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Gender recognition based on face image

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***Abstract*—The research on the biometrics recognition of facial image has made great progress. Compared with other biometrics, facial features are stable, simple, intuitive, friendly, non-intrusive, and easily accepted by people. Therefore, facial gender recognition technologies have been successfully applied to many commercial fields. However, the current gender recognition methods still have shortcomings such as low recognition rate and easily affected by surroundings. For this reason, a gender recognition method based on BP neural network is proposed. Firstly, this paper preprocesses the face images, extracts feature of face images, designs a BP neural network and uses the feature parameters to train BP neural network. Afterwards, a classifier based on the face image is obtained. Finally, the classifier is tested using pictures from the database, if demands are not met, BP neural network parameters would be redesigned and the training would be conducted on the BP neural network.**

Keywords-component; formatting; style; styling; insert (key words)

I. INTRODUCTION

The increasing development and progress of computer application technology has made the development of automatic identification of people's identity in daily life and industry demanding. The form of authentication has entered people's daily life and plays an increasingly important role, like magnetic cards, IC cards, ID numbers. These mature authentication methods often use encryption security and privacy protection, but all these technologies always come with security challenges. Face gender recognition is uniquely stable, intuitive, concise, friendly, and easier to be widely accepted by people. As one of the important biological characteristics human face containing lots of information, such as age, gender, identity, race and so forth. With the development of face detection technology, more and more researches focus on face gender, and massive face recognition systems have been put into use. Gender identity is used as a function of "pre-filter", the detected information can be applied to recognize faces rapidly, improving the recognition speed and precision of security system.

In actual problems, the image may be interfered by factors such as noise, geometrical change and gray-level differences, such as changes in illumination, viewing angle, translation, scale, and rotation. To get accurate matching results, a stable and robust character must be used, which becomes a key problem in image processing. Navneet Dalal and Bill Triggs[1] proposed the HOG (Histogram of Oriented Gradient) algorithm in CVPR. They mainly applied this method to pedestrian detection in static images, afterwards applied in the detection of pedestrians in movies and videos, as well as the detection of vehicles and common animals in static images. Zhu Wenqiu and others used the heuristic search algorithm in the AdaBoost algorithm to generate a good classification feature with an accuracy rate of over 93%, which is equivalent to SVM, but with higher speed. Huang Hong et al. improved the accuracy of classification by reducing the dimensionality of features, reaching more than 90%.

Traditional facial gender recognition technologies are based on the secondary sex characteristics of human faces, such as beard, the thickness of eyebrows and other unique gender characteristics. Although this method of matching and identifying gender based on unique gender characteristics is simple to implement and effective, but when external conditions change, the gender characteristics on the face are not obvious causing incomplete gender characteristics in face image. Therefore, avoiding the influence on gender recognition algorithm to achieve effective gender recognition of human faces has become a difficult problem.

Aiming at the difficulty of traditional gender recognition methods when face gender characteristics are not obvious, this paper proposes a new gender determination algorithm based on gender models. In the pre-processing stage, positioning and aligning the picture, removing massive interference. The dimensionality of the input is greatly reduced before feature extraction. Then normalize the image to obtain a normalized face image. Use Gabor wavelet transform and image gray-scale to extract feature. Through Gabor wavelet feature extraction, face recognition is performed within limited features and use BP neural network for training and classification.

II. IMAGE PREPROCESSING

The image produces images of different quality due to factors such as illumination and background. It is necessary to remove the complex background from the input image. In

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addition, the detected faces are of different sizes, so further image scale normalization processing is required. Due to the influence of light, the brightness of the image is not the same, so it is necessary to normalize the gray level of the image.

A. *Variable scaling of Image*

The face samples used in the experiment come from different face databases, including the collected face images and online images with different sizes. In order to extract feature smoothly, it is necessary to normalize the size of the obtained face image. In addition to the size modification, geometric normalization also includes operations such as translation and rotation. The geometric normalization can effectively eliminate the possible geometric structure deformation of the face image, so as to achieve the standardization of the image sets, which is conducive to the subsequent facial feature extraction and gender classification.

B. *Reduction and Enlargement of Image Size*

$$f'(x,y) = f(\frac{x \cdot l}{l'}, \frac{y \cdot h}{h'}) \quad (1)$$

In the formula, f' is the gray value function of the transformed image, f is the gray value function of the original image before transformation, l is the width of the image before transformation, l' is the width of the transformed image, and h is the height of the image before transformation, h' is the height of the transformed image.

The bilinear interpolation algorithm can solve the problem of mosaic caused by image enlargement. Since the image is larger than the original image, some new pixels will definitely appear in the enlarged image compared with the original image. These pixels that were not in the original image need to be completed by interpolation. The algorithm firstly enlarges the gray value of the vertex corresponding to the rectangle of the image from the gray value of the vertex of the rectangle in the original image. The next step is to use the bilinear interpolation algorithm to calculate the gray value of all points in the original image to achieve size normalization. Assuming that (x_0, y_0) and (x_1, y_1) are two diagonal fixed points of a rectangle, (x, y) is a point in this rectangle, the algorithm for finding the gray value of this point is as follows:

$$f(x,y_0) = f(x_0,y_0) + \frac{(x-x_0)}{(x_1-x_0)}\left[(f(x_1,y_0) - f(x_0,y_0)\right] \quad (2)$$

$$f(x,y_1) = f(x_0,y_1) + \frac{(x-x_0)}{(x_1-x_0)}\left[(f(x_1,y_1) - f(x_0,y_1)\right] \quad (3)$$

$$f(x,y) = f(x,y_0) + \frac{(y-y_0)}{(y_1-y_0)}\left[(f(x,y_1) - f(x,y_0)\right] \quad (4)$$

After scale normalization, all facial expression images are converted into 92×112.

C. *Gray Normalization of the Image*

The gray normalization of the image refers to the processing of illumination compensation. Uneven illumination often appears on face images that waits to be processed, which directly affect the accuracy of feature extraction, so light treatment on the input image is necessary to improve the quality of the image, increasing the recognition rate of the target image.

The image histogram [2] is an important statistical feature of the image, which represents the statistical relationship between each gray level in the digital image and the frequency of the gray level. Through the statistics of the image gray value, a one-dimensional discrete image gray statistical histogram function can be obtained. Mathematically, it counts the probability of each gray level in an image; graphically speaking, it is a two-dimensional graph, the abscissa represents the gray level of each pixel in the image, and the ordinate represents the probability of the appearance of the image pixel on each gray level. Histogram reflects the general picture of the image, so the contrast of the image can be reduced by modifying the histogram to improve image quality.

III. FACE FEATURE EXTRACTION

Features are used to characterize and distinguish different things. For face gender recognition [3], the impact of facial feature extraction on recognition results are major. For image recognition, extracting effective image features is the primary task. The whole process is shown in figure 1.

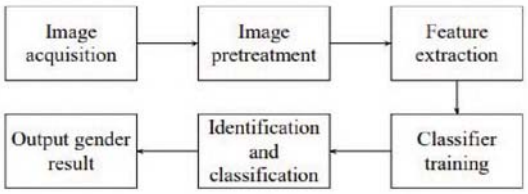

Figure 1. Gender recognition based on human face

A. *Feature extraction based on Gabor local transform*

Gabor transform [4] is one type of wavelet transform, which has the multi-resolution characteristics of wavelet transform [5], directivity and locality of Gabor function at the same time, so it has been widely used in time-frequency joint analysis of signals and image processing. The features extracted based on multi-direction and multi-scale Gabor transform fully describe the local features of the face, and is considered to be the most effective face feature extraction methods at present. Gabor transform is not sensitive to brightness changes and geometric deformation. In addition to the gray-level mean value information of the image, the original image can be reconstructed by using wavelet features without losing the useful information of the image.It has multi-resolution features, the size of the feature can be adjusted as needed. Based on these advantages, Gabor transform is adopted in this paper to extract facial features.

The two-dimensional Gabor filter function [6] is actually the mother wavelet in the wavelet transform. It can generate a

series of filters through scale rotation and scaling, namely two-dimensional Gabor wavelets. Design Gabor filters with multiple frequencies and multiple directions to form a set of Gabor wavelet filter combinations and act on the image for description.

$$\overline{k_j} = \begin{pmatrix} k_{jx} \\ k_{jy} \end{pmatrix} = \begin{pmatrix} k_v \cos\varphi_\mu \\ k_v \sin\varphi_\mu \end{pmatrix} \tag{5}$$

parameter φ_μ, k_v reflects the sampling method of the two-dimensional Gabor wavelet in the direction and frequency space. This paper uses Gabor wavelet to extract image texture features. Select some directions, and the result of filtering in each direction represents the texture of that direction, and then calculate the gray level co-occurrence matrix of each texture as a feature parameter.

The face image is passed through the Gabor filter set to generate a set of face images with scale and direction information. Gabor feature face image is the result of convolution operation on face image and Gabor filter bank. Assuming that the original face sample image is $I(x, y)$, the Gabor feature of the face image can be obtained by the formula:

$$G(x, y, v, u) = G_k(x, y) \otimes I(x, y) \tag{6}$$

Among them, v is the Gabor filter scale, u is the direction of the Gabor filter, and $G(x, y, v, u)$ is the Gabor coefficient map in the direction u of the scale v. Then the Gabor Magnitude Maps (GMM) of the face can be expressed as:

$$GMM = \sqrt{[Re(G)]^2 + [Im(G)]^2} \tag{7}$$

Since v , u represent different sampling methods, the value of v , u must be taken into account for more comprehensive texture information, so that the filter bank can sample uniformly on the image. Since $[0, \pi)$ can describe all the sampling intervals required by the image, the direction factor u only needs to take the interval $[0, \pi)$. Although the more scales extracted, the more detailed the information is, but the amount of calculation will also increase. Under actual conditions, uniform sampling at equal intervals is usually adopted.

B. Feature Extraction Based on Gray Characteristics

As a natural form, face has individual differences, factors such as position, posture and orientation will affect the face image detection process, but the gray distribution obtained through certain preprocessing, such as smoothing, sharpening shows certain regularity. These gray-scale features contain the inherent characteristics of the face. By extracting a series of face features and recognizing the subsequent process, the face positioning can be completed.

The method based on grayscale is the simplest and most intuitive. It uses gray horizontal and vertical statistical values of its own characteristics. Images can be seen as an arrangement of many pixels. Each image can be regarded as a two-dimensional matrix of real numbers in MATLAB. Therefore, each pixel is actually a parameter, and the two-dimensional image is arranged into a row of data for direct use. This method uses the gray value of the image as a parameter, and treats the image as a two-dimensional random process, introducing statistical order reliability as characteristics to describe and analyze images which can greatly reduce the dimensionality of features while retaining the main classification information.

IV. BP NEURAL NETWORK

The specific steps of BP algorithm learning include:1)From the training samples, input the input information extracted from the collection into the network; 2) Calculate the output of each layer node by the network; 3) Compare actual and expected errors; 4) Reverse calculation from the first hidden layer of the output layer, adjust the connection weight of the network according to the learning rules in the direction of reducing the error; 5) Repeat the above steps until the entire training set error meets the required requirements.

```
net = newff( minmax(input) , [140 40 80 2] , { 'logsig' 'purelin','logsig','purelin'} , 'traingdx','learngdm' )

net.trainparam.show = 50 .
net.trainparam.epochs = 20000 .
net.trainparam.goal = 0.00000001 .
net.trainParam.lr = 0.01 .
net.trainparam.min_grad=1e-15.
```

Figure 2. the desinged BP neraul network

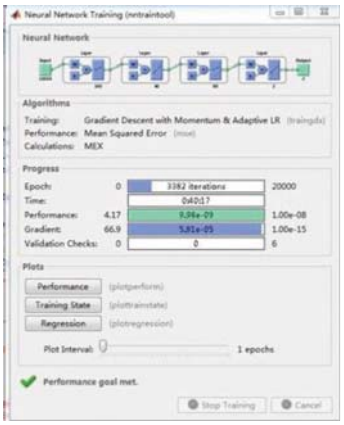

Figure 3. BP neraul network training

Figure 2 shows the BP neural network designed in this paper, wherein: net is the new created BP neural network; minmax is the matrix of the network input vector range; [140 40 80 2] represents the number of neurons in the hidden layer and output layer of the network; logsig represents S-type transfer function; purelin represents linear transfer function, express linear relationship; traingdx represents the training function of the network; learngdm represents the weight learning function of the network (gradient descent weight/threshold learning function), which calculates the rate of change of the weight or threshold through the input and error of the neuron, and the learning rate of the weight and threshold. Figure 3 shows the BP training process.

V. EXPERIMENT VERIFICATION AND DISCUSSION

The face samples in experiments come from many sources, including well-known ORL face databases, self-collected face databases, and photos published online. To meet the needs of actual use, and to enhance the robustness of the system, the collected samples contain different age groups; various races; different expressions; samples with heavy makeup traces and unnatural exaggerated expressions are excluded. Before training, detect face for all pictures, and after excluding all the pictures with obvious detection errors, the remaining frontal face images are used for experiments. Figure 4 is the initial interface of the face gender recognition software. Figure 5 shows the interface of image waiting to be selected. Figure 7 and 8 display the results of gender recognition.

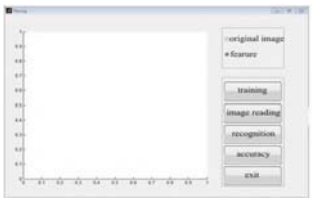

Figure 4. Initial interface

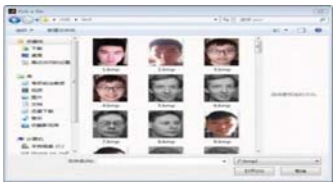

Figure 5. Image selection

Figure 6. Gender recognition result disaplay 1

Figure 7. Gender recognition result display 2

Gender recognition rate based on different database is as follows:

TABLE I. GENDER RECOGNITION RATE

Accuracy	Face database		
	ORL face database	*Collected face image*	*Online face image*
Male	82.67%	73.25%	77.59%
Female	80.14%	74.08%	76.67%

It can be seen from the table that the male recognition rate is much lower than the female recognition rate. Among all databases, gender recognition rate of the collected face image is the lowest, ORL face database has the highest recognition rate. Because images are most standard, recognition rate of collected face images is low due to sharpness and light. As for pictures downloaded from the Internet, the recognition rate is higher due to high pixel.

This article focuses on the face gender recognition method based on BP neural network. Firstly, the image size and gray level are normalized, then features are extracted based on Gabor and gray level. Afterwards, BP neural network is trained with the obtained feature parameters. Finally, this paper uses various face database to improve BP neural network for better accuracy rate. However, images used in this article are basically frontal faces with no obvious occlusion, but in real life the face to be detected may be sideways, or other occlusions, so more factors should be considered.

VI. .ACKNOWLEDGMENT

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