QUID 2017, pp. 1813-1818, Special Issue N°1- ISSN: 1692-343X, Medellín-Colombia

EYE DETECTION IN IMAGE THROUGH MORPHOLOGY AND COLOR

(Recibido el 24-05-2017. Aprobado el 30-08-2017)

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Abstract: Eye detection has multiple applications including iris recognition, identifying people in video conferencing, face recognition, and identification. This paper presents a new approach of eye detection in digital images through using morphology operations and color. As observed, an area of image where the eye is located shows low brightness level, large edge density and high contrast comparing other parts of face. The proposed method is highly effective for full faces. In this regard, the area characterized with skin features is initially identified in image by existing color devices such as RGB and/or HSV. Then, two spots are localized as eyes using morphology and removing redundant points. The results revealed that the proposed method is particularly effective for full- face images.

Key terms: Eye detection, face recognition, color space, morphology

Citar, estilo APA: Brooghani, Z., & Navabi, M. (2017). Eye detection in image through morphology and color. Revista QUID (Special Issue), 1813-1818.

1. INTRODUCTION

Face detection, identification and analysis are of the main issues of computer vision and pattern recognition. Of the several issues, automatically eye detection is discussed as one of the basic and major issues. Eye is a significant feature in face such that eye extraction from face image is much easier than extraction of other face features. Identification is effortlessly completed through eye detection and matching iris characteristics. As earlier stated, eye detection is of the major steps in most face detection methods. For face comparisons, two faces are wholly matched such that eyes' location and distance overlapped; the distance is often identical in many individuals.

Eye localization in image also largely aids in finding other face features in image. In addition, eyes significantly contribute in facial expressions recognition due to several eye modes in any facial expressions.

Common eye detection methods include model matching (Brunellu, 1993), (Beymer, 1994), eigenspace methods applied by eigenvalues and eigenvectors (Shafi & Chung, 1998), (Pentland, Mognanddam & Starner, 1994), as well as Hough transform-based methods (Song, Chi & Liu, 2006).

In model matching, input images are compared by correlation criterion to assess the similarity with earlier saved images. Model matching method fails to resist versus scale adjustments, rotation and brightness. Using multiple-scale model may to some extent remove this disadvantage.

Yuille et al (Yuille, Hallinan & Cohen, 1992) suggested a method using modified patterns. The proposed method benefited from simultaneously finding eyes' additional properties such as size and form; however, the efficacy depends on the pattern initial status.

Pentland et al (Pentland, Mognanddam & Starner, 1994) presented an approach using feature space to localize face and eye in the image. If training data may change by brightness level and direction; then, the proposed method is more efficient that pattern matching method. However, its effectiveness largely relies upon training data. Furthermore, this method requires training data and standard test considering size and various directions.

Hough transform is the other common method used for image eye detection. It relies upon iris morphological features often used for edge detection (Lam &Yan, 1996), (Chow, Li, 1993). The disadvantage is that the efficacy depends on image edging threshold, as if the threshold is low for edging, most unnecessary spots may remain after edging; moreover, if the threshold is large, useful points may be probably removed for post-edging Hough transform. Apart from three mentioned classic approaches, many eye detection methods are recently presented. Fang and Yuen (Fang &Yuen, 2001) applied intensity. (Fang &Yuen, 2001) utilized line direction linking eyes' centers, and eye filter convolution response by face, as well as variance projection function (Fang &Yuen, 1998) for eye detection. Zhou and Geng (Zhou & Geng, 2004) developed the idea of variance projection function and provided extended projection function. According to the experimental results, they demonstrated that hybrid projection function is a typical extended projection function outperforming variance projection function and integral projection function in eye detection.

Cava Gucci and Rison (Lam &Yan, 1996) localized iris by edge information using pattern features, separator filter, Hough transform and pattern matching. Sieroie and Rosenfield suggested an eye detection method using linear and nonlinear filters. Huang and Wechsler (Huang & Wechsler, 2000) employed GA (genetic algorithm) and decision-making tree for eye detection.

Wu and Zhou (Wu & Zhou, 2003), in face detection, to find analogue parts of eyes in grayscale images applied size and intensity data. Hen et al (Hen, Liao, Yu & Chen, 2000) benefited morphological techniques such as closing and expanding for detecting eye analogue spots. Hsu et al (Hsu, Abdel Mottaleb, Jain, 2001) recognized the eyes through color information. Despite many attempts on automate eye detection and abundant developments; eye detection problem is still unsolved. Facial expressions, on plane and in depth face rotation, as well as masking and brightness adjustment are the factors challenging eye detection problem. The proposed method includes face (skin) detection for background elimination for eye detection.

2. FACE (SKIN) DETECTION

Detecting face skin area is regarded as the important issue of eye detection. Therefore, many spots mistakenly recognized as eyes may be removed and only the areas with large probability are maintained. This paper used RGB, HSV, and NTSC to enhance efficiency of skin color and eye detection in image. Training approach employed for eye detection is discussed in the following. Firstly, the code is manually trained for skin color detection in multiple images. Next, hue data are obtained and matched on a Gaussian curve. It requires considering face hair as well as wrinkles, within training, that are unwanted pixels may be wrongly detected as eyes. And finally, six-sigma method was used for detection. The results showed that HSV color space is more efficient than other color spaces for skin detection. Figure 2 represents skin detection result of Figure 1.

Figure 1: Original image

Figure 2: Skin detection in original image

3. EYE DETECTION

This paper recognized eye using intensity level such that once the face receives sufficient intensity, the eyes glow as two sharp spots under the reflection. These spots are referred as light spots. NTSC space efficiently extracts these light spots. Therefore, the image is firstly transferred to NTSC space; then, pixels' color values are extracted for further processing. Finding the edge is the next step in eye recognition. The contours are discovered by morphological operations. The next steps are extending, abrasion, and measuring the difference between two points of the image. The structural element used for development and abrasion is a 9*9 identity matrix clearly and narrowly extracts the contours. The morphological edge finding method is more efficient comparing canny edge finding approach. Threshold value is largely important in this method as light spots are limited and the first elimination candidates due to large threshold. Thus, threshold value is important so that the spots are not removed. Selecting threshold value is a complex and critical process; in addition, it varies depending on any images. Hence, an adaptive method is used for threshold selection. The value is computed by an iterative process. The initial value of 220 was selected from 0-255 range of image pixel brightness; the initial value minus five per iteration. The final goal of this iterative procedure is to attain the minimum and maximum values of 4 and 6 bubble-like points, respectively. The results revealed that the threshold within these minimum and maximum values recognizes the eyes in image by least noise. Prior thresholding, redundant spots are removed through morphologically closing operations. Output points of Figure 3 are illustrated in Figure 4.

Figure 3: Original image

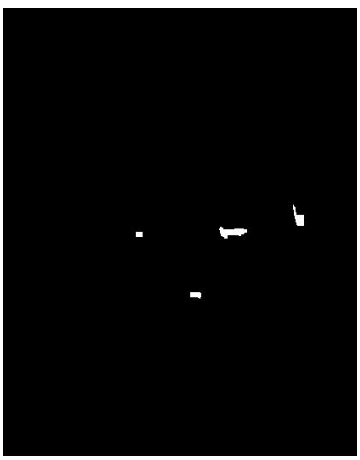

Figure 4: Extracted points following morphological operation

Some bubbles are small and some others are extremely large; however, no spots resemble the desired candidate for eye. Thus, very large or very small bubbles are eliminated through morphologic operations since it is assured that these are not eyes. Then, again using morphological operations, this image is matched with the image obtained from skin detection (Figure 2); hence, the only spots in the obtained image also contain the eye. These steps are in a cycle iterated for any threshold; if the remaining bubble at the end of the cycle was outside 4-6, the cycle goes to the next threshold. If it finds the value in the aforementioned range; then, the desired threshold is obtained.

Now, image noises are eliminated to find the two bubbles representing the eyes. Since full-face images are used here for eye detection, the features are used for research hypotheses. The images are majorly characterized with eyes' horizontally vector orientation. In other word, respecting to coordinates, y-coordinate is almost equal for eyes; while, x-coordinates differ; thus, other bubbles lacking this feature may be removed. Another feature of full-face images is eyes' distance, which is almost identical in all individuals; therefore, the bubbles with distances larger or smaller than this distance are also eliminated. But, when three bubbles are horizontally located along a line, it would be difficult to detect two bubbles as eyes. To solve this problem, horizontal morphological operations is utilized resulted in two bubbles as eyes. Figure 6 represents eye candidate bubbles following noise removing for Figure 5; and Figure 7 shows algorithm final result.

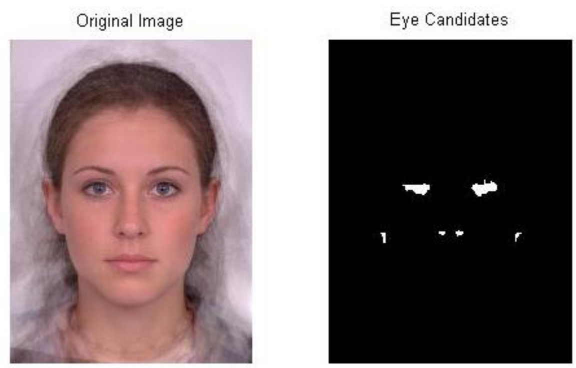

Figure 5: Eye candidates

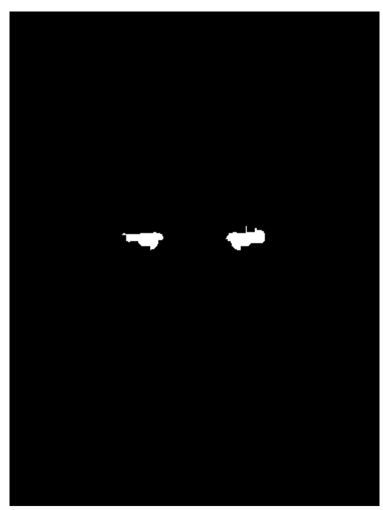

Figure 6: Eye detection after redundant bubbles removed

Figure 7: Eye detection in image

4. CONCLUSION

This paper used an efficient, straightforward method of eye detection for color images. It relied upon face (skin) detection reducing existing eye candidates. Redundant spots and noises were removed through morphological operations. And finally, using the regulation of face structure, two candidates of the existing eye candidates were selected as eyes. It is seen that in 90% of full-face images, this method properly detects and localizes eyes. However, it is inefficient in many images, especially where one or two eyes are closed. It is recommended for further research to find an approach for face detection that is applied in any direction.

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