Research on Face Recognition System Based on Hadoop Cloud Computing Environment

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Abstract: In order to improve the accuracy and anti-interference of face recognition, a face recognition system based on Hadoop cloud computing environment is proposed. Facial corner feature detection technique is used to sample facial image feature of moving face, and face image position and pose adjustment and grayscale feature matching are applied to the collected face image. Wavelet feature decomposition method is used to reduce the interference of noise to dynamic face feature extraction, and adaptive feature separation method is used to detect the edge contour of face and segment the face image in gray face image. The feature quantity which reflects the difference information of mobile face is extracted, and the corner location is used to locate and recognize the facial features. All the key points of facial features are extracted from the active contour area, and the face recognition algorithm is improved. Facial feature extraction method is used to extract spectral density feature of Hadoop cloud computing environment. Based on face image information recognition technology, face image information collection design of face recognition image, face image information integration processing and cross-compilation control under VIX bus protocol are realized, the face recognition system software development and design are obtained. The software test results show that the face recognition system has better real-time performance, the face detection accuracy is improved, it has better reliability and better running intelligence performance.

1. Introduction

Face recognition is a biometric technology for the identification of human facial features. It has a wide application prospect, such as video surveillance, public security, justice and criminal investigation and other security areas. The key of face recognition is how to extract the appropriate information to recognize the face[1]. In the past few decades, researchers have proposed many algorithms for feature extraction. With the development of intelligent image processing technology, the accuracy and anti-interference requirements of face recognition are constantly improved. In the moving state of human body, the face is affected by the jitter of the acquisition equipment and the factors of fuzzy noise. As a result, the accuracy of face recognition is not high and the ability of anti-interference is not strong, which affects the accuracy of face recognition in mobile state. In order to improve the ability of dynamic face recognition, we need to study an effective face recognition system, combined with Hadoop cloud computing technology. Improve the design of face recognition system[2].

Traditionally, face recognition methods mainly include geometric feature based method, linear discriminant analysis method, feature face method and neural network method. However, these methods are difficult to deal with high dimensional images and are easily affected by objective factors such as light[3]. In recent years, the local method is becoming more and more popular, because the local method can not only solve the problem of too high data dimension, but also have invariance to illumination and expression[4]. Local binary pattern (LBP) is an effective texture description operator. LBP algorithm is originally used in texture description. It is used in face recognition because of its simple calculation and strong feature classification ability. The algorithm first calculates the binary relationship between each point in the image and its neighboring points on the gray scale; forms a local binary pattern for the binary relationship according to some rules; and finally uses the resulting feature vectors to describe the image features. However, the local binary mode will produce a lot of noise information when calculating LBP operator, and the computation

quantity will become larger because of the dimension of eigenvector is too large, which will affect the recognition efficiency[5-7]. In reference [8], a design method of face recognition system based on GUI communication interface multi-line addressing technology is proposed. The collected original face recognition image feature data and environment data are input into A/D module of detector for digital-to-analog conversion control. The hardware modularization design of face recognition image intelligent detection system is carried out. The cross compiling design scheme is used to design the feature sensing module of face recognition image in the system to improve the intelligence of face recognition image detection. But the batch processing ability of this method for face recognition image detection is not good and the real-time ability is not strong[9].

Aiming to solve the above problems, a face recognition system is proposed based on Hadoop cloud computing environment. Facial corner feature detection technique is used to sample facial image feature of moving face, and face image position and pose adjustment and grayscale feature matching are applied to the collected face image. Wavelet feature decomposition method is used to reduce the interference of noise to dynamic face feature extraction, and adaptive feature separation method is used to detect the edge contour of face and segment the face image in gray face image. Facial feature extraction method is used to extract spectral density feature of Hadoop cloud computing environment. Face image information collection design of face recognition image, face image information integration processing and cross-compilation control under VIX bus protocol are realized, the face recognition system software development and design are obtained. Finally, the performance test is carried out through the simulation experiment, which shows the superior performance of this method in improving the ability of face recognition.

2. Feature Sampling and Preprocessing of Face Image

2.1. Face image feature sampling

Combined with dynamic face feature extraction method, face recognition algorithm is improved. Firstly, face image feature sampling is carried out by using facial corner feature detection technology[10], and face facial feature sampling is carried out under different pose features. The schematic diagram is shown in figure 1.

Fig.1. Face localization sampling under different pose features

In the sampling model shown in figure 1, the feature subspace reconstruction method is used to extract the face feature coefficients to determine the facial information features, and the training face database of facial features under different pose is established[11]. After orientation mapping, the facial features of face images under various poses are tested, and the corner points of moving faces are located and sampled in the set of given image vectors. The face images are obtained as follows:

$$H = \sum_{r=1}^{t} \sum_{q=1}^{k_2} (x_{ir} - x_{irq})(x_{ir} - x_{irq})^T B_{irq} \tag{1}$$

The scale information of moving face image in the upper local block binary mode is determined. After determining the neighborhood gray value H_1 and H_2 of the face noise, the single amplitude W_i of moving face is obtained by geometric structure distributed projection:

$$W_i = (H_1 - H_2)\omega = \lambda\omega \tag{2}$$

Let $\{w_1, w_2, ..., w_{d_i}\}$ be the face noise of moving face image, the feature distribution coefficient is $\{\lambda_1 \geq \lambda_2 \geq ... \geq \lambda_{d_i}\}$, the upper expression is the sequence of face noise distribution obtained by sorting according to the intensity of the noise point, which represents the d_i sequence of

eigenvalues arranged by the feature points of the face. The feature vector corresponding to $\{\lambda_j \mid j=1,2,...,d_i\}$ represents the feature quantity of moving face pose. According to the inequality $\{\lambda_1 \geq \lambda_2 \geq ... \geq \lambda_{d_i} > 0 \geq \lambda_{d_i+1} \geq \lambda_{d_i+2} \geq ... \geq \lambda_d\}$ to determine the two-dimensional histogram of face pose distribution, the pattern of N projection matrix output weight vector $W1,W2,...,W_N$ is used to realize the feature sampling of face image, which provides the input basis of original image data for dynamic face feature extraction[12].

2.2. Position and pose adjustment and grayscale feature matching

Based on the pose adjustment and gray level feature matching of the collected face image, the affine invariant matrix of the face pixel set $W=\{w_1,w_2,...,w_{d_i}\}$ is determined in the face feature distribution subspace (SFS), and the face pose transformation is carried out in the Riesz kernel. The local binary pattern for obtaining facial posture of a human face is obtained as follows:

$$(h_x,h_y)=\left(\frac{x}{2\pi \| z \|^3},\frac{y}{2\pi \| z \|^3}\right) \tag{3}$$

Where, $z=(x,y)$. In the center pixel of the face noise, the image is divided into two parts, and the Riesz transform of the face is expressed as:

$$f_R(z)=\begin{pmatrix} f_x(z) \\ f_y(z) \end{pmatrix}=\begin{pmatrix} h_x * f(z) \\ h_y * f(z) \end{pmatrix} \tag{4}$$

Where, $f(z)$ is the convolution operation of the center distance, $*$ is the input primitive human face image. By Riesz transform, the positive and negative images are obtained as $H_x=-j\omega_x/\|\omega\|$ and $H_y=-j\omega_y/\|\omega\|$, where $\omega=(\omega_x,\omega_y)$ is obtained. For the inputted moving face corner location image $f(z)$, its single feature sequence is defined as:

$$f_M(z)=(f(z),\ f_x(z),\ f_y(z)) \tag{5}$$

Where, $f(z)$ is real value part, $f_x(z)$ and $f_y(z)$ are Riesz transform of the x and y axis under different pose respectively. Then band-pass filter and gray level feature matching are used to get the center pixel of facial gray feature matching in moving face image as follows:

$$G(w)=\exp\left\{-[\log(\omega/\omega_0)]^2/2[\log(\sigma/\omega_0)]^2\right\} \tag{6}$$

On the basis of single amplitude, the binary mode of corner location in moving face image can be expressed as follows:

$$\begin{aligned} f_{\lg-M}(z)&=(f_{\lg}(z),\ f_{\lg-x}(z),\ f_{\lg-y}(z)) \\ &=(f_{\lg}(z),h_x * f_{\lg}(z),h_y * f_{\lg}(z)) \end{aligned} \tag{7}$$

Where, $f_{\lg}(z)=f(z)*F^{-1}(G(\omega))$, the local structure of the image is expressed as:

$$\begin{aligned} &A=\sqrt{f_{\lg}^2+f_{\lg-x}^2+f_{\lg-y}^2} \\ &\phi=-sign(f_{\lg-x})\arctan 2\left(\sqrt{f_{\lg-x}^2+f_{\lg-y}^2}/f_{\lg}\right) \\ &\theta=\text{atan}(f_{\lg-y}/f_{\lg-x}) \end{aligned} \tag{8}$$

According to the upper formula, the grayscale feature matching of moving face image is carried out, facial expression and facial noise feature are extracted, and face recognition is carried out according to the extracted feature quantity to improve the recognition accuracy[13].

3. Face Recognition Algorithm Optimization

On the basis of facial corner feature detection technology, face image feature sampling, pose adjustment and gray feature matching, face recognition algorithm is improved. Let I_c represent the gray value of the current corner location pixel, $Pimg$ and $Nimg$ denote the negative value image

in the mouth region of the image represented by the positive image ads in the grayscale face image[14], and extract the feature of the vector point which reflects the facial feature of the face. The process of obtaining negative face image is satisfied:

$$\begin{aligned} Pimg &= WLD(f(I)) \geq 0 \\ Nimg &= WLD(f(I)) \leq 0 \end{aligned} \tag{9}$$

Where, $WLD(\cdot)$ is the upper and lower characteristic points in the middle of the mouth, and the operator $f(\cdot)$ represents the weighted average. After locating the eye feature region, the corner location mapping $f:\theta|\to\theta'$ is obtained:

$$\begin{aligned} &\theta' = \arctan 2(v_s^{11}, v_s^{10}) + \pi \\ &\arctan 2(v_s^{11}, v_s^{10}) = \begin{cases} \theta, & v_s^{11} \geq 0 \,\&\, v_s^{10} > 0 \\ \theta + \pi, & v_s^{11} \geq 0 \,\&\, v_s^{10} < 0 \\ \theta - \pi, & v_s^{11} \leq 0 \,\&\, v_s^{10} < 0 \\ \theta, & v_s^{11} \leq 0 \,\&\, v_s^{10} > 0 \end{cases} \end{aligned} \tag{10}$$

The range of angles from left to right and from right to left to search for face noise distribution is expressed as follows: $\theta' \in [0 \quad 2\pi]$, for an image of $n \times m$ size, $I_x^{i,v}$ is divided into M_b blocks, and covariance matrices can be constructed as follows:

$$C = O^T O \begin{bmatrix} \sum H_x(t)H_x(t) & \sum H_x(t)H_y(t) \\ \sum H_y(t)H_x(t) & \sum H_y(t)H_y(t) \end{bmatrix} \tag{11}$$

The singular value decomposition of the corresponding local block is carried out, and the matrix O is decomposed, the sequence number of the sub-block is obtained by $m = 1, \cdots, M_b$, $n = 1, \cdots N_b$, and the main direction of the local region is obtained:

$$O = USV^{\mathrm{T}} \tag{12}$$

The corner location output is serially connected into a high-dimensional histogram $H_m^{i,v}$ is a matrix of $N \times 2$, so the face recognition algorithm is improved.

4. Design and Implementation of System Software

4.1. System bus design

The bus design of face recognition system is implemented by cross-compiling method. The program of face recognition is compiled and controlled under the embedded Linux operating system, and the program loading and bus output control module are constructed to load the data. The data of the original face recognition image is loaded into the system, and the Linux version 2.6.29 is selected as the platform of the application program[15]. The program control instruction set of face recognition image detection is obtained in Table 1.

Table 1. Program Control instruction set for face recognition image intelligent recognition system

Type	Structure	Bytes / bits	Hexadecimal value
PCI Bus configuration	CAN	12	10101001
	Addressing	8	10101001
	A/D	10	10101111
PCI Bus monitoring	Cross compile	6	11110011
	Initialize	16	010100111

According to the control instruction set in Table 1, the bus control of face image information recognition and face recognition is carried out. First, the clock frequency initialization and memory

initialization are performed to determine whether the A D sampling satisfies the interrupt condition. Energy spectrum measurement program is designed to analyze the spectral characteristics of face recognition image. When can receives the data of energy spectrum feature detection of face recognition image, bus output control is carried out through clock initialization and memory initialization program. An early warning module for face recognition image detection is designed based on the human-computer interface, and the software for face recognition image detection is designed according to the code development process.

4.2. Development and design of integrated software for face recognition

In the development of software platform, the function components of collecting face image information and detecting face image feature based on TinyOS are designed, and 6LoWPAN adaptor layer command is executed to control the laser sensing information sampling of face recognition image. The Busybox installation script is used to develop the engineering management application program of the face recognition system. Before the development of the program, the interrupt bit control is designed, and the feature extraction and analysis of the face image is realized by using the low power 802.15.4 data link layer. The output interface of face image feature extraction system based on API embedded bus control model is developed. Under the visual interface, the application program is developed, the human-computer interaction module is constructed, the embedded ARM and Linux kernel are used for face image information processing, and the upper layer component is used as the unit for communication and interactive design. RunNextTask (true) is used to execute the interface communication command of intelligent face recognition system, the relatively abstract operation is completed, the man-machine interaction interface is constructed with event-driven mechanism, the integrated development and design of the face recognition system are and realized. The development process is shown in figure 2.

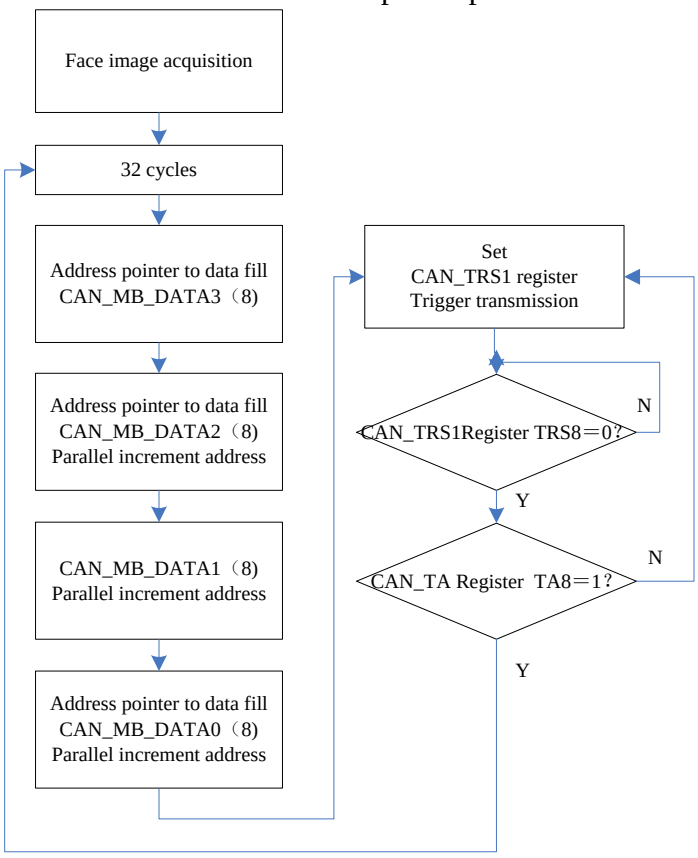
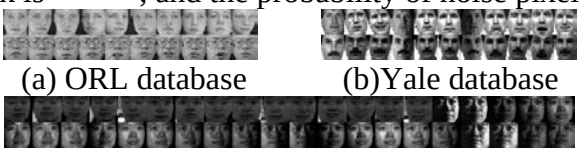


Fig.2. Code development flow

5. Simulation Experiment and Result Analysis

In order to test the performance of the face recognition algorithm designed in this paper, a

simulation experiment is carried out. The software used in the experiment is MATLAB 2010b, OpenGL and VC++, PC are dual-core Pentium (R) 4 CPU 5.06 GN 16.98 G, memory 4.0 GW Core i5. Face recognition algorithm simulation is realized on Hadoop cloud computing platform. The face test sample set comes from 15 groups of face images in Yale face database. Each group of images uses Laser 2016 corner locator to collect face image features. The collected face noise feature combination includes 11 training sample sets, in addition, the face images in ORL face database and pie face database are used as the standard training set. As shown in figure 3, it is used to verify the accuracy of face recognition. The registration set of different face poses contains 1040 people. The experimental parameters are set to: corner location wavelength, the iterative compensation and standard error are $\lambda_{\min} = 4, u = 0.64, \sigma = 2.0$, the number of sample face images is 1024, the range of skin color brightness of facial features is [77,156], [121,123], and the rotation angle of face pose transformation is controlled within the range of positive and negative 45 °. The adaptive weighted sub-block is 12×12, and the probability of noise pixels is set to 0.12.



(a) ORL database (b)Yale database

(c) PIE database

Fig.3. Face images in standard training set

According to the above simulation environment and parameter setting, the simulation design of face recognition algorithm is carried out. Experiment 1 is based on 25 groups of images in ORL face database. The tilt angle of face is 25 degrees, 50 degrees and 75 degrees, respectively. In this paper, the corner location correction method is used to recognize three groups of faces in different moving states, such as inclined face, left and right rotating face and upper and lower rotating face. The results before and after the correction are shown in figure 4.

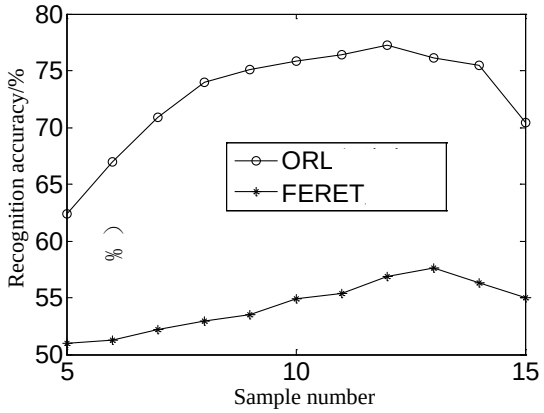


Fig.4. Comparison of recognition rates of face recognition in three different moving states

The result of analysis figure 3 shows that the method of this paper is used to extract the dynamic face features, and the effect of improving the recognition rate is not obvious when the corner location correction is used in the oblique moving face recognition. But the recognition rates of left and right rotating face and upper and lower rotating face are 4.7% and 3.8% respectively. This method is used to detect the edge contour of face and segment the face image, extract the feature quantity which reflects the difference information of moving face, and extract all the key points of facial feature in the active contour region. The accuracy of face recognition is further improved, and the comparison results of the optimized face recognition rate are shown in figure 5.

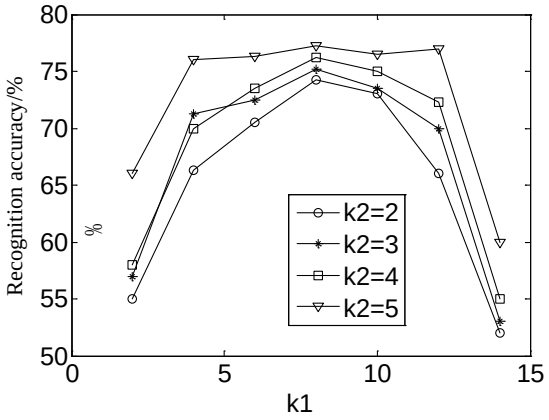


Fig.5. Comparison of recognition rates between improved and traditional face recognition methods

The result of analyzing figure 4 shows that the method of this paper is used to extract the dynamic face features, and the accurate recognition rate is high. The method can converge to 100 points quickly with 40 iterations, and the recognition rate of comparison method is 97.4% and 94.3%, respectively. It shows that the performance of this method has obvious superiority.

6. Conclusions

In this paper, a face recognition system based on Hadoop cloud computing environment is proposed. Facial corner feature detection technique is used to sample facial image feature of moving face, and face image position and pose adjustment and grayscale feature matching are applied to the collected face image. Wavelet feature decomposition method is used to reduce the interference of noise to dynamic face feature extraction, and adaptive feature separation method is used to detect the edge contour of face and segment the face image in gray face image. The feature quantity which reflects the difference information of mobile face is extracted, and the corner location is used to locate and recognize the facial features. All the key points of facial features are extracted from the active contour area, and the face recognition algorithm is improved. Facial feature extraction method is used to extract spectral density feature of Hadoop cloud computing environment. Based on face image information recognition technology, face image information collection design of face recognition image, face image information integration processing and cross-compilation control under VIX bus protocol are realized, the face recognition system software development and design are obtained. The software test results show that the face recognition system has better real-time performance, the face detection accuracy is improved, the method has good application value in the optimization design of face intelligent recognition system.

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