Study of Radar Target Range Profile Recognition Algorithm Based on Optimized Neural Network

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Abstract. Neural network as an important aspect of artificial intelligence has received extensive research and long-term development. Radar target range profile recognition is a commonly used method in radar target recognition, in this paper, it is combined with neural network. The LVQ (Learning Vector Quantization) neural network has excellent classification and identification capabilities. This paper applies it to radar target one-dimensional range image recognition and achieves good results. This paper studies the problem of LVQ neural network sensitive to initial connection weights, and uses PSO (Particle Swarm Optimization) algorithm to optimize it of recognition classification. The experimental results show that the study of radar target range profile recognition algorithm based on optimized neural network can overcome the sensitivity of the LVQ neural network to the initial weight and improve its recognition ability.

Keywords: 1-D range profile recognition
LVQ (Learning Vector Quantization) · PSO (Particle Swarm Optimization)

1 Introduction

The radar target one-dimensional range image recognition uses the relevant information provided by the target echo of the high-resolution radar to make a corresponding decision on the class attribute of the target. The one-dimensional range image can reflect the geometric shape and structural information of the target, and can provide more required feature information than the low-resolution radar, and is easy to obtain and process. Therefore, target recognition based on one dimensional range profile of radar target has become a popular method [1, 2]. Some studies have proposed the application of subspace method, optimal clustering center method and BP neural

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network to radar target one-dimensional range image recognition [3–5], and achieved good results.

Neural network as an important aspect of artificial intelligence has received extensive research and long-term development. LVQ neural network has strong classification recognition ability and has been widely used [6]. In this paper, it is applied as a classifier to the radar target's one-dimensional range image recognition, which has achieved good results. The LVQ network algorithm is sensitive to the initial connection weights of the output layer and the competition layer. For this paper, the PSO algorithm is used to optimize and improve, and a PSO-LVQ radar target one-dimensional range image recognition algorithm is proposed. Experimentally verified that this method significantly improves the recognition effect.

2 LVQ Neural Network Model Analysis

The LVQ neural network is a supervised network for training the competition layer. And the algorithm is derived from the Kohonen [7] competition algorithm.

Figure 1 shows the structure of LVQ neural network [8]. LVQ neural network has three layers of neurons, input layer, competition layer and output layer. Set each distance image as a vector X_i, each input mode of the input layer is a distance image. The network input layer and the competition layer are fully connected, and the connection weights will change when the network is trained. The network training is the learning classification of the input vector based on the distance criterion. It is assumed that there are a total of M distance images from the K class targets, The input is $M = (x_1, x_2 \ldots, x_M)$, Then the number of input neurons is also M. Follow these steps to train:

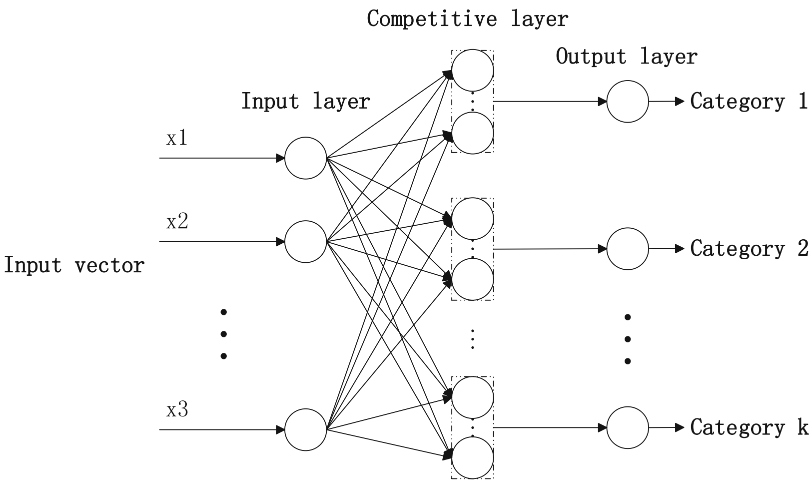

Fig. 1. The model of LVQ neural network

Step 1: Initialize the connection weight ω_{ij} between the input layer and the competition layer and learning rate $\eta(0)$. $i = 1, 2, \ldots, P$. P is the number of neurons for the competition layer, $j = 1, 2, \ldots, M$

Step 2: Send the one-dimensional range image as input to the network and calculate the Euclidean distance between the input vector and the competitive layer neuron

$$d_i = \sqrt{\sum_{j=1}^{M} \left(x_j - \omega_{ij}\right)^2} \tag{1}$$

Step 3: Establish the minimum Euclidean distance standard

Step 4: Determine if the classification is correct. Adjust the weight vector according to the following rules:

If $C_x = C_i$

$$w_{ij\_new} = w_{ij\_old} + \eta\left(x - w_{ij\_old}\right) \tag{2}$$

If $C_x \neq C_i$

$$w_{ij\_new} = w_{ij\_old} - \eta\left(x - w_{ij\_old}\right) \tag{3}$$

Step 5: Adjust the learning rate

Step 6: Determine whether the number of iterations exceeds, if it exceeds, the iteration ends, otherwise go to the second step.

Each neuron in the output layer corresponds to a radar target category.

The advantage of this training method is that there is no need to normalize and orthogonalize the input vector, only the distance between the input vector and the competitive layer neuron is calculated.

It was observed that the "winning" neurons were determined by calculating the minimum distance by (1). Using only information of "winning" neurons results in insufficient utilization of information resources between the input samples and the competition layer. Observing formula (1), it is easy to find that when the initial weight deviation is too large, the calculation error will be very large, which will affect the convergence speed and classification recognition effect of the LVQ network.

3 PSO-LVQ Radar Target One-Dimensional Range Recognition System

To solve the problem that the LVQ network mentioned above is sensitive to the initial connection weights of the output layer and the competition layer, this paper proposes a PSO-LVQ radar target one-dimensional range profile recognition system.

The particle swarm optimization algorithm is an optimization algorithm that was proposed by Kennedy and Eberhart [9] and others to simulate the swarm intelligence behavior of birds. In the particle swarm algorithm, a particle represents a bird. Each particle is represented by its own position and velocity, and is updated according to its own initial orientation, its own optimal direction of experience, and the empirical optimization direction of the surrounding particles. The performance of each particle is evaluated by defining a fitness function.

In this paper, particle swarm optimization algorithm is used to optimize the initial weights of LVQ neural network. The particle coding of the particle swarm is directly assigned to the weights and threshold matrix of the LVQ neural network. Then the predicted value is predicted by the LVQ neural network, and compared with the actual value of the training data to predict the error rate and the objective function to obtain the fitness of each particle.

The specific implementation steps of the PSO-LVQ radar target one-dimensional range profile recognition system are as follows:

Step 1: Create an LVQ network

An LVQ neural network is created, and each target selects a certain number of samples as input vectors for network training. Randomly generate n × m-dimensional matrices (n is the number of hidden layer neurons of the LVQ network, m is the dimension of the one-dimensional distance image) as the initial weight of the network. The number of neurons in the hidden layer affects the effect of the network. Too few will affect the recognition accuracy, and too many will affect the training speed. Determine the number based on the actual experiment.

Step 2: Initialization

Set the PSO algorithm parameters c_1, c_2, r_1 and r_2. Initialize the particle swarm, which defines parameters such as population size, number of iterations, and initializes the particle's velocity and position.

Step 3: Iterative optimization, adjusting the particle's velocity and position

Population iteration updates:
The speed of the particles is updated according to formula (4):

$$v_{ij}(t+1) = v_{ij}(t) + c_1 r_1 \left[y_{ij}(t) - x_{ij}(t)\right] + c_2 r_2 \left[\hat{y}_j(t) - x_{ij}(t)\right] \tag{4}$$

The position of the particle is updated according to formula (5):

$$x_{ij}(t+1) = x_{ij}(t) + v_{ij}(t+1) \tag{5}$$

$v_{ij}(t)$ is the velocity of particle i in j th dimension at t, $i = 1, 2, \ldots, m$, m indicates the number of particles. $j = 1, 2, \ldots, J$, J represents the dimension of the particle. c_1, c_2 express acceleration constant. r_1, r_2 are the random numbers between the intervals [0, 1]. $y_{ij}(t)$ indicates the past optimal position of the i th particle while $\hat{y}_j(t)$ indicates the past optimal position of the entire particle swarm. $x_{ij}(t)$ is the position of particle i in j th dimension at t.

Step 4: Calculate the fitness value and update the individual extremum and population extremum
Step 5: Repeat (3) (4) two steps until the iteration is completed
Step 6: Assign an optimal value to the LVQ neural network and input samples for training.

4 Experiment

4.1 Data Preprocessing

One-dimensional range images have azimuthal sensitivity and amplitude sensitivity, which are one of the key issues in the identification of one-dimensional range images. In order to effectively identify the target, the data must be pre-processed. The fast Fourier transform (FFT) [10] method is used to divide the observation interval to solve the azimuth sensitivity. The HRRP sequence in the observation interval is defined as a frame distance image and represents a corresponding angle field. Normalize the range image amplitude spectrum to resolve amplitude sensitivity.

The experimental data is 260 distance images taken for each of the three types of aircraft. The data is processed as follows:

Step 1: Normalize, normalize each image with its total energy
Step 2: Distance alignment, using the Fourier invariant translation invariance, aligns a one-dimensional range image as a Fourier transform.

Each target selected 160 samples to form a training set, and the remaining 100 samples formed a test set. The number of neurons in the hidden layer is set to 20 and the number of output layer neurons is 3, the number of training is 100, the size of the population of particles is 50, and the number of iterations is 50.

4.2 Result Analysis

As shown in Table 1, the classification accuracy of LVQ algorithm and PSO-LVQ algorithm.

Table 1. Comparison of classification accuracy of LVQ and PSO-LVQ algorithms

Target	Accuracy of LVQ (%)	Accuracy of PSO-LVQ (%)
Target 1	75.652	86.149
Target 2	95.023	95.293
Target 3	96.873	98.856
Average recognition rate (%)	89.183	93.433

Table 1 summarizes the performance of the two methods mentioned in the article applied to the radar target one-dimensional range image recognition. The LVQ algorithm can achieve a good classification effect, and after being optimized by the particle swarm optimization algorithm, the classification and recognition performance can be further improved. The classification accuracy of PSO-LVQ algorithm is much better than LVQ, and the average accuracy rate can reach 93.433%.

This shows that after optimizing the weights of the LVQ neural network through the PSO algorithm, the sensitivity of the LVQ neural network to the initial weight is overcome to a certain extent, and the classification effect of the network is better. Experiments prove the correctness of the algorithm.

5 Conclusion

In this paper, the LVQ neural network method is applied to the radar target's one-dimensional range image recognition to obtain a good recognition effect. And for the problem that the LVQ algorithm is sensitive to the initial weights, the particle swarm optimization algorithm is used to optimize the initial weights of the LVQ neural network. Through experimental tests, it is verified that this method can overcome the sensitivity of LVQ neural network to the initial weight to a certain extent and improve the classification effect of the classifier.

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