Research of Standard Handwritten English Letters Recognition System Based on the PSO-BP neural network

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Abstract—**the Particle swarm optimizer is intelligent searching in space to find the optimal solutions through the cooperation and competition between particles, being based on the theory of swarm intelligence global optimization algorithm. Its advantage is that simple operation and easy achievement. In this paper, a new algorithm PSO- BP was studied, giving full play to both of the particle swarm algorithm of global optimization ability and BP algorithm's local search advantage, and compared identification of 140 pixels of English letters together with BP algorithm. Experimental results show that particle swarm algorithm used for the optimization of the neural network has a faster convergence speed, and simpler algorithm.**

Keywords-Particle swarm algorithm; Artificial neural network; English letters recognition

I. INTRODUCTION

English letters recognition is an important branch of words recognition, having higher theoretical research value and practical needs. Standard handwritten English letters recognition usually adopts the artificial neural network techniques. The BP algorithm of multilayer network is by far the most widely application in neural network, and it has strong nonlinear approximation ability, adaptive ability, and self-learning ability. Basic BP algorithm based on the error of the gradient descent algorithm has slow convergence, and easily fall into the local minimum for most practical application. To cope with the disadvantages of the BP algorithm, the particle swarm optimization based on the BP neural network is adopted in this paper.. And we designed a kind of English letters recognition training system. The improved BP algorithm greatly reduced the number of network training, effectively prevented the training of network from the local minimum point. And we obtained better effect.

II. THE ACQUISITION PREPROCESSOF WRITTEN-LETTER IMAGE

The script English letters recognition is the digital image processing to identify the numerals from images. When identifying a specific picture, processing steps may not completely the same. But in general, we get the results after identification image acquisition by a complete identification system in recognition. They are image pretreatment, the feature extraction, classifier and post-processing five stages,.

The script image mainly acquired through scanner or other digital equipment. To simulate the real handwritten numerals, we adopt 200 groups of various and complex written digital numeral samples of different formats on A4 paper, including 150 groups for the training sample, with the order of training sample from "A" to "Z" ---the order of the 26 letters. The rest of the 50 group are test samples, which is upset over the order of the 26 letters. Because the input device and paper reason will cause the distortion, in order to remove the noise, before recognition of the English letters we need preprocessing to compress redundant information and input font and noise interference. Generally we acquire characteristics in the preprocessed images, so if this step is not ideal, it can often cause mistakes to the followed steps that unable to correct. So the quality of pretreatment directly related to identifying correct or not, and related to the the performance of the identification algorithm. Pretreatment mainly includes two threshold, the noise removing, the tilt correction, division, normalization, thinning processes.

Binary is to convert digital image each pixel from 0 ~ 255 gray to black and white colors. The noise removing is to remove isolated noise black spots of binary images, to fill depressions of characters or delete small protrudings of edge lines. Tilt correction is to correct over the possible existence tilt of the collected digital images, and we the commonly use the projection method, Hough transform method and the nearby method. Division is to eliminate the useless image segmentations, and divide several independent character from each other, the traditional methods are direct division of segmentation method, the division on the basis the basic recognition method and self-adaptive cent secant clustering method. Normalization is to unify the letters of image to the same size in order to reduce the network training time, to improve identification accuracy. Since the capital letters and lowercase letters of five English letters "c", "o" , "p", "s" and "z" are very similar, if we used each letter normalization alone, the five letters case deterrent rate is higher. If we use the whole normalization, although we can reduce the five letters case

978-1-4577-0536-6/11/$26.00 ©2011 IEEE

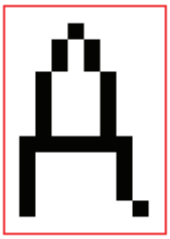
deterrent rate, but the whole system recognition rate will reduce. The system uses each letter normalization alone to be the method. The thinning processes is to unify all the lines to the same width--- general is a pixel--- it is convenient for feature extraction.

III. FEATURE EXTRACTION

The main purpose of feature extraction is to distinguish different types of nature from the original data. According to statistics point of view, good feature extraction method must meet the following condition, being independent among features, increasing the distance between classes while reducing the distance in one class, the dimension of characteristic vector being as low as possible.

For the script handwritten numerals, according to the characteristics of digital extraction method there are into three categories: the general per-pixel features extraction, statistical characteristics method and the structure characteristic method.

We adopted the per-pixel features extraction method through the contrast experiment among the per-pixel features extraction, skeleton feature extraction method and 13 points of feature extraction method. Per-pixel feature extraction method is one of the most simple feature extraction method. We take its features white pixel value is 1, when take the black pixel characteristic value as 0 while we scan the listed image by line. after the scan it forms feature vector matrix with the same number of pixels as one dimension and the image. Per-pixel extraction's weakness is more characteristic value, slow speed. So we need 14 * 10 size normalization. Figure 1 (a) is one of the training sample after refined the handwritten script "a", figure 1 (b) is its characteristic vector.



(a) "A" after refined

1	1	1	1	1	1	1	1	1	1
1	1	1	1	0	1	1	1	1	1
1	1	1	0	1	0	1	1	1	1
1	1	1	0	1	0	1	1	1	1
1	1	0	1	1	1	0	1	1	1
1	1	0	1	1	1	0	1	1	1
1	1	0	1	1	1	0	1	1	1
1	1	0	1	1	1	0	1	1	1
1	0	0	0	0	0	0	0	1	1
1	0	1	1	1	1	1	0	1	1
1	0	1	1	1	1	1	0	1	1
1	0	1	1	1	1	1	0	1	1
1	0	1	1	1	1	1	1	0	1
1	1	1	1	1	1	1	1	1	1

(b) "A" feature vector

Figure 1. "A" after refined and it's feature vector

IV. ENGLISH LETTERS RECOGNITION

This paper used the PSO-BP neural network as the recognition of the English letters. PSO-BP neural network is an optimization algorithm using particle swarm algorithm on BP neural network..

A. The BP neural network

BP Network (Back-Propagation neural Network) is a kind of the neural Network having three layer or layer 3 above, with the connection between each layer and without connection between neurons in same layer. Given a pair of learning samples available to the network, the activation value of neurons spread from the input layer by to output layer through middle layers, and get response in each input neuron network. Next, come back to the input layer according to reduce target output and the direction of the actual error, with correction of connection weights value in each middle layer. BP algorithm formed by two process, forward data flow (positive communication) and the backward propagation of error signal. When positive communicating, the direction of propagation is from input layer, hidden layer to output layer. Each neuron only affects neurons of its next layer. If in the output layer there is no expected output, then it turns to the error signal back propagation process. Through the two processes in alternating, in vector space, it carries out gradient descent strategy implementation of error function, it dynamicly and iteratively searches a group of weight vectors, in order to make the network error function to a minimum, thus completes information extraction and memory process [1].

B. PSO algorithm

PSO algorithm a kind of evolution algorithm which was put forward by Dr. Kennedy and Dr. Eberhart in the meeting of 1995 IEEE neural network [2]. Supposed in a D D target search space, there are M of particles in a swarm, we name the first I particle a D D vector X = [xi1, xi2, xi3... xid], I = 1, 2... M, the first I particle in D D search space is in the position of the xi. Each particle is potential solution, taking yuan into an objective function we can calculate adaptive value, according to the adaptive value, we can eveluate the quality by measuring the size of the value of the yuan. The "flying" speed of the first I particles is also a D D vector, noting V = [vi1, vi2... vid], the speed decides the iteration times of particle's displacement in searching space unit. Note the first I a particle swarm so far to search for the optimal location Pi = [Pi1, Pi2,... Pid], also known as Pbest. The optimum position of the particle swarm searching is Pg = [Pg1, Pg2 Pgd],..., also known as gbest. in the process of PSO algorithm operation, it randomly generated a initial population and gives each particle a random speed, and updates the particles of speed and position according to the formula (1) as follow:

$$\begin{cases} V_{id}(t+1) = \omega V_{id}(t) + c_1 rand1(P_{id}(t) - X_{id}(t)) \\ \qquad\qquad + c_2 rand2(P_{gd}(t) - X_{id}(t)) \\ X_{id}(t+1) = X_{id}(t) + V_{id}(t) \end{cases} \quad (1)$$

In formula (1), V_{id} is the speed of the particle inertia, ω is right value, c1, c2 is real, called learning factor, rand1, rand2 is

random numerals between (0, l), X_{id} is the current position, P_{id} is on behalf of the best position of the swarm. PSO optimization algorithm is developed very rapidly, and there are also a lot of the improved algorithm. The iterative algorithm by type (1) is usually considered standard PSO algorithm.

C. *The particle swarm optimization algorithm and basic principle BP algorithm*

The BP neural network is typical of feedforward neural networks. Using PSO algorithm is to optimize BP neural network, with particle swarm algorithm to optimize network initial parameter optimization, training network weights and threshold instead of the gradient descending method to avoid network in training local minima, so as to improve the network training speed. The key is to establish reflection reltionships between PSO particles neural network and the dimensions, weights and the threshold. And neural network learning process is basically the weight and the threshold renewal process, PSO search process is basically the change of speed and position in different dimensions. So the BP algorithm should corresponds the weight and threshold and the position of the particles. The particles degree function should be minimum mean variance MSE:

$$MSE = \frac{1}{P}\sum_{i=1}^{p}\sum_{i=1}^{N}(t_i - o_i)^2 \qquad (2)$$

Type (2) N is for output vector dimension, P representative .

V. PSO-BP NETWORK DESIGN AND THE RESULT OF THE EXPERIMENT

A. *Design of PSO -BP network*

Each hand written letters is stored alone after pretreatment, pixel 14 x 10. We should establish the training sample library as the neural network's input. When optimizing by the PSO algorithm, amount of particles is 40, initial inertia right value is 0.8, and diminishing to 0.3 with the linear iteration times. We BP choose three-layer network structure, 140 input node input layer, 27 node output, 3000 largest training number, 0.05 degree of network training. The convergence as shown in figure 2 shows, is in higher convergence speed, achieved the convergence error requirements.

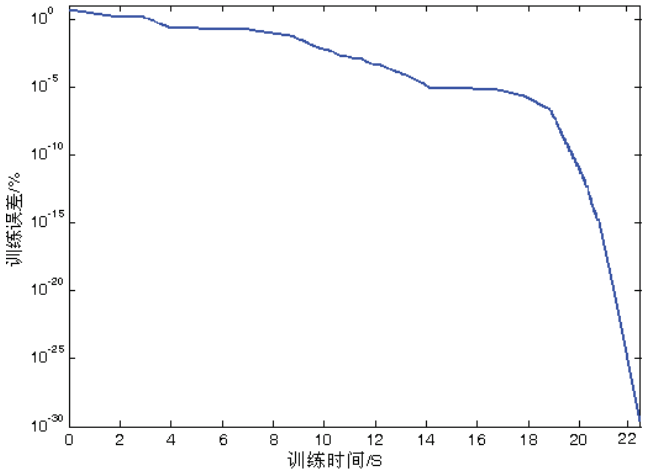


Figure 2. PSO-BP neural network classifier training process

B. *the experimental results*

We had identified the system respectively for the capital letters written training, handwritten lowercase letters of the training and case mix row of training. Draw recognition rate in table 1, including that English letters mix row recognition rate is regardless of the wrong data of the "c", "o" and "p", "s", "z" five letters. Through the experiments we proved the system recognition rate is higher, there are certain practical value.

TABLE I. LETTERS RECOGNITION RATE TAB

Letters type	samples type	recognition rate(%)
Capital letters	The training sample	90.3
	The test samples	86.8
Small letters	The training sample	89.5
	The test samples	85.3
Big and lowercase letters mix row	The training sample	89.1
	The test samples	84.7

VI. CONCLUSION

In this paper to cope with standard offline digital recognition, we studied the PSO-BP neural network classifier establishment and the identification process. optimized BP algorithm using PSO improved the global search ability of neural network, accelerated the network convergence speed, guaranteeed the network generalization ability. Because both of PSO-BP network and the single BP neural network algorithm in network is based on the back propagation network algorithm, it made no big difference in digital recognition rate. This optimization algorithm can be used to to identify handwritten letters with its high speed and precision, reliable prediction, and it has a good value in theory and practical application.

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