Face Recognition Algorithm Comparison based on Backpropagation Neural Network

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Abstract. Face recognition is a hot research direction in the field of computer in recent years. Due to the constant update and progress of computer hardware technology and software algorithm, face recognition technology is becoming more and more perfect, and face recognition technology starts to appear in different fields. Because of the high security of face recognition, we can design a face recognition access control system based on backpropagation neural network. This paper mainly compare three different face recognition algorithms based on matlab and test the accuracy of these algorithms.

Keywords: BP neural network, face recognition.

1. Introduction

In the daily interpersonal communication, face often plays a vital role. Face is the most basic biometric that we use to judge a person's identity, and face recognition technology has also received more and more attention. The end of 1980s is the beginning of face recognition technology. The face recognition system designed by Bledsoe and Chen is the representative work of face recognition technology. At present, with the vigorous development of network technology, the era of intelligence has gradually approached us. With the face recognition technology being used in various fields, "face swiping" has gradually become a new fashion. The most familiar thing is Alipay's "face swiping" function. It can easily pay without mobile phone without money, and brings many conveniences to our life. Nowadays, face recognition is needed in railway ticket purchase and bank card processing. Compared with traditional biometric recognition, face recognition has the advantage of rapid information collection and verification.

There are many image-based face recognition algorithms. They have a general understanding of some basic features of the target, build a face model through those basic features, and then match the face through the model. The establishment of the model is mainly through the computer vision system. The computer vision system is different from the human eye. The human eye can see things because of the reflection of light. The reflected light falls on the retina through the pupil, and then imaging in the brain. But the computer can't recognize the object directly, all it can see is a bunch of binary matrix, different binary matrix represents the different degree of light and shade of the image. It is a complex process for the computer to judge a person's face through these digital signals, and the training
processing is the most complex step in the process. Three layer backpropagation (BP) neural network is used to realize the recognition of standard face ORL database.

Common three-layer BP neural network is shown as follows, there are n neuron nodes in the input layer, there are m neuron nodes in the output layer, and there are k neuron nodes in the hidden layer. Using BP learning algorithm to train the neural network.

The structure of BP neural network is shown in Figure 1.

![BP neural network](image)

**Figure 1.** BP neural network

BP network is a kind of mapping from input to output in essence. It can learn a large number of mapping relations between input and output without any precise mathematical expressions between input and output. As long as BP network is trained with known patterns, the network has the mapping ability between input and output pairs.

BP network performs teacher training, and its sample set is composed of vector pairs in the form of (input vector, expected output vector). Before training, all weights and thresholds should be initialized with different small random numbers.

2. Steps of face recognition

There are four steps of face recognition as shown below.

2.1. Face image acquisition and image processing

The system collects the face images captured by the camera, and then starts the gray processing of the collected face images. Gray processing is the first step of face image processing, the most important is to convert the face data into gray image for convenient processing, and there are external factors such as the change of light brightness, imperfect pictures captured by the camera, which may affect the contrast of the face and make some errors in the face image processing by the computer, so we need to increase the accuracy of image enhancement processing. In order to improve the image contrast, we need to stretch the gray of these places to make the image easier to recognize, so as to improve the accuracy of system recognition. Set the number of images collected by define function, and then read the images.

ORL face data set contains 400 images of 40 different people. It was created by Olivetti research laboratory in Cambridge, UK from April 1992 to April 1994. The part of faces in ORL face data set are shown in figure 2.
This data set contains 40 directories, each directory has 10 images, each directory represents a different person. All the images are stored in pgm format, grayscale, image size, width 92, height 112. For images in each category, these images are collected in different time, different light, different facial expressions (open / close eyes, smile / no smile) and facial details (with / without glasses). All the images were taken against a dark, uniform background, with the front face (some with a slight sideslip).

The matlab code to read the images is as follows:

```matlab
Allsamples = []; % all training images
for i=1:40
    for j=1:5
        a = imread ( strcat ('ORL_Faces\',num2str(i),',num2str(j),'.pgm'));
        B = a (1:112 * 92); % B is the row vector 1 × n, where n = 10304. The extraction order is column first and then row, that is, from top to bottom and from left to right
        b=double(b);
        Allsamples = [allsamples; b]; % allsamples is an M × n matrix. Each row of data in allsamples represents a picture, where M = 400
    end
end
```

2.2. Extract the feature matrix of the image with Principal Component Analysis (PCA) method

The matlab code of PCA method is as follows:

```matlab
Samplemean = mean (allsamples); % average picture, 1 × n
for i=1:200
    Xmean (i,:) = allsamples (i,:) - samplemean; % xmean is an M × n matrix, and the data stored in each row of xmean is "per picture data average picture"
end
Sigma = xmean * xmean'; % m × m matrix
[v d]=eig(sigma);
d1=diag(d);
[D2 index1] = sort (D1); % in ascending order
Cols = size (V, 2); % column number of eigenvector matrix
for i=1:cols
    Vsort (:, I) = V (:, index1 (cols-i + 1)); % vsort is a matrix of order m × col (Note: col is generally equal to m), which stores eigenvectors arranged in descending order, and each column constitutes an eigenvector
    Dsort (I) = D1 (index1 (cols-i + 1)); % dsort stores the eigenvalues in descending order and is a one-dimensional row vector
end % complete descending order
%Choose 85% energy below
dsum = sum(dsort);
dsum_extract = 0;
p= 0;
while( dsum_extract/dsum < 0.85) p=p + 1;
    dsum_extract = sum(dsort(1:p));
end
i=1;
%The coordinate system of feature face formation is calculated
while (i<=p & & dsort(i)>0)
    Base(:, I) = dsort(I)^(- 1 / 2) * xmean'* vsort(:, I); % base is n × P matrix, divided by dsort(I)^ (1 / 2) is the standardization of face image
    i = i + 1;
end
%In the following code, the training sample is projected on the coordinate system to obtain an M * P matrix allcoor
    allcoor = allsamples * base;

2.3. Creating and training BP neural network
Algorithm of training BP neural network: 'trainscg' means Scaled conjugate gradient backpropagation; 'traindxg' means Gradient descent with momentum and adaptive learning rate backpropagation; 'trainrp' means Resilient backpropagation. All of these algorithms, use the same 60 neurons of first hidden layer, and the same 15 neurons of second hidden layer. The structure of BP neural network is shown in figure 3.

![Figure 3. Structure of BP neural network](image)

The matlab code of creating and training BP neural network is as follows:

```matlab
%Generating input P for training BP neural network
P = mapminmax(allcoor); % normalization
%Generating target output vector t
T=zeros(200,40);
for i=1:40
    for j=1:5
        T((i-1)*5+j,i)=1;
    end
end
%Disorganize training sample order
gx2(:,1:47)=P;
gx2(:,48:87)=T;
xd=gx2(randperm(numel(gx2)/87),:);
gx=xd(:,1:47); d=xd(:,48:87);
P=gx';
T=d';
%Building BP neural network
```
\[[R,Q]\]=\text{size}(P);
\[[S2,Q]\]=\text{size}(T);
net=newcf(minmax(P),T,[60,15],\{'tansig','logsig'\},\'trainscg');
net.trainparam.epochs=5000;
net.trainparam.goal=0.0001;
net.divideFcn = '';  
net=train(net,P,T);
%Simulation BP neural network
Y=\text{sim}(net,P);

2.4. Test BP neural network and calculate its accuracy

The matlab code of testing BP neural network is as follows:
%Test BP neural network
s=0;
for i=1:40
    for J = 6:10
        a=imread(strcat('ORL_ Faces\s',num2str(i),',num2str(j),'.pgm'));
        b=a(1:10304); b=double(b);
        Tcoor = b * base; \% calculation coordinates, is 1 × P order matrix
        X = mapminmax (tcoor); \% normalized
        Z=\text{sim}(net,X);
        [zi,index2]=\text{max}(Z);
        if index2==i
            s=s+1;
        else
            J\% output identifies the person who made the mistake
            Index2\% output the picture with recognition error
        end
    end
end
%Calculate the recognition rate
accuracy=s/Q
\%Using Scaled Conjugate Gradient algorithm, the test accuracy is 83.5%. Using Gradient descent with momentum and adaptive learning rate backpropagation, the test accuracy is 87.5%. Using Resilient backpropagation algorithm, the test accuracy is 86%. All test results of performance by different algorithm are shown in Figure 4. Training states of different algorithms are shown in Figure 5.
a) Scaled conjugate gradient backpropagation  
b) Gradient descent with momentum and adaptive learning rate backpropagation  
c) Resilient backpropagation  

Figure 4. Performance of different algorithm
3. Conclusions

The main content of this paper is to compare three different face recognition algorithms based on MATLAB and test the accuracy of these algorithms. We know that face recognition is a complex process, the algorithm is the core technology of face recognition. We test Scaled Conjugate Gradient Algorithm, Resilient Backpropagation algorithm, and Gradient descent with momentum and adaptive learning rate backpropagation, the results show that the Gradient descent with momentum and adaptive learning rate backpropagation is the best face recognition algorithm in this case.

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