TECHNICAL SCIENCES

ALGORITHM OF GEOMETRIC NORMALIZATION OF FACE IMAGE

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Abstract

Face image identification and verification has been a popular research topic in computer vision for several years. Geometrical normalization of the face image is important in this, and it has a direct impact on the recognition accuracy. This article is devoted to face image geometric normalization algorithms, it describes a face image normalization algorithm with high recognition speed and real-time performance.

Keywords: face image, normalization, algorithm, scale, brightness, recognition, warp matrix, threshold, segment.

Introduction

The practical application of facial recognition is becoming more and more interesting for many reasons. Facial recognition systems are widely used in video conferencing, robotics, intelligent security, and access control. In this case, the face image will have a geometric normal of large size, which will protect the recognition accuracy. The normal image addition problem exists in many image-related additions. Add-on acceleration uses on-the-fly image preprocessing [1-13]. Usually, this starts with adding normal image manipulation methods and it is removed based on the modified sequence given by [14]. Before normalization of the face image, it is necessary to clarify the location of the front face. Methods and algorithms for identifying face problems are detailed in [15-19].

One of the quality features in the arrangement of geometric images of the face is the central point of the eyes. today there are great algorithms for determining the location of the eye in the image. Below is the image of the normal operation algorithm of product production as the recognition speed and real-time operation efficiency are high. This algorithm is determined by the detection of the surface of the depicted face. The eyes and mouth center are found on the detected face. Then it moves to the operation of eliminating geometric boundaries on the face, that is, geometric normal operation. In this, the face image is normalized by applying eye location production warping and affine exchange. The following steps are required in the algorithm:

– determination of left and right eye center;
– determining the center of the mouth;
– orientational normalization;
– scale normalization;
– determination of the pupil.

Pupil location is determined based on image comparison and luminance histogram. In order to ensure high calculation speed, the image is converted to grayscale, and the comparison starts from the upper left corner (Fig. 1).

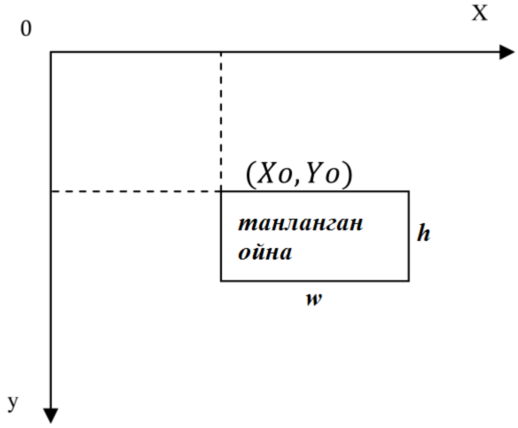

Figure 1. Scheme for finding the coordinates of the pupil

Determining the pupil area can be done by estimating the proximity of the candidate area to the sought area. A rectangular window size is required to be large enough to fully cover the eye area. Usually, the height and width of the window are specified by h and w, respectively. For example, let the selected coordinates for the upper left window be (35, 15, 50, 30), then its height will be h=20 and width w=20. In a selected mirror, pupils and eyebrows can be considered lower in brightness than other areas of the face.

The selected window is scrolled from left to right and from top to bottom. In this case, the initial state is taken as 0 and moved to 15 in 3 steps. All pixels in the window are sorted based on their gray value. The first value is taken as the threshold value and all irreversible threshold values are determined. The most recent value is taken as the maximum limit. The candidate region for the pupil is taken as 15% of the smallest gray value region.

$$T = g(x, y)(0.15 * N) \tag{1}$$

$$f(x) = \begin{Bmatrix} 0\ x \le T \\ 255\ x \ge T \end{Bmatrix} \tag{2}$$

where (x, y) is the pixel coordinate at the $i-$ index of the array sorted by the gray value of the pixels in the selected window, N is the number of all pixels in the window, T is the segment threshold value.

Pupils and eyebrows can be segmented in a face image. A grayscale image can be converted to a binary image by formula (2). For a binary image, horizontal and vertical histograms are constructed using the following formulas.

$$P_v(y) = \sum_{x=1}^{N} I(x, y) \tag{3}$$

$$P_v(x) = \sum_{x=1}^{N} I(x, y) \tag{4}$$

Usually, a horizontal histogram has two minimum limits. The one below corresponds to the eye, and the one above corresponds to the eyebrow. The horizontal histogram is sorted in descending order, where if the distance between the two indices of the horizontal histogram is in the range [54, 60], then the horizontal left index is assigned a value of 2, otherwise 1.

If there are at least 4 white pixels to the left or right of a pixel, then this pixel is considered to be the candidate pixel x coordinate for the left eye, otherwise, the above steps are repeated. In this way, the y coordinate of the candidate pixel for the left eye is also determined, and the median of these points gives the final point for the left eye. Detection of the right eye pupil is performed in the same way as detection of the left eye.

Determining the center of the mouth. The position of the mouth cavity is found by the centers of the left and right eyes, and their coordinates are determined as follows:

– left eye horizontal position + (right eye horizontal position)/2 + 25;

– left eye horizontal position + (right eye horizontal position)/2 + 60;

– left eye vertical position + (right eye vertical position)/2 - 15;

– left eye vertical position + (right eye vertical position)/2 + 10.

The threshold percentage is taken as 40, and the horizontal and vertical position of the mouth center is determined based on the operations used for the center of the right pupil.

Face normalization. Geometrical normalization of the facial image can be performed after the above steps have been performed. If the vertical distance between the vertical coordinates of the left and right eye is from 20 to 30, then the face image is normalized.

A line passing through the centers of the pupils of the left and right eyes is taken and their center deviation is calculated. The angle between the horizontal line and the line through the eyes is determined. If the value of the angle is less than 6, the normalization is carried out by turning the angle (Fig. 2). Otherwise, the given image is considered normalized. In this case, the turning angle is determined by the following formula:

$$\alpha = -\arctan\left(\frac{b_y}{b_x}\right), \tag{5}$$

where b is the vector connecting the pupil centers.

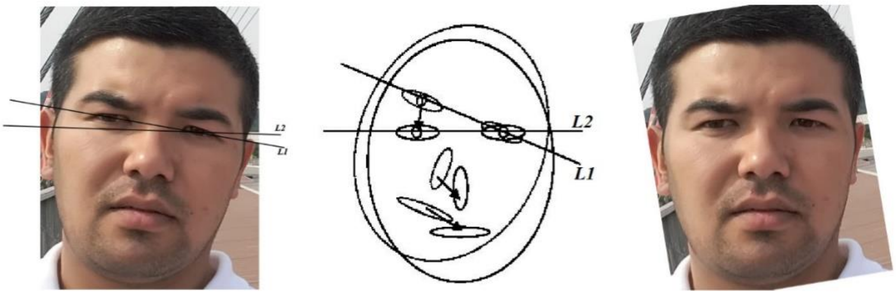

Figure 2. *Geometric normalization of face image*
The torsion matrix is expressed as:

$$T = \begin{pmatrix} \cos\alpha & \sin\alpha \\ -\sin\alpha & \cos\alpha \end{pmatrix}, \quad (6)$$

where α is the turning angle.

The new coordinate of the point with coordinate (x, y) is calculated as follows after the rotation operation:

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = T * \begin{pmatrix} x \\ y \end{pmatrix}. \quad (7)$$

Changing the warping algorithm by shifting as follows minimizes distortions in the image. In this case, the torsion matrix is expressed as a product of three displacement matrices:

$$\begin{pmatrix} \cos\alpha & \sin\alpha \\ -\sin\alpha & \cos\alpha \end{pmatrix} = \begin{pmatrix} 1 & a \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ b & 1 \end{pmatrix} \begin{pmatrix} 1 & c \\ 0 & 1 \end{pmatrix}, \quad (8)$$

where $a = \frac{tg\alpha}{2}$; $b = -\sin\alpha$; $c = \frac{tg\alpha}{2}$

Scale normalization. Before face images can be compared, bringing them to a certain standard appearance is necessary. In this case, the left and right eyes must be on the same horizontal line and the distance between the pupils must have a constant predetermined value.

Recognition methods and algorithms require normalized images based on certain requirements. Therefore, in scaling normalization, the number of pixels between the pupils is brought to a certain value according to the previously developed requirements.

The scaling factor is determined by the following formula:

$$k = \frac{eye_{dist}}{|b|}, \quad (9)$$

where eye_{dist} is the fixed distance between the pupil centers.

A scaling algorithm can be built based on the nearest neighbor principle. The brightness of the field in the new image (x', y') is determined based on the following formula:

$$f(x', y') = g\left(\left[\frac{x'}{k}\right], \left[\frac{y'}{k}\right]\right). \quad (10)$$

Here $[x]$ is the closest integer to x, $g(x, y)$ is the brightness function of the given image, k is the scaling factor, $k > 0$

Based on the algorithms presented above, a software package was developed and tested based on several facial images [19]. The proposed algorithms have shown the expected performance in experimental studies. Therefore, they can be used in facial recognition systems.

Conclusion

Face image normalization algorithms are widely used in various applications. This is due to their improvement in image quality and accuracy of facial image analysis. In this paper, a face image normalization algorithm with high recognition speed and real-time performance is proposed, and it is recommended to apply it after the detection of the face area in the image. Before face images can be compared, making them look like a certain standard is necessary. In this case, it is also necessary that the left and right eyes are on the same horizontal line, and the distance between the pupils must have a fixed pre-fixed value.

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