Face Recognition Based on Haar Like and Euclidean Distance

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Abstract. In order to improve the recognition rate of multi-face image, this paper proposes a face image recognition method based on haar-like and Euclidean distance. First of all, the initial features of Haar are moved in the image and gradually enlarged, the pixel sum of the feature area is obtained quickly by using the integral graph. The Haar feature is obtained by calculating the difference between black and white pixels in the feature region, and the threshold of weak classifier is calculated. Then, the extracted facial feature data is trained and classified to form a cascade classifier for face detection. Finally, the face of the image to be detected is compared with the training samples by using Euclidean distance. The experimental results show that the time of one attendance is 5-10 seconds and the success rate of face recognition is 91.1%, which verifies the advantage of the algorithm in improving the efficiency of attendance.

Keywords: Intelligentize; Haar; Euclidean distance; Face recognition.

1. Introduction

With the development of artificial intelligence technology, image processing technology has also continuously improved and has been more widely used. Among them, as a hotspot direction in image processing-face image recognition has played an active role in areas such as transportation and payment and so on. The Haar classifier is an algorithm widely used in the field of face recognition. It is the core of face detection framework first proposed by Viola Jones. The algorithm uses the integral image to extract the feature value of the image and filter the feature by the classifier, which reduces the computational complexity of the detection, and then trains and adjusts to become a cascade classifier, reducing the rate of missed detection and false detection [1]. The distance between images reflects the similarity of the images, so the efficient calculation of the distance between images will further improve the face recognition rate. Euclidean distance is a distance measurement method that is simple and efficient for calculating face similarity. Chen Huiming proposed a method of linear transformation of image based on data field, combined with image Euclidean distance to measure face features. The introduced potential function formed the data field space of the entire gray image into a data field, the Euclidean distance calculated after the linear transformation of the image reduces the image's sensitivity to translation and deformation [2]. Considering the influence of the illumination angle change on the face recognition rate, Yang Guoliang et al proposed an improved face recognition method based on eigenface and Euclidean distance, calculate the covariance matrix obtained by calculating the difference vector between each face feature and the average face feature to build a feature face space, which improves the positive face recognition rate under strong light [3]. Aiming at the problem that a single classifier cannot effectively segment all face regions, Naeem Iqbal Ratyal et al proposed a three-dimensional face recognition method based on a two-layer integrated classifier. This method uses the weighted count combination and reordering stage to classify the face area, and
combines with Markov cosine to match the face, which verifies the effectiveness of the combination of feature extraction and distance measurement for improving performance [4].

The above algorithm is improved based on face feature description or distance measurement. Although the face recognition rate is improved to a certain extent, it is not ideal for multi-face image recognition rate. Considering the actual application, the image is taken by a mobile phone and the illumination angle is not the same. This paper proposes a face image recognition algorithm based on Haar-like and Euclidean distance based on the above two aspects. The face feature data is extracted through the Haar model. Train the sample data to obtain a cascade classifier, and then compare the image to be detected with the facial feature data in the training set one by one. Finally, the effectiveness of the algorithm was verified on the collected face data set of our students, and the face recognition rate was quite improved.

2. Haar Model for Face Image Detection

2.1. Haar Characteristic Integration Graph Acceleration Algorithm

When processing face image, Haar characteristic is used to describe the face feature in the gray-processed image. The basic structure of the Haar characteristic is used as a sub-window and is moved on the image by a unit length. The process of feature extraction is the process of window movement until the entire image is traversed. After traversing the image for the first time, the window magnification is calculated and the feature extraction process is repeated until the window is no longer enlarged. One dimension of the Haar characteristic is the value of the black area pixel sum of the window minus the white area pixel sum [5].

There are often a lot of Haar characteristics in the images to be detected, and the 68 feature points required for face detection cannot be quickly extracted only by changing the size and position of the rectangular features. Take the following integral diagram as an example to build a Haar characteristic acceleration algorithm:

![Figure 1. Haar characteristic integral graph.](image)

First, gray the image to be detected and construct an integral graph with the same size as this digital image. The upper left corner of the integral graph is the initial position 0. The characteristic value of any point in the graph is the sum of the pixels from the initial position to the area enclosed by the point. For a two-dimensional face detection image, the integral graph is constructed after traversing the image to be detected. Then, the pixels of any rectangular feature area in the image can be obtained, and subtracting the pixels sum of the two rectangular regions to obtain the Haar feature value.

As shown in figure, suppose \( p(x, y) \) represents the sum of pixels in the horizontal direction of the image, \( w(x, y) \) represents integral graph. Initialize to get \( p(x, -1) = 0, \ w(-1, y) = 0 \). The eigenvalues for the D region are calculated as follows:

\[
\text{sum}(D) = w(x_4, y_4) - w(x_2, y_2) - w(x_3, y_3) + w(x_1, y_1)
\] (1)
Assume that when the rectangular feature is located as shown below:

![Figure 2. Rectangular window.](image)

Then its Haar eigenvalue is:

\[ \lambda = p_{AC} - p_B \] (2)

\[ p_{AC} = w(0,1) + w(0,4) - w(0,3) \] (3)

\[ p_B = w(0,3) - w(0,1) \] (4)

\[ \lambda = w(0,4) + 2 \times w(0,1) - 2 \times w(0,3) \] (5)

Finally, the Haar feature calculation is accelerated by integral graph, which is convenient and fast to match the feature points needed for face detection.

2.2. Cascade Classifier

Strong and weak classifiers use the idea of a decision tree to judge facial features layer by layer based on the calculated eigenvalue. After training, combine several weak classifiers into one strong classifier, and finally form a cascade classifier with higher recognition rate [6]. Use Haar features f1, f2, and f3 to determine whether the input data is a human face. The decision tree is as follows:

![Figure 3. Feature decision tree.](image)

As can be seen from the figure, a Haar feature judgment constitutes the weakest classifier. The output of each feature judgment needs to be compared with a threshold value. When the input data is greater than the threshold value, it can be output as a face feature. Train the optimal weak classifier to get the classification threshold, thereby minimizing the error.
Sort the feature values of the training samples. Assuming that the sum of all sample weights is \( s_1 \), the sum of all non-sample weights is \( s_2 \), the sum of sample weights before the current feature is \( t_1 \), and the sum of non-sample weights before the current feature is \( t_0 \), then each feature classifier error \( u \) is:

\[
u = \min((t_1 + (s_0 - t_0)), (t_0 + (s_1 - t_1)))
\]

(6)

The optimal classification threshold is the minimum value of \( u \).

3. Face Similarity Calculation Based on Euclidean Distance

3.1. Euclidean Distance

The Euclidean distance can be used to calculate the distance between any two points in two-dimensional space, and also to measure the absolute distance between points in \( N \)-dimensional space. For face recognition, smaller values indicate more similar faces. The feature points representing facial features were calculated according to the Haar feature values, the image to be detected is processed by a function to obtain a 128-dimensional face feature vector, this constitutes the condition for face similarity calculation under Euclidean distance [7].

Suppose the face feature of the image to be detected \( A = (x_1, x_2, \ldots, x_{128}) \), training sample face features \( B = (y_1, y_2, \ldots, y_{128}) \), the Euclidean distance calculation formula is as follows:

\[
AB = \sqrt{(x_1 - y_1)^2 + (x_2 - y_2)^2 + \cdots + (x_{128} - y_{128})^2}
\]

(7)

The value of \( AB \) is the Euclidean distance between two points in 128 dimensions.

3.2. Face Recognition

After the above process, the human face in the image to be detected is successfully intercepted. Then, using the face_encodings function, 128 feature vectors representing facial features can be extracted, the Euclidean distance is calculated by comparing the face features of the image to be detected with the trained face feature library. When the Euclidean distance value of the two sets of feature vectors is less than the threshold value (set as 0.43 in this paper), it indicates the success of face recognition, and the failure of face recognition on the contrary.

4. Algorithm Test

4.1. The Experiment Platform

The technology platform USES windows10 operating system; Use Pycharm as compilation software; Deploy the python environment using Anaconda; MySql database stores user data; OpenCV library, Dlib library, Face_recognition library and so on are used to complete the main image processing work of the system. Among them, a machine learning model Haar is used for face detection, and Euclidean distance algorithm is used to complete face recognition. The algorithm is simple to implement and has shorter execution time. Through experiments, we comprehensively consider the influence of 128 dimensional feature vector of face and image acquisition light of attendance photos, the comparison threshold of Euclidean distance can be adjusted within the range of 0.4 to 0.5. The face recognition rate of the six testers finally selected was the highest when the threshold was 0.43.

4.2. Analysis of Experimental Results

We collected images of 6 students in our classroom, and each student had 30 different attendance photos. Ten images were taken in the morning, afternoon and evening to distinguish between different lighting conditions, and the subjects' face orientation, position and expression details were different. These images basically cover different situations of classroom attendance in real scenarios [8]. Part of the original training images are as follows:
We preprocessed the acquired image. After face coding, they are divided into training samples and test images. In the experiment, 5 attendance photos at three time points were selected as the training set, and another 5 attendance photos were selected as the test set. The recognition time of two face images based on this algorithm is 5-10 seconds. The name is displayed on success, and unknown is displayed on failure. A complete attendance effect diagram is as follows:

![Attendance effect map](image)

Figure 4. Partial face training map.

Figure 5. Attendance effect map.

Under the same conditions, Euclidean distance, Mahalanobis distance, Haar feature and image Euclidean distance algorithm are compared, the comparative success rate of face recognition is shown in the following table:

| TIME          | TRAINING SAMPLES | EUCLIDEAN DISTANCE FACE RECOGNITION RATE | FACE RECOGNITION RATE IN MAHALANOBIS DISTANCE | FACE RECOGNITION RATE OF THIS METHOD |
|---------------|------------------|-----------------------------------------|-----------------------------------------------|-------------------------------------|
| MORNING       | 60 face images   | 85%                                     | 88.3%                                         | 93.3%                               |
| AFTERNOON     | 60 face images   | 83.3%                                   | 85%                                           | 91.6%                               |
| NIGHT         | 60 face images   | 78.3%                                   | 75%                                           | 88.3%                               |
| THROUGHOUT    | 180 face images  | 82.2%                                   | 82.7%                                         | 91.1%                               |

Table 1. Comparison of face image recognition rate of different algorithms.

From the table, for the collected image data set, the recognition success rate of face image based on Haar feature and image Euclidean distance is higher, this shows the effectiveness of this algorithm in the classroom attendance in colleges and universities. The face recognition success rate is calculated by dividing all face images that normally display names by the total number of faces in the image.
5. Conclusion
This paper combines haar-like features and Euclidean distance algorithm for face image recognition, fully considering the influence of face feature selection and different lighting conditions on attendance image, the recognition rate of multi face image is improved. In this paper, the gray image of face is processed by Haar model, the feature value of face is screened, the cascade classifier is obtained after training, and then the face similarity is calculated by combining Euclidean distance algorithm to complete face recognition. Experimental results show that under the same data set, compared with the single improved Mahalanobis distance and Euclidean distance algorithm, Haar feature and Euclidean distance are better for face image recognition.

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