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HUMAN EYE DETECTION ALGORITHMS BASED ON THE SURF AND GEOMETRICAL REGIONAL LIMIT

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ABSTRACT

According to the problem of human eye detection technology is being paid more and more attention, and the existing human eye detection algorithm can't satisfy the stability of dynamic human eye detection. This paper proposes a human eye detection strategy based on SURF algorithm and geometric area limit, first building Hessian matrix, and then constructing scale space, then fixing position of human eye's feature points and confirming the direction, and carrying out the dynamic matching of feature points and the operation of limited detection region in the human eye detection process. The experimental results show that the proposed scheme can effectively extract the feature points of the human eye, and presents a good stability in the dynamic human eye detection.

Keywords: *SURF Algorithms, Human Eye Detection, Human Eye Identification, Regional Limit*

1. INTRODUCTION

Face recognition is an important part of Biometric Identification Technology [1]. Biometric Identification Technology refers to the identification of humans by human body biologic characteristics or traits. The history for the usage of Biometrics can date back to when ancient Egypt identify though measure the dimension of human body. Modern Biometrics starts from the mid-60s [2,3]. With the development of identification accuracy, Biometric Identification Technology has been widely used in every field of police and civilian. As a branch of Biometric Identification Technology, face recognition becomes an attractive area of international research in the recent years whose broad prospects in application has drawn keen attention [3].

In the area of intelligent man-machine interaction technology and machine vision, face recognition is a very important technology, it refers to extract face position or angle change information in streaming video [4]. As the premise of human face recognition, Face detection's precision and speed directly affects the accuracy and speed of recognition [5]. Eye feature is one of the important characteristics of face [6]. As a pretreatment method, the accuracy of human eye detection can effectively improve the face recognition rate, therefore, as the premise of face recognition, the human eye detection is very important [6, 7].

Along with the emergence of classical human recognition algorithm, Haar algorithm [8], AdaBoost algorithm [9], etc, human face recognition algorithm has made great progress, and put out many other recognition algorithm by the thoughts' improvement of two algorithm, such as Hsu algorithm [10], SNAKE algorithm [11], Hough algorithm [12], activity shape model method [13], etc., but these algorithms still exist some defects such as lack of stability, etc.

According to these defects, this paper put forward a human face detection strategy based on SURF algorithm and geometric area limit, for the purpose of improving the stability of feature detection affected by hardware, action and expression during dynamic human eye detection.

2. FEATURE EXTRACTION BASED ON SURF ALGORITHM

2.1 An Overview on SURF Arithmetic

SURF Arithmetic is the local feature descriptor David Lowe put forward in 1999 and was further developed and improved in 2004 [14]. Sift feature matching arithmetic can deal with the matching problem of 2 images in translation, rotation and affine transformation with strong matching capability [15]. In general, Sift Arithmetic has the following features:

1) Sift feature is invariant to image translation, rotation, scaling, illumination changes, occlusion and noise, and partially invariant to viewpoint and affine change.

2) Outstanding good distinction and rich information allow it to be appropriate to the rapid and accurate match in huge-amount feature databases.

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3) Abundance: even a small number of objects can produce large amount of Sift feature vector.

4) Quite rapid speed. Optimized Sift matching Arithmetic can even match the real-time demand.

5) Strong expandability. It can be convenience to match with other forms of feature vector.

The three process Sift Arithmetic: 1) Extraction key points; 2) Appending detailed information (local feature) to the key points, so-called describer; 3) finding out several local feature points matched each other by pair wise comparison local feature (attached key points of feature vector) and it also establishes a congruent relationship between photographic fields. Extracting key points and Appending detailed information (local feature) to the key points, the so-called describer, can be called generation of Sift characteristic, that is extracting eigenvector unconcerned to measure zoom, revolve, brightness variation [16,17].

Surf arithmetic is the accelerating edition of measure invariant transformation, under the proper condition it can accomplish the real-time matching of objects in two images. Its speediness foundation actually has the only one---- integral image "haar" derivation.

2.2 The Construction of Matrix

When using SURF algorithm to detect human eye, first constructing a Hessian matrix G :

$$G(X,j)=\begin{bmatrix} T_{xx}(X,j) & T_{xy}(X,j) \\ T_{xy}(X,j) & T_{yy}(X,j) \end{bmatrix} \quad (1)$$

$$T(X,j)=F(j)*H(X) \quad (2)$$

In the formula: $T_{xx}(X,j)$ is the presentation of point X on scale j, which $F(j)$ is the second order derivative of Gaussian filtering in $I(X)$, $X=(x,y)$, and $F(j)$'s concrete presentation is:

$$F(j)=\frac{\partial^2}{\partial x^2} f(j) \quad (3)$$

$$f(j)=\frac{1}{2\pi j^2} e^{-(x^2+y^2)/2j^2} \quad (4)$$

$f(j)$ is the Gauss function, j is the Gauss variance, T_{yy} and T_{xy} are the same way.

The determinant value concluded through the formula (1) can be used to discriminate feature points. For the convenience of application, Bay has proposed using box filtering to replace second-order Gaussian filtering, that' to say using W_{xx} to replace W_{xx}, because of the error between approximation and the actual value, so put into weight value ρ, weight value ρ changes along with changes of scale, so it can be further get the discriminant of matrix G :

$$\Delta(G)=W_{xx}W_{xy}-(\rho W_{xy})^2 \quad (5)$$

2.3 The Construction of Scale Space

In the field of visual calculation, scale space is symbolically expressed as an image pyramid, in each step, choose scale image of 4 layers, the construction parameters of 4 orders is shown in Figure.1.

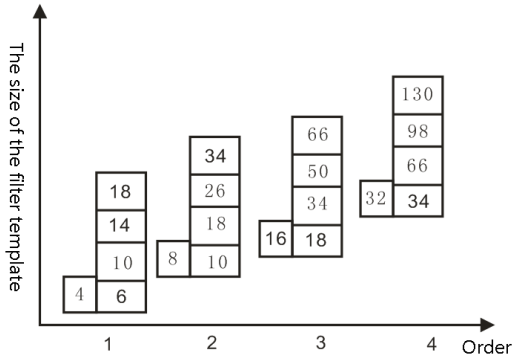

Figure 1: Box Filter Size In Scale Space

Numbers with Grey background represent the size of box filter template, if image size is larger than the template size, then it can continue to increase the order number. Such as filter template size is , the corresponding scale is ; after determined the extremum with Hessian matrix, then carry out the non-maximum fiction in stereo neighborhood of , the extreme value point which is only bigger or smaller than the 26 neighborhood value points of the last scale, the next scale and the scale itself can be chosen as a candidate feature points, then carry out the interpolation operation in the scale space and image space to get stable feature point position and the scale value [18].

This article uses the SURF algorithm to construct pyramid structure which is shown in Figure.2, differ from the traditional image size change, this structure repeatedly use Gaussian function to carry out the smoothing process to sub layer, the original image of this structure keeps constant, what changes is the size of the filter. Thus it greatly increases the stability of the proposed algorithm.

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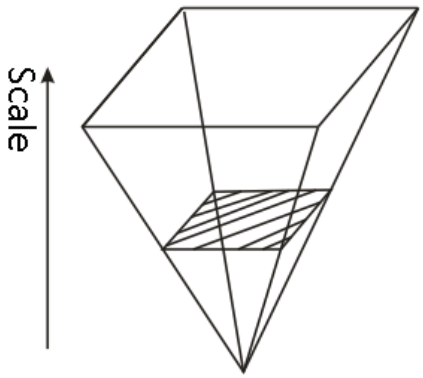

Figure 2: Pyramid Structure Of SURF Algorithm

2.4 The Construction of Scale Space

All the evaluations which are less than the present value are all be discarded, increasing the extremism to make the detected feature points less, and finally, only a few strongest feature points will be detected .

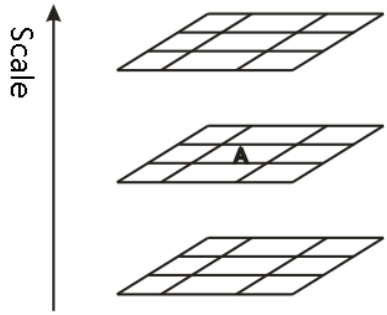

Figure 3: Feature Point Positioning

In the process of testing, the paper uses the filter which is relative to the size of this scale layer resolution to test, with 3×3 filter as an example, one of the 9 pixels of this scale layer image with its other eight points compare with 9 points of two scale layers above and below, totally 26 points, in Figure.3, if the characteristic value of pixel point of mark A is more than surrounding pixels, then we can confirm that this point is the feature points of this region.

2.5 Determine Principal Direction and Characteristic Point Description

To ensure the feature point's rotation invariance, through calculation with the response value(record respectively as dx and dy) on x and y axis of all the points' Haar wavelet in the neighborhood which based on feature point as the center, setting value as radius, and finally determine the feature point's principal direction.

Finally, with a feature point as the center, feature point's principal direction as x axis, select square area of 4×4 , and calculator Haar filter response value of each area, forming the four dimensional vector.

$$v=\left[\sum dx,\sum dy\sum|dx|\sum|dy|\right] \qquad (6)$$

Finally the feature points can be described by a 64 dimensional feature vector.

3. THE HUMAN EYE DETECTION AND GEOMETRIC REGIONAL LIMIT

3.1 Dynamic Human Eye Detection

Considering in image acquisition process, because of many uncertain factors, the feature points of human eye will change along with the time, this paper will study the feature points' matching pursuit of human eye matching of two images. Assume on moment a, the human eye image contains P feature points, use D_a indicate the set, we can get the formula:

$$D_a=\{q_a^i\}_{i=1}^P \qquad (7)$$

By the same token, assuming moment $a+1$, the human eye image contains U feature points, then the feature point set can be expressed as:

$$D_{a+1}=\{q_{a+1}^j\}_{j=1}^U \qquad (8)$$

For any one of the feature points $q_a^i\in D_a$, computing in turns the Euclidean distance of this feature point and each feature point of moment $a+1$'s set D_{a+1}, get the shortest Euclidean distance d_1 and subordinate short Euclidean distance d_2 .

Assume that the preset threshold is φ , then carry out the following decision operation:

$$\begin{cases}\dfrac{d_1}{d_2}<\varphi, Y\\ \dfrac{d_1}{d_2}\geq\varphi, N\end{cases} \qquad (9)$$

That is to say if d_1/d_2 is less than φ, then we can determine the feature point of D_{a+1} who produces the shortest Euclidean distance match the q_a^i.

3.2 Human Eye Detection Area Limit

In order to increase the speed of algorithm, the paper add geometrical area limit in the process of human eye feature points' matching. For

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point (x_i, y_i) of image S_1, find the corresponding point (x_j, y_j) on image S_2, then draw a rectangle area base on the corresponding point as centre for geometrical limited area of human eye detection, it is not allowed to beyond the geometrical area when using the algorithm to carry out eye detection, the expression is shown as below:

$$O(x,y)\,|\,(x_j-\theta, y_j-\theta) \le (x,y) \le (x_j+\theta, y_j+\theta) \quad (10)$$

4. ALGORITHM SIMULATION

Using digital camera to take 20 face images, taking 2 of them for experimental objects. First of all, extracting respectively the feature points of two images, and the results is shown in table 1. Then carrying out the human eye detection and matching of the two images, the result as shown in figure 4 ~ figure 5.

Table 1: Testing Result Of Human Eye's Feature Points

image	Image 1	image 2
number of feature points	50	48

From table 1, we can see the error of human eye's feature points of two images is about 4%, which are very similar, so it proves that the SURF algorithm can extract the feature points.

Figure 4: Right Eye's Detection Result Of Image 1

From Figure.4 to Figure.5, we can see that although the angle and position of two image are different, the human eye detection effect is good, and which proves that the proposed algorithm is of high robustness and high stability.

Figure 5: Right Eye's Detection Result Of Image 2

5. CONCLUSIONS

This paper proposes a human eye detection scheme based on SURF algorithm and geometric area limit, which applies SURF algorithm into the detection of human face. "After the algorithm simulation experiment, the results show that the SURF algorithm can extract the human eye's feature point, the error is very small, and shows a high robustness and strong stability in dynamic human testing.

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