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Face Recognition of the Rhinopithecus Roxellana QinlingensisBased on Improved HOG and Sparse Representation

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***Abstract*—With the researches on face recognition of Rhinopithecusroxellanaqinlingensis, this thesis comes up with some methods that refining traditional HOG and Sparse Representation in order to improve the efficiency in recognizing golden monkeys. As we know, improved HOG is an optimal way to show partial information of an image. Besides, it can also plays an crucial role in staying stability in both optical and geometric distortion, which means the changes in expressions, postures and angles of golden monkeys can also be ignored. By using these characteristics as a alternation of original images to be a part of Sparse dictionary, and make a facial recognition on golden monkey with Sparse Representation, which can be a ideal method to erase many unnecessary messages and improve the accuracy on facial recognition of golden monkeys. Compared with mainstream method in recognition, this method is more reliable and effective and has a higher efficiency in recognition.**

Keywords-Rhinopithecus roxellana qinlingensis;Face recognition;Histogram of Oriented Gradient;Sparse Dictionary;Sparse Representation

I. INTRODUCTION

The Rhinopithecusroxellanaqinlingensis in the Qinling area is more precious and attracts people's attention [1 ~ 3], which is distributed in the Gansu, Sichuan, Hubei and Shaanxi regions, and is in the endangered state. In the recent years, the study of face recognition has been very mature [4 ~ 8], but, the animal recognition is less [9 ~ 10]. Especially for the monkey face recognition.

This paper presents a hybrid recognition algorithm based on improved histogram of Oriented Gradient (HOG) and sparse representation. The HOG can be used to maintain the invariance of the geometric and optical deformation of the image, and it is modified by the Gaussian smoothing filter and the cubic linear interpolation method [11]. On the other hand, the sparse representation algorithm is used to establish the Qinling Golden Monkey Face Recognition Model.

II. FACE RECOGNITION PROCESS OF THE RHINOPITHECUS ROXELLANA QINLINGENSIS

Golden monkey face recognition system consists of image acquisition, image preprocessing, HOG feature extraction, the classification of the sparse solution for improvement.Using the following steps to describe the specific process:

1) Take picture for the Rhinopithecusroxellanaqinlingensis using high pixel SLR cameras.

2) The golden monkey in the scene image need to denoisingand normalized .Next, we build the database for the Rhinopithecusroxellanaqinlingensis'face though face detection and segmentation.

3) With the Gaussian smoothing filter and the cubic linear interpolation method to improved the HOG, we can setup the characteristics of the samples which is texture feature extraction of golden monkey face.

4) Last,we can use the sparse representation based dictionary to get the recognition results .

A. *Face Detection Location of the RhinopithecusRoxellana Qinlingensis*

Golden monkey face detection is prerequisite for the identification of golden monkeys. State of the art uses the skin color to the animal face segmentation, skin color with the composition of melanin and saturation looks a bit different, but these differences are concentrated in the brightness, so the brightness of the skin in the analysis of skin plays a significant role [12]. In this paper, through the study of the brightness channel of the golden monkey picture, we found that there is a great difference in brightness between the golden monkey face image and the background of the brightness channel as shown in Fig .1.

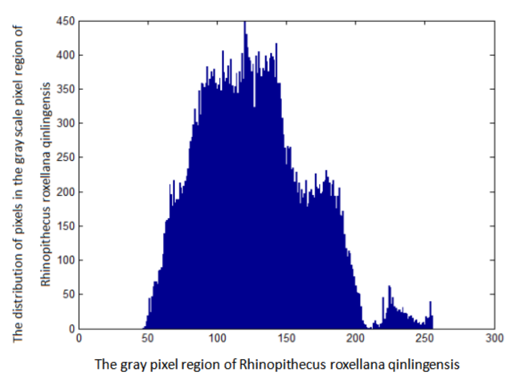
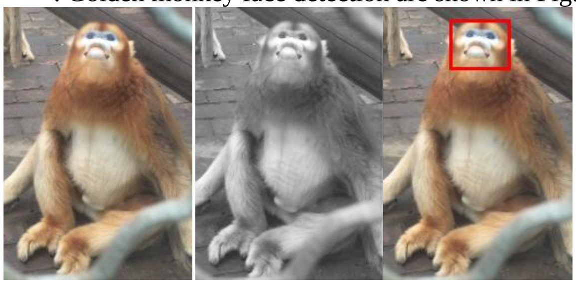


Figure 1. Luminance channel statistics of the Rhinopithecus roxellana qinlingensis

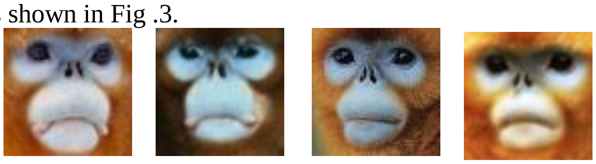
In Fig.1, the background pixels are basically concentrated between 50 ~ 200pix, while the golden monkey face pixels concentrated in the 200 ~ 250pix between. So the golden monkey image is separated by YUV method [13] in this paper, divided into face and other regions by threshold segmentation. the golden monkey face data is normalize to the $N*N$. Golden monkey face detection are shown in Fig. 2:



(a)The sample images (b)YUV space(c)Face detection positing

Figure 2. Face Detection of the Rhinopithecus roxellana qinlingensis

The data of the correct positioning of the golden monkey face image is defined as a positive sample, others is defined as a negative sample due to the lighting, environment and so on. The result of dividing the positive and negative samples is shown in Fig .3.



(a) Positive samples

(b) Negative samples

Figure 3. Split positive and negative sample results

Remove negative samples and keep positive samples as test image data.

B. *Improved HOG Feature Extraction Algorithm*

HOG is a local descriptor whose features are the local gradient amplitude and direction.The traditional HOG feature extraction process is described below:

1) First,the gradient of the image abscissa and the ordinate direction is calculated on the local unit of the image. Next,the gradient direction value of each pixel position is calculated.

the gradient of the pixel (x, y) in the image is:

$$\begin{cases} G_x(x,y) = H(x+1,y) - H(x-1,y) \\ G_y(x,y) = H(x,y+1) - H(x,y-1) \end{cases} \quad (1)$$

In the formula(1), $G_x(x,y)$ is the horizontal direction gradient value of the pixel (x,y) in the input image; $G_y(x,y)$ is the vertical direction gradient value; $H(x,y)$ is the pixel values.

Thegradient at the pixel (x, y) amplitude and gradient direction are:

$$\begin{cases} G(x,y) = \sqrt{G_x(x,y)^2 + G_y(x,y)^2} \\ \mathrm{a}(x,y) = \tan^{-1}\left(\dfrac{G_x(x,y)}{G_y(x,y)}\right) \end{cases} \quad (2)$$

2) Construct the unit histogram. The target image is divided into small blocks of 16×16 pixels, each of which is called a unit. The gradient histogram of each cell is counted and form a block use each 9 gradient histogram .The gradient histogram of all the blocks is connected to form the HOG character descriptor of the image. As shown in Fig.5 (c), the traditional HOG feature extraction method is unbefitting in the golden monkey image. In this paper, the HOG characteristics of golden monkey were extracted by using the Gaussian smoothing filter and cubic linear interpolation to remove the color or change in the image.

The concrete description is as follows:

$$G(x,y) = \frac{1}{2\pi\sigma^2} \mathrm{e}^{-\frac{x^2+y^2}{2\sigma^2}} \quad (3)$$

x, y is the distance where the current point to the corresponding point. And the Gaussian filter binomial approximation σ , so the minimum variance of the binomial coefficients can be calculated by Gaussian function.

The cubic linear interpolation is used to poll the gradient direction in each cell, and the statistics of the gradient direction in the block are realized[14]. The cubic linear interpolation mathematical description is shown in equation (4):

$$h(x_1, y_1, \theta_1) \leftarrow h(x_1, y_1, \theta_1) + |\nabla f(x,y)|(1 - \frac{x-x_1}{dx})(1 - \frac{y-y_1}{dy})(1 - \frac{\theta-\theta_1}{d\theta})$$

$$h(x_1, y_1, \theta_2) \leftarrow h(x_1, y_1, \theta_2) + |\nabla f(x,y)|(1 - \frac{x-x_1}{dx})(1 - \frac{y-y_1}{dy})(\frac{\theta-\theta_1}{d\theta})$$

$$h(x_2, y_1, \theta_1) \leftarrow h(x_2, y_1, \theta_1) + |\nabla f(x,y)|(\frac{x-x_1}{dx})(1 - \frac{y-y_1}{dy})(1 - \frac{\theta-\theta_1}{d\theta})$$

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$$h(x_2,y_2,\theta_2) \leftarrow h(x_2,y_2,\theta_2)+|\nabla f(x,y)|(\frac{x-x_1}{dx})(\frac{y-y_1}{dy})(\frac{\theta-\theta_1}{d\theta}) \quad (4)$$

The three parameters of the cubic linear interpolation x, y, θ are the angular space of direction, direction and gradient. As shown in Fig. 4, when voting is done using the gradient amplitude as the weight, the pixel (x, y) is weighted according to the distance of the pixel from the center of the other lattice,as well as,the gradient direction of the pixel (x, y) is also interpolated in its adjacent interval.Improved Hog features of the golden monkey face are shown in Fig .5 (d).

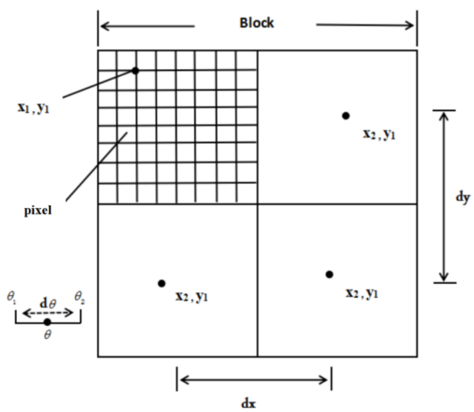

Figure 4. Three linear interpolation schemes of block

(a) The sample (b) Image definition(c)HOG feature (c)Improved HOG imagesextraction feature extraction

Figure 5. HOG feature extraction

III. FACE RECOGNITION OF THE RHINOPITHECUS ROXELLANA QINLINGENSIS

Signal sparse representation is very important in the signal processing, and represent signals from as many atoms as possible in a given super-complete dictionary, making it easier to obtain information contained in the signal.

In the traditional sparse representation, the original image is input, and dictionary is establish by the sparseness of the image, Finally the images can be classified in the dictionary[15]. However, this simple way to build sparse tables not only contains a lot of redundant useless information, increased computing load, but also can not effectively to use the basic characteristics of the image. In order to solve these problems, this paper presents a hybrid method based on improved HOG and sparse dictionary to identify the golden monkey face. The sparse representation's input is the features by extracting the improved HOG feature of the golden monkey face image and creating a complete dictionary, the monkey face is effectively identified and classified. The specific process is as follows:

$$y = C * x \quad (5)$$

In the formula(5), y is the golden monkey face data information, C is the dictionary, x is the sparse coefficient. The algorithm description process is:

Firstly,We extracts the improved HOG feature in the golden monkey face image to establishment matrix C . Next, we uses the least squares method to perfect the dictionary represented by the matrix linearity [16].

$$C = \begin{bmatrix} a_{11} & a_{12} & a_{13} & \cdots & a_{1n} \\ a_{21} & a_{22} & a_{23} & \cdots & a_{2n} \\ a_{31} & a_{32} & a_{33} & \cdots & a_{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & a_{m3} & \cdots & a_{mn} \end{bmatrix} (6)$$

In the formula(6), m is the golden monkey; n is the HOG feature matrix ; a_{mn} is the Hog feature matrix of the n thphotograph of the m th golden monkey.

Secondly, the linear combination of the base vector is the test picture after pretreatment and feature extraction. A small number of non-zero elements in the sparse coefficient, and the other elements are zero, by this idea we can classify the golden monkey faces. In order to improve the accuracy of sparse solution classification, we can improve the sparse vector solution.

For each type of the golden monkey face,we can extract their HOG feature and define a feature function P to select the corresponding coefficient for the mth class, y is the golden monkey face data information,the non-zero sparse coefficients of the mth class form a new vector $P_m(y_m)$ .With this coefficient, the test sample Z can be reconstructed approximately:

$$Z_m = C * P_m(y_m) \quad (7)$$

Residual δ :

$$\delta = x - Z \quad (8)$$

In the formula(8),the residual δ is the difference value between the calculated value of the original test sample and the component value of each object corresponding to the test sample.

Finally, calculate the residuals, output the results [17]. In this paper, the smaller the residual, the image sample which is reconstructed using the train sample is more similar to the original test sample,so we classify the two groups(one is test sample,other is train sample) with the least residuals as a class.

IV. ANALYSIS OF RESULTS

The entire experiment are completed on the computer in the frequency of 4 core 1.6GHz, 4G memory, code written in the matlab .

In this experiment, a total of 530 pieces of golden monkey data were collected in this experiment. A total of 504 pieces of golden monkey faces were detected, and 422 of them were positive samples, which obtained the golden monkey face pattern correctly Data, negative samples of 64; did not detect the golden monkey face data images a total of 44. false positive samples of 26(the image of the golden monkey is not facing the front, that means does not contain the golden monkey face image); false negative samples for 18(the golden monkey face image failed to detect). Fig .6 is the ratio of Qinling Golden Monkey face detection.

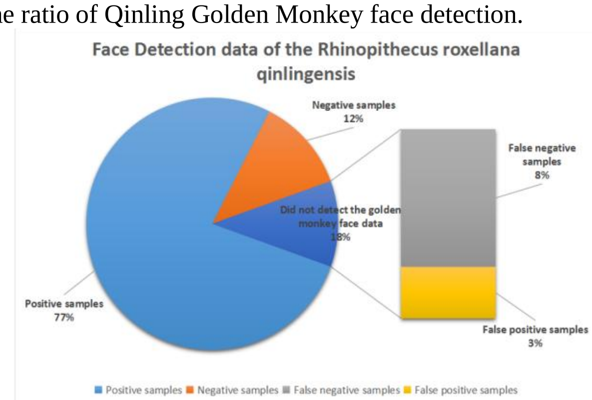

Figure 6. Face Detection data of the Rhinopithecus roxellana qinlingensis

Recall and Precise are two measures that are widely used in the statistical analysis and quality evaluation. From the above data we can see that the recall ratio of this experiment is about 95.91% (the number of positive samples/(the number of positive samples+the number of negative samples)). The accuracy is about 86.83% .

It contains 12 categories in the positive sample images of the golden monkeys, and each golden monkey have 30 images. For the experiment, a part of the images are used to establish sparse dictionary, and the other part of the image is used as test data. The stability test of the method is carried out according to the total data ratio and the recognition accuracy. The results are shown in Fig .(7).

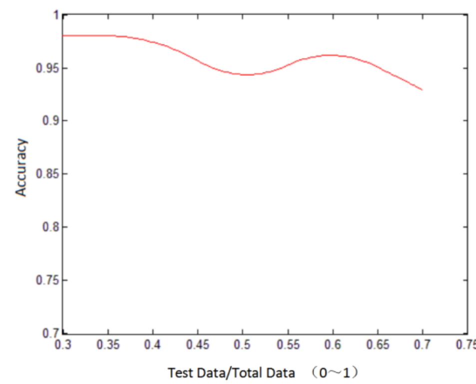

Figure 7. Face recognition stability test of the Rhinopithecusroxellanabase on Improved HOG feature extraction + Sparse Representation

It is found that the accuracy of the method is between 97.22% and 92.86%, which proves that the method has good robustness.

The following two experiments verify the recognition effect of the algorithm. Experiments were made in 70% (252 images)of the sample database for the data dictionary (or training data) ; 30% (108 images)of the image for testing data .

1) The image recognition experiment is carried out with the image sparse representation algorithm combined with different input data. The original image, the HOG feature and the improved HOG feature were used as input data in turn, and the results are shown in Table 1.

TABLE I. COMPARED WITH OTHER MAINSTREAM METHOD OF EXPERIMENTAL RESULTS

Recognition methods	**Correctly identify the number of images**	**Accuracy**
The original image+Sparse Representation	70	64.81%
HOG+Sparse Representation	87	80.56%
Improve HOG+Sparse Representation	105	97.22%

2) The image recognition experiment is carried out with the different algorithm combined the improved HOG feature as the input data. The support vector machine (SVM), BP neural network and image sparse representation were used to perform the golden monkey face recognition experiment, the results are shown in Table II.

TABLE II. COMPARED WITH OTHER MAINSTREAM METHOD OF EXPERIMENTAL RESULTS

Recognition methods	**Correctly identify the number of images**	**Accuracy**
Improve HOG+SVM	82	75.93%
Improve HOG+BP	61	56.48%
Improve HOG+Sparse Representation	105	97.22%

The results of experiments in Table 1 and Table 2 show that the recognition method based on the improved HOG feature and the sparse representation of the image is better in different input data and different recognition algorithms.

V. CONCLUSION

In this paper, a golden monkey face recognition algorithm is proposed based on an improved HOG feature and image sparse representation, which distinguishes individuals taking advantage of golden monkey images. Meanwhile, a sample library of wild golden monkeys in Qinling Mountains was established. This method is robust to the illumination andpose changes of the tested object. It can not only remove a large amount of redundant information, reduce the recognition speed, improve the accuracy of face recognition effectively, but also has a higher recognition accuracy.

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