

Target Recognition Algorithm Based on BP Networks and Invariant Moments

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Abstract

On the basis of multi-sensor fusion algorithm, a target recognition algorithm based on Back Propagation (BP) neural networks and invariant moments was proposed. Invariant moment takes advantage of overall information of the targets. It has good differentiating effect and high identification technique. On the other hand, BP neural networks not only have the adaptive learning ability, but also are insensitive to imperfection of input mode. Therefore, it has proper classification and extensibility. It is effective for the algorithm based on BP neural networks and invariant moments that decrease the adverse impacts for the images, which are always subject to the changes of imaging distance, direction and position. Simulation results show that the algorithm has strong recognition capability for surface targets from infrared image sensors.

Keywords: target recognition, BP neural networks, invariant moments

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1. Introduction

Target recognition technology can recognize and track the specific target by handling the outputs of sensors, which makes great significance on tactical missile precise striking target, attacking targets intelligently, and improving the survival ability of the launch platform. At present, the scholars and engineers domestic and abroad have done a lot of fruitful researches in the image recognition algorithm [1-6]. The invariant moment proposed by Hu [7] is a widely used description based on shape features; Wong and Siu [8] extended the geometric invariant moments and proposed a fast algorithm; an target recognition algorithm based on invariant moments and corner features was proposed in the paper [9] and used in the identification of maritime targets.

This paper presented a target recognition algorithm based on BP neural network and moment invariants, which first introduced the image recognition algorithm structure of active radar/infrared imaging sensor; then introduced the feature extraction and the algorithm based on invariant moments; and in the final designed the BP network classifier to identify and classify feature vectors. Compared with the traditional image recognition algorithms, this algorithm has a better recognition effect to overcome the shortcomings of the traditional target recognition algorithm, such as being vulnerable to outside interference and image recognition errors.

2. Fusion Algorithm Structure

According to the algorithm based on active radar / infrared imaging sensor, the infrared sensor recognize targets with the information of the target space position and distance proposed by the radar, in order to improve the recognition capacity of the infrared imaging module and simplify realization difficulty and the amount of calculation of the infrared image recognition and tracking module [10].

There are many ways for the identification of surface targets by extracting the different characteristics of image recognition. The recognition algorithm on surface targets can be divided into two parts, offline and online. First, BP network is trained off-line by using infrared image samples. Then, the infrared image is identified on line by the trained BP network. The identification can be completed by extracting the target from the infrared image after

preprocessing and region segmenting, and then computing invariant moments on the binary image of the target, and finally entering the image invariant moment group as the input of the BP network. The surface target recognition principle based on BP neural network and moment invariants is shown as Figure 1.

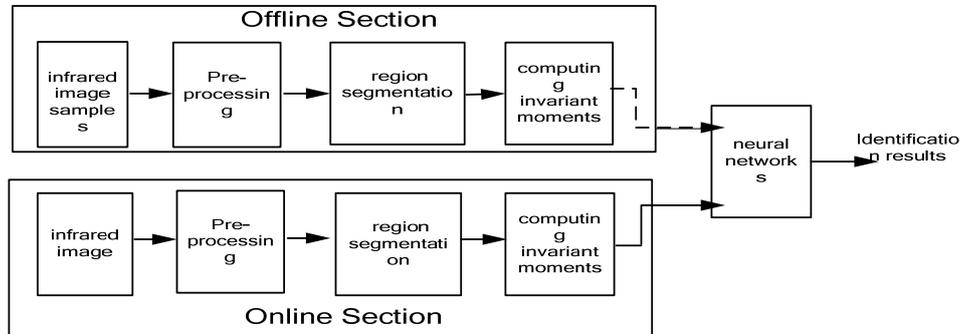


Figure 1. Target Recognition Algorithm Based on BP Neural Network and Moment Invariants

3. Feature Extraction and Invariant Moment Algorithm

For any recognition system, selecting the appropriate image features is very important and how to select the most effective features from the many features is the key to the image recognition. Invariant moment group is a special function. If the target image is a binary image, moment group can only describe the target point in the X-Y plane of space on the arrangement of information, which is the target shape information. Different targets species of the same moment group is different, and therefore it can be used to identify the target. The following is the specific principle and algorithm.

Assume $g(i, j)$ is the gray value in (i, j) , then pq order moments of the image is defined as :

$$M_{pq} = \sum_i \sum_j g(i, j) i^p j^q \quad (p, q = 0, 1, 2, \dots) \tag{1}$$

In order to make these moments remain unchanged when image is translated scaled or rotated, the following three transformations must be carried.

(1) Image (central) moment

$$m_{pq} = \sum_i \sum_j f(i, j) (i - \bar{i})^p (j - \bar{j})^q \quad (p, q = 0, 1, 2, \dots) \tag{2}$$

(\bar{i}, \bar{j}) is the image centroid, defined as

$$(\bar{i}, \bar{j}) = \left(\frac{M_{10}}{M_{00}}, \frac{M_{01}}{M_{00}} \right) \tag{3}$$

Clearly, the image (central) moment satisfies the translational invariance.

(2) Normalize central moment to meet translation and scale invariance, and get the formula is as follows:

$$v_{pq} = \frac{m_{pq}}{m_{00}^{(p+q+2)/2}} \quad (p + q = 2, 3, \dots) \tag{4}$$

(3) Seven invariant moments can be obtained as follows by algebraic invariant-moment theory, which are the invariants of the image after translation, scale and rotation.

$$M_1 = v_{20} + v_{02} \quad (5)$$

$$M_2 = (v_{20} - v_{02})^2 + 4v_{11}^2 \quad (6)$$

$$M_3 = (v_{30} - 3v_{12})^2 + (3v_{21} - v_{03})^2 \quad (7)$$

$$M_4 = (v_{30} + v_{12})^2 + (v_{21} + v_{03})^2 \quad (8)$$

$$M_5 = (v_{30} - 3v_{12})(v_{30} + v_{12}) \left[(v_{30} + v_{12})^2 - 3(v_{21} + v_{03})^2 \right] \\ + (3v_{21} - v_{03})(v_{21} + v_{03}) \left[3(v_{30} + v_{12})^2 - (v_{21} + v_{03})^2 \right] \quad (9)$$

$$M_6 = (v_{20} - v_{02}) \left[(v_{30} + v_{12})^2 - (v_{21} + v_{03})^2 \right] \\ + 4v_{11}(v_{30} + v_{12})(v_{21} + v_{03}) \quad (10)$$

$$M_7 = (3v_{21} - v_{03})(v_{30} + v_{12}) \left[(v_{30} + v_{12})^2 - 3(v_{21} + v_{03})^2 \right] \\ + (v_{30} - 3v_{12})(v_{21} + v_{03}) \left[3(v_{30} + v_{12})^2 - (v_{21} + v_{03})^2 \right] \quad (11)$$

As a result of the large variation range of the seven invariant moments, in order to facilitate the BP network processing, the logarithm method can be used for data compression, and considering the invariant moments may appear negative, the actual moment invariant is [11]:

$$I_k = \lg |M_k| \quad (k = 1, 2, \dots, 7) \quad (12)$$

$I_1, I_2, I_3, I_4, I_5, I_6, I_7$ are used as the invariable features in this paper.

4. BP Neural Network Classifier

After the extraction of the image feature, a group of data to reflect the target attribute is obtained (feature vectors). The next step is to identify and classify based on this set of feature vectors. Practical classification algorithm is one of the core technologies of infrared image automatic target recognition system

BP network is a multilayer feedforward neural network and takes the error back propagation learning algorithm, which is widely used in function approximation, pattern recognition, classification, data compression and so on. Processing of the neural network classifier includes training and identification, where training is the process of the classifier design on the basis of the training sample; identify is the process of identifying unknown images by matching unknown images and classifiers which have been trained.

In this paper, three-layer BP network is designed as the classifier with each input of the network corresponding to one of the characteristics of the sample, the output nodes equaling to the number of categories, all output nodes composing an output column vector and an output column vector corresponding to a category. In the simulation, training sample includes two classes. In the training phase, if the input training samples are for the first goals, then the desired output is (1, 0), while (0,1) for the second goals. In the recognition phase, if a new image is used to the input, a one-dimensional column vector output can be got via the trained BP network mapping.

5. Simulation experiments and results analysis

Aircraft image on the above algorithm is simulated in the experiment. Using BP network as the classifier can achieve recognition, with the input of the network as invariant moment group and the output as image category. So, the design uses three-layer BP network, including the input layer of seven neurons, the output layer of two neurons, and the hidden layer of 10

neurons. The neurons in the hidden layer of neural network select hyperbolic S-shaped transfer function and neurons in the output layer choose linear transfer function.

Lots of infrared image for neural network training can't be got in the simulation, so we select the plane image for simulation analysis. In this paper the invariant moment group satisfies translation, rotation and scale invariance. When the target image deforms, the invariant moment will change. The simulation includes distorted images, which are divided into two kinds of plane images and figure 2 is the standard image. The experiments selected 10 binary images of the two aircraft as the sample for feature extraction and the BP network training, and finally, used the trained neural network for target recognition. Figure 3 shows the 20 training samples, in which the front 10 pieces for the first types of images and back 10 pieces for the second types.



Figure 2. Standard Image



Figure 3. Neural Network Training Samples

Compute the above 20 image invariant moments as neural network's input, and train the neural network by MATLAB trainpbx function. The trained neural network can be used to classify two types of aircraft. In the simulation, 40 images which are different from training samples were used to test the network. Figure 4 shows the 20 test images.

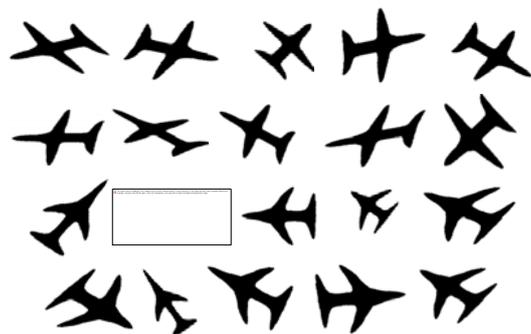


Figure 4. Neural Network Test Samples

According to the image characteristic of infrared image test, this paper uses the median filter on the image smoothing, uses thresholding segmentation algorithm for target extraction, uses moment invariants to extract aircraft feature vectors, and uses neural network as the

classifier to classify the feature vectors extracted. Table 1 shows the output of neural network, where 1-10 and 21-30 for the first type image. After the neural network output is rounded, the value (1,0) is for the first type, the value (0,1) is for the second type, and else values are for other targets.

Table 1. Neural Network Output

groups	1	2	3	4	5
output	0.95019	1.0576	1.0185	0.98918	0.98102
	0.050804	-0.06056	-0.01385	0.016079	0.017601
groups	6	7	8	9	10
output	0.94377	1.0686	0.97443	0.93384	1.0922
	0.051405	-0.05402	0.024798	0.083205	-0.09327
groups	11	12	13	14	15
output	-0.01426	0.004848	0.023692	-0.04835	-0.01057
	1.0177	0.99441	0.9761	1.0488	1.0115
groups	16	17	18	19	20
output	-0.04383	0.037304	-0.01448	-0.03257	0.052416
	1.0388	0.96603	1.0147	1.0334	0.94945
groups	21	22	23	24	25
output	0.9705	1.0649	1.0934	1.0131	0.91302
	0.038342	-0.06632	-0.10514	-0.01509	0.11121
groups	26	27	28	29	30
output	1.053	1.0139	0.99155	0.87853	0.99429
	-0.04981	-0.01284	0.002829	0.1155	0.010121
groups	31	32	33	34	35
output	0.051965	0.046421	0.050754	-0.24535	-0.03534
	0.94788	0.95273	0.94977	1.2463	1.0373
groups	36	37	38	39	40
output	-0.03027	-0.01677	-0.0161	-0.05817	0.036802
	1.0307	1.0177	1.0168	1.0587	0.96238

The table shows that the neural network of 40 test images can be correctly classified, and the image recognition algorithm based on BP neural network and invariant moments proposed in this paper has good recognition performance to the infrared imaging sensor surface targets. It is superior to papers [11-12] on the correct classification rate, which is higher than 98%. Invariant moment with global information has a good distinction and a high recognition rate. BP network not only has the self-adaptive learning ability, but also being insensitive on the incompleteness of input pattern or the defect of characteristics, so it has good classification and generalization properties. Therefore, the BP network and invariant moment group algorithm, effectively reduces the impact of imaging distance, direction, location and other factors' changes on images, enhances recognition system robustness and improves the recognition reliability.

6. Conclusion

The target recognition algorithm based on back propagation (BP) neural networks and invariant moments proposed in this paper is an important part of the active radar/infrared imaging fusion system. According to the characteristics of infrared image, the median filter is used on the image smoothing, thresholding segmentation algorithm is used for target extraction, invariant moments are used for the extraction of aircraft feature vectors and neural network is chosen as the classifier to classify the extracted feature vectors. The simulation results show that the method has good classification ability.

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