 2848 × 2144 which also includes closed eyes.

### Results of Eye localization

To create eye template, a set of eye images of 18 people is considered. NCC is used to localize the eye. To detect open eye open eye template is used and for closed eye detection closed eye template is used. Points having maximum NCC values are declared as the detected eye. For eye verification Euclidean distance threshold is used. This experiment is performed on 100 images of CVL dataset, 40 images of Indian face database and 50 images of general dataset. For left and right eye detection two different left and right eye templates are used respectively. [Fig-3] shows examples of some of the positive detections in which closed eye detection is also shown. [Fig-4] shows examples of some of the false detections. Generally cause of false detection is spectacles. Accuracy of the localization is defined by (genuine localization/total sample) × 100. The accuracy of the presented method on the above mentioned database is obtained to be 91%. The average time to detect an eye from a front face image is approx.1.42 seconds with Matlab environment.

### Conclusion

The proposed method does not have any effects on the detection of eyes from different environments. The constraint for getting very good result is that the template has to be recreated for different datasets otherwise it degrades the performance of detection. Here template is moved over the skin region, so ideal skin segmentation is required. Method does not give accurate result for images with spectacles. The required detection time is approx. 1.42 seconds with Matlab environment. Experimental results on real side face images also demonstrate the effectiveness of the presented approach.

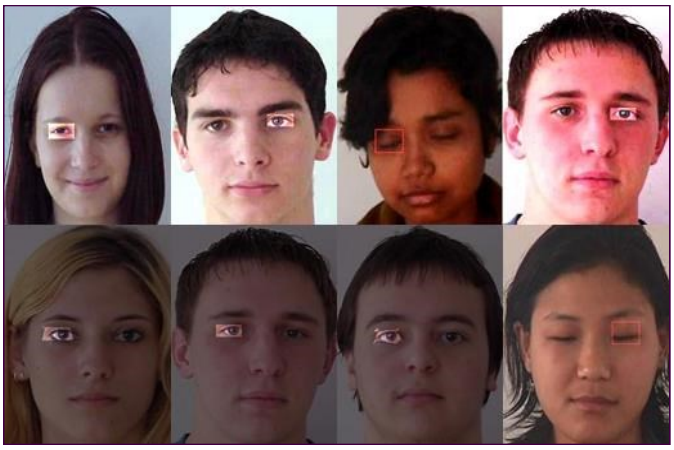

**Fig. 3-** Positive detection

**Fig. 4-** False detection

**Conflicts of Interest:** None Declared.

### References

[1] Kawaguchi T. and Rizon M. (2003) *Pattern Recognition,* 36, 549 -562.

[2] Haro A., Flickner M. and Essa I. (2000) *IEEE Conf. Computer Vision and Pattern Recognition,* 1, 163-168.

[3] D'Orazio T., Leo M., Cicirelli G., and Distante A. (2004) *17th Int. Conf. on Pattern Recognition,* 3, 278-281.

[4] Wang Q. and Yang J. (2006) *Journal of Pattern Recognition Research,* 1, 55-62.

[5] Peng K., Chen L., Ruanand S. & Kukharev G. (2005) *Journal of Computer Science and Technology,* 5(3), 127-132.

[6] Asteriadis S., Nikolaidis N., Hajdu A. & Pitas I. (2006) *An eye detection algorithm using pixel to edge information*, *Int. Symp. on Control, Commun. and Sign. Proc*.

[7] Nasiri J.A., Khanchi S. & Pourreza H.R. (2008) *IEEE Second Asia International Conference on Modeling & Simulation*, 344-349.

[8] Sidibe D.D., Montesinos P. & Janaqi S. (2006) *A simple and efficient eye detection method in color images*, *International Conference Image and Vision Computing*, New Zealand, 385-390.

[9] Shafi M. & Chung P.W.H. (2009) *International Journal of Electrical and Electronics Engineering*, 3(4), 231-236.

[10] Chiang C.C., Tai W.K., Yang M.T., Huang Y.T. & Huang C.J. (2003) *Real-time Imaging*, 9(4), 277-287.

[11] Rajpathak T., Kumar R. & Schwartz E. (2009) *Eye detection using morphological and color image processing*, *Proceeding of Florida Conference on Recent Advances in Robotics,* 1-6.

[12] Bhoiand N. & Mohanty M.N. (2010) *International Journal of Computer Applications,* 12(5), 15-18.

[13] Vezhnevets V., Sazonov V. and Andreeva A. (2009) *International Journal of Expert Systems With Applications,* 3, 4497-4507.

[14] bin Abdul Rahman N.A., Wei K.C. & See J. (2007) *RGB-H-CbCr Skin Colour Model for Human Face Detection*, Faculty of Information Technology, Multimedia University.

[15] Foley J.D., Dam A., Feiner S.K. & Hughes J.F. (2006) *Computer Graphics Principles and Practice,* Pearson Education.

[16] Gonzalez R.C. & Woods R.E. (2002) *Digital Image Processing,* Pearson Education.

[17] Joshi K.V. & Chauhan N.C. (2011) *Edge detection and template matching approaches for human ear detection*, International Conference on Intelligent Systems and Data Processing, 50-55.