Advanced Science and Technology Letters
Vol.31 (MulGraB 2013), pp.189-192
http://dx.doi.org/10.14257/astl.2013.31.42

Radar Signal Recognition Algorithm Based on Fractal Theory and Neural Network

Jinfeng Pang, Yun Lin, Xiaochun Xu

College of Information and Communication Engineering
Harbin Engineering University, Harbin, China
{pangjinfeng, linyun, xuxiaochun }@hrbeu.edu.cn

Abstract. Nowadays, the traditional recognition method could not match the development of radar signals. In this paper, based on fractal theory and Neural Network, a new radar signal recognition algorithm is presented. The relevant point is extracted as the input of neutral network, and then it will recognize and classify the signals. Simulation results show that, this algorithm has a distinguish effect on classification under the condition of low SNR.

Keywords: Signal Recognition; Fractal Theory; Neural Network

1 Introduction

Radio signal recognition [1] plays an extremely crucial role in contemporary radar count measure, which has a cardinal step named feature extraction and classifier design. As the development of radar signal, radar signal recognition based on traditional feature parameters would not afford the request, and a much more careful and effective feature is need for recognition.

Fractal theory[2] has been widely used in the fields of seismic wave detection and image processing, which can quantificationally describe the complex and irregular degree of signals. Hausdorff Dimension[3] is a basic fractal dimension in the theory, however, it brings out difficulties in the calculation. Relevant dimension can calculate the relevant of different sample points of signals' internal, it is able to extract the character of radar signals much more accurately. Therefore, in this paper, the relevant dimension feature of radar signals has been extracted and Neutral Network[4] is used to classify the modulation type of radar signals.

2 Relevant dimension theory

Relevant dimension is an exception of multiple fractal dimensions. Here we would introduce the relevant dimension simply from another aspect—multiple fractal dimension. Multiple dimension describes the feature of different layers of substance and discusses the statistical distribution characteristic of parameters. We cut the research subject into N areas(taking the linear degree as 1), and suppose the linear

ISSN: 2287-1233 ASTL

degree of the area i as e_i , then the density distribution function P_i of area i could be described in different scaling components as: $F_i = e_i^{\alpha_i}, i = 1,2,\cdots,N_i$.

Non-integral is commonly called singular exponent, whose value is concerned with the area.

To get the distribution characteristic of series subsets, we define the function $X_q(e)$ to get the weight sum of every areas' probability: $X_q(e) = \sum_{i=1}^{N} P_i^q$ And we define general fractal dimension D_q as:

$$D_q = \frac{1}{q-1} \lim_{e\to 0} \frac{\ln X_q(e)}{\ln e} = \frac{1}{q-1} \lim_{e\to 0} \frac{\ln \left(\sum_{i=1}^{N} P_i^q \right)}{\ln e} \qquad (1)$$

We can get the relevant dimension when q equals to 2.

3 Neutral Network theory

The poor self-adaption of traditional classifier could hardly satisfy the request of recognition effect even in the complex circumstance. The Neutral Network gives us an amazing method of classifier design.

The process of Neutral Network can be summarized as below:

Suppose the input pattern vector as:

$$A_k = (a_1, a_2, \cdots, a_n), k = 1,2,\cdots, m \qquad (2)$$

In the equation: m —learning model component; n —input layer unit number.

The expected output in response to the input pattern is: $Y_k = (Y_1, Y_2, \cdots, Y_q)$

q means output layer unit number.

We calculate the input of middle layer units:

$$S_j = \sum_{i=1}^{n} w_{ij} a_i - \theta_j \qquad (3)$$

In the equation: w_{ij} -- connection weight between input layer and middle layer; θ_j -- threshold of middle layer unit; p -- number of middle layer units.

Taking S_j as function (Sigmoid function), we calculate the output of every unit in middle layer:

$$b_j = f(S_j) = \frac{1}{1+e^{\square}} \qquad \textbf{(4)}$$

In the equation: b_j --motivate value of the unit in the middle layer.

In the same way, we could get the input and output of every unit in the output layer:

$$L_t = \sum_{j=1}^{n} J_{jt} b_j - Y_t \qquad (5)$$

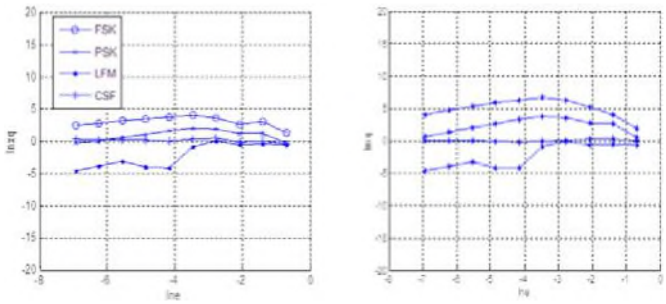
$$C_t = f(L_t) = \frac{1}{1+e^{-L_t}} \quad t = 1,2,\dots q \qquad (6)$$

In the equation: J_{jt}-- connection weight between middle and output layer; Y_t-- unit threshold of output layer.

Neutral Network does excellent in pattern recognition and self-adapt to the environmental change, and what is more, it can handle complex non-linear recognition problem well. It is always using in the design of signal classifier which benefit from the stability and potential fault tolerance.

4 Simulation experiment and analysis

Here we take four kinds of radar signals which are FSK, PSK, LFM and CSF, extract their relevant dimension characters, which is shown if figure 1.



(a) q=2 (SNR=0dB)   (b) q=2 (SNR=15dB)

Fig. 1. relevance character curves of 4 kinds of radar signals

We can see from Fig.1 that there are some differences in relation curves of different signals. Since the relation curve of $\ln e - \ln X_q$ which does not have a perfect linear relationship? This experiment directly draws the relationship of $\ln X_q$ and $\ln e$ separately as features of different radar signals and input the neutral net in order to train for recognition. The recognition rate is as shown in Fig.2.

For these four kinds of radar signals, we extracted 100 samples of each kind and took 50 samples as training samples and the else as testing samples. Then we got 200 training and 200 testing samples as input of neutral network. The input layer of neutral network has 4 units which are accidently to be the number of output layers, and units of hiding layer are set to be 3. The result in Fig.2 suggests that we have got a better recognition rate when SNR is larger than -5db, and even a perfect 100% recognition rate. So, it has been testified that this radar signal recognition algorithm has got a terrific effect on classification based on relevance curve feature and NNs.

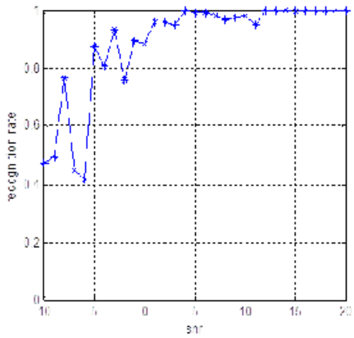


Fig. 2. The recognition rate of radar signals in different SNR

5 Conclusion

This paper has been exhibiting a radar recognition algorithm based on relevance feature and neutral network. Since the relevant feature extracted has a poor linear character, the paper gave out a new method to regard the points of relevance curves as feature vectors which are the input of neutral network. Simulation analysis shows that the method has got a perfect recognition effect, and a high recognition rate when SNR is larger than -5db. Especially, this feature extracting method has a much more widely utilization in the circumstance of fickle radar style environment.

Acknowledgment. This work is supported by the Nation Nature Science Foundation of China No.61301095 and 61201237, and the Fundamental Research Funds for the Central Universities No. HEUCFZ1129, No. HEUCF130810 and No. HEUCF130817.

References

1. Yu Shi, Xian-Da Zhang. “A Gabor atom network for signal classification with application in radar target recognition”, Signal Processing, vol. 49, no. 12, pp.2994-3004(2001)
2. Xiong Ying, Liu Min, Tang Bin, etal. Feature-Extracting Method for Radar Compound Jamming Signal Based on Box Dimension and L-Z Complexity[J]. vol. 23(6), pp:663-667.Journal of Data Acquisition and Processing(2008)
3. Guo Tie-jun, Guo Shuang-bing, Xiao Xian-ci. Fractal characteristics of modulation signals[J]. Science in China(Series E), vol. 31(6), pp:508-513 (2001)
4. Ghate, V.N., Dudul, S.V.. “Cascade Neural-Network-Based Fault Classifier for Three-Phase Induction Motor” Industrial Electronics, vol. 58, no. 5, pp. 1555-1563(2011)

