Research on Seismic Signals for Vehicle Targets and Recognition by Data Fusion

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Abstract

This paper researches seismic signals of typical vehicle targets in order to extract features and to recognize vehicle targets. As a data fusion method, the technique of artificial neural networks combined with genetic algorithm(ANNCGA) is applied for recognition of seismic signals that belong to different kinds of vehicle targets. The technique of ANNCGA and its architecture have been presented. The algorithm had been used for classification and recognition of seismic signals of vehicle targets in the outdoor environment. Through experiments, it can be proven that seismic properties of target acquired are correct, ANNCGA data fusion method is effective to solve the problem of target recognition .

1 Introduction

Because seismic properties of vehicle targets are an important index of target recognition[1,2], the seismic features of typical vehicles have been tested and analyzed in this paper. In order to realize the target classification and recognition of a single sensor, a data fusion technique of artificial neural networks combined with genetic algorithm(ANNCGA) is discussed. Comparing the experiment results, it can be confirmed that the ANNCGA is effective in classification and recognition of seismic signals.

2 Seismic Properties' Test and Result of Vehicle Targets

First, the seismic signals from a vehicle target was acquired by seismic sensors. Second, the signals were stored in a large dynamic range, low noise, wide frequency band, magnetic recorder. Third, the data were acquired by a quick speed A/D-D/A data acquisition card of computer. Finally, analysis of seismic properties was completed with software, and its results were stored in the form of files with the soft disk.

The seismic signals of targets were acquired and converted into the digital signals. Then they were put into a computer to be analyzed in time-domain and frequency-domain. Typical frequency spectra of diesel engine vehicle, heavy diesel engine vehicle and gasoline engine vehicle were as follows.

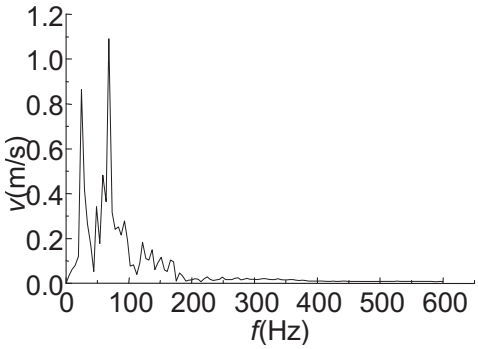

Fig 1. Seismic frequency spectrum of diesel engine vehicle

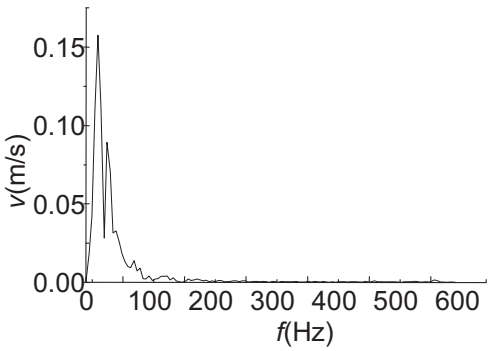

Fig 2. Seismic frequency spectrum of gasoline engine vehicle

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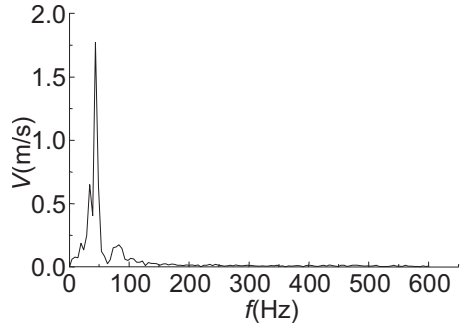

Fig 3. Seismic frequency spectrum of heavy diesel engine vehicle

According to the result of the data processing, the following conclusions can be drawn:

(1) From Fig 1., Fig 2. and Fig 3., it can be seen that the seismic amplitude of heavy diesel engine vehicles is the biggest one, diesel engine vehicles' is less than heavy diesel engine vehicles', and gasoline engine vehicles' is the smallest one.

(2) The majority of seismic energy from vehicle concentrates on below 600Hz, and there is an obvious feature peak. The frequency composition of heavy diesel engine vehicle is pure.

(3) It is possible that the target classification can be completed according to structure of frequency spectrum and amplitude from the seismic signal, because the different targets have very different structures of frequency spectra and amplitudes.

3 Method and Technique Realization of Recognition Data Fusion

In the system, the feature extraction of the data of different measuring point and different kinds of sensors is the input of neural networks. The weight of this neural network has trained and data input cause the production corresponding output. ANNCGA data fusion principle of target classification and recognition as shown in Fig 4.

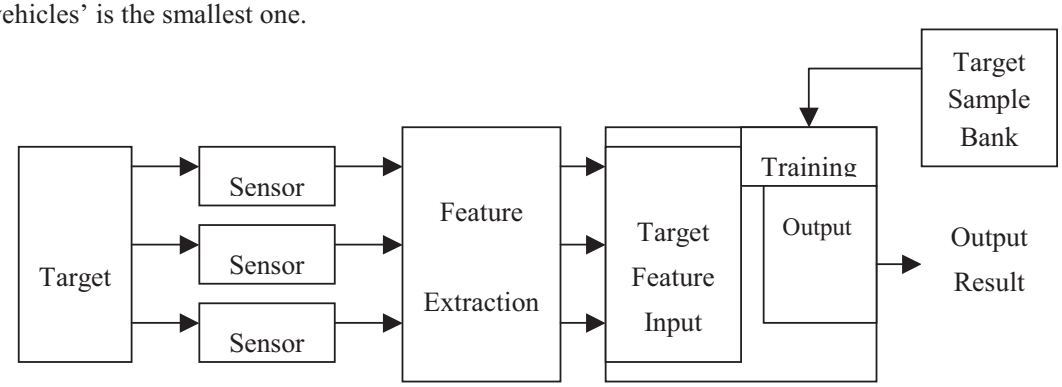

Fig 4. ANNCGA data fusion principle of target classification and recognition

The BP network is the most widely used artificial neural networks, simple structure, stable work state and easy realization by hardware. However its learning speed is not rapid enough and there are local minimum points in error curve[3]. In order to improve BP algorithms more efficiently, a new learning algorithm named ANNCGA is put forward to overcome these disadvantages. This algorithm firstly searches the global range for a best starting point with genetic algorithm, and BP algorithms begin with this starting point. Because the genetic algorithm deals with many individuals in search space at one time, it has stronger ability to optimization[4]. Combined BP algorithm with genetic algorithm, it can avoid local minimum points in error curve and increase training speed. Fig. 5 is the training flow chart of ANNCGA data fusion.

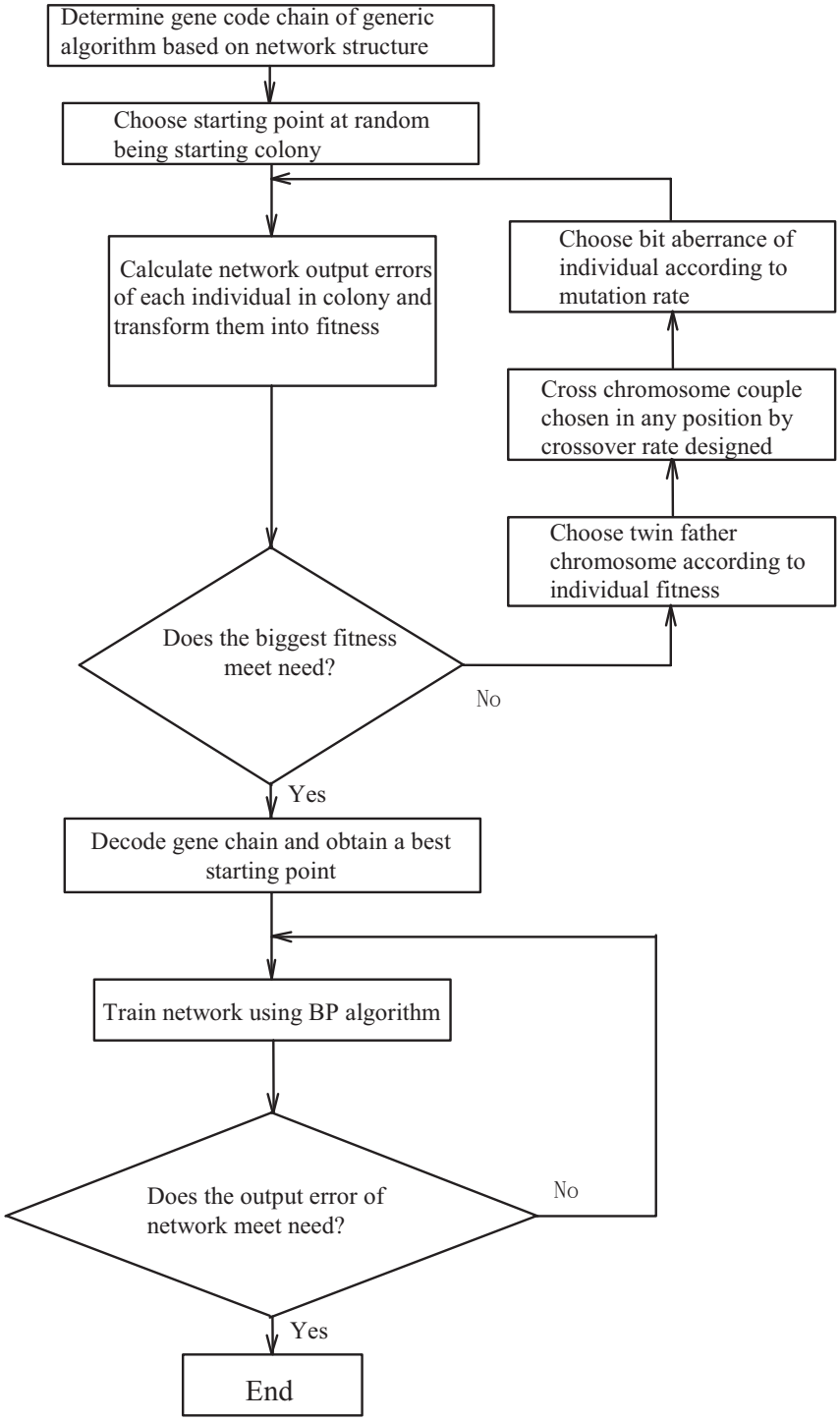

Fig 5 Training flow chart of ANNCGA data fusion

For the encode problem of GA, the corresponding weight w has a range of (-1,1). Suppose every weight is s in binary digit, the relation between a binary digit and corresponding weight is:

$$w = -1 + \frac{2u_w}{2^s - 1} \qquad (1)$$

In formula (1), u_w is the binary value of corresponding weight. Proportion method of fitness

combine with the saving method for optimal individual is applied in genetic selection mechanism of father generation. In every iteration, an individual is selected according to sufficiency ratio method and become children generation. The worst individual of children generation is replaced by the best individual of father generation, thus an evolution is complete. The fitness function has the following form:

$$f(x) = C_{\max} - g(x) \qquad (2)$$

In formula (2), $f(x)$ denote fitness function, $C_{\max}$ is the maximum value of $g(x)$, $g(x)$ denote output error of neural networks.

The traditional BP algorithms error curve is given in Fig. 6. The ANNCGA error curve is as shown in Fig. 7. From Fig. 6 and Fig. 7, we can conclude that the ANNCGA can reduce the time of training and magnanimously increase the speed of learning.

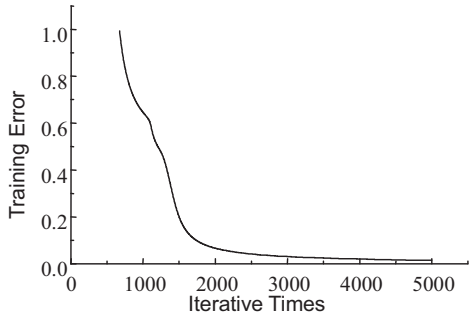

Fig 6. Traditional BP algorithms error curve

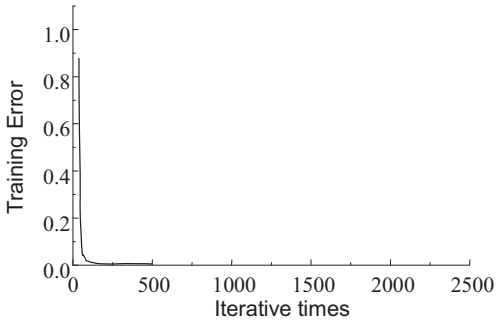

Fig 7. BP Algorithms combine with genetic algorithms error curve

4 Application Result and Conclusion

ANNCGA data fusion is used in target classification and recognition for actual measurement seismic data. The result of ANNCGA data fusion to target classification and recognition as shown in Table 1.

In this paper, we have successfully applied ANNCGA data fusion to recognize of seismic signals for vehicle targets. According to experiments, target seismic properties acquired outdoor are correct. And ANNCGA data fusion to target classification and recognition can acquire a high recognition rate.

Table 1. Result of ANNCGA Data Fusion To Seismic Signal Classification and Recognition Under Typical Environment

	diesel engine vehicle	gasoline engine vehicle	heavy diesel engine vehicle
Total number of sample	44	30	50
Correct recognition number of sample	36	29	42
Incorrect recognition number of sample	8	1	8
Recognition rate	81.82%	96.67%	84.00%

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