Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(6):2173-2177

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

High resolution radar signal detection based on feature analysis

[1]Xiaowei Niu and [2]Zhiming He

[1,2]School of Electronic Engineering, University of Electronic Science and Technology of China, Chengdu city, Sichuan, China
[1]School of Electronic and information engineering Chongqing Three Gorges University, Wan Zhou, China

---

ABSTRACT

The wideband radar signal has random parameters features, and traditional radar signal detection methods mainly detect the low resolution narrowband radar signal, the wideband and high resolution radar signal detection performance is bad. An improved high resolution wideband radar signal detection method is proposed based on feature analysis. A group of full range of wideband high resolution radar signal features is extracted for analyzing the wideband high resolution features of radar signal accurately, the concept of level feature quantity accumulation point is proposed, the scale factor and level factor can control the signal feature quantity, the resolution and the sensitivity of the radar signal are improved, feature cluster analysis method is used in analyzing the radar signal, the feature relationship of high resolution radar signal is analyzed, the artificial neural network algorithm is used to realize the detection of radar signal. Experiment results show that the new method can improve the radar signal detection efficiency and accuracy.

Key words: feature; wideband high resolution radar signal; detection analysis

---

INTRODUCTION

With the rapid development of science technology, the traditional narrow-band radar cannot adapt to the current military requirements, the wideband radar with high range resolution has higher application value. The wideband radar signal has better target range resolution, so it can classify and recognize the targets. It has good strong anti-interference capability, and it has good clutter suppression performance for the low altitude targets. Therefore, the wideband high resolution radar signal detection should be researched to improve the detection performance. The wideband high resolution radar signal has random parameters features, but traditional radar signal detection methods mainly detect the low resolution narrowband radar signal, the wideband and high resolution radar signal detection performance is bad[1].

In this paper, an improved high resolution wideband radar signal detection method is proposed based on feature analysis. A group of full range of wideband high resolution radar signal features is extracted for analyzing the wideband high resolution features of radar signal accurately, the concept of level feature quantity accumulation point is proposed[2], the scale factor and level factor can control the signal feature quantity, the resolution and the sensitivity of the radar signal are improved, feature cluster analysis method is used in analyzing the radar signal, the feature relationship of high resolution radar signal is analyzed, the artificial neural network algorithm is used to realize the detection of radar signal. Experiment results show that the new method can improve the radar signal detection efficiency and accuracy.

1. HIGH RESOLUTION RADAR SIGNAL DETECTION METHOD BASED ON FEATURE ANALYSIS

2.1. Feature analysis of wideband high resolution radar signal

In the recognition of the target distance, the clutter interference is serious, the amplitude of radar signal decreased.

With the increase of target distance, the wideband radar signal has been extended, the signal changes from single peak to dual peaks. When changing the object distance in the detection process, the length and width of wideband high resolution radar signal changes, the distance between signal two peak valley is stable, it shows that the effect of the linear relationship is not affected by the signal resolution and wave length. The feature is effective[3].

In order to describe the width and depth of wideband high resolution radar signal, the above factors should be considered, through repeated experiments, the following 3 features are extracted [4].

(1) Length of the radar signal
Because the length of signal has interference to the amplitude of radar signal, so it can be used as a feature. Firstly, the optimal sensors n_b of radar signals should be solved, the distance of two peak valleys is fl, and the linear regression radar signal length is l.

$$fl = x(\min_{x=m_b}^{m_2} z_{xn_b}) - x(\min_{x=m_1}^{m_b} z_{xn_b}), \quad l = a * fl + b \tag{1}$$

Where, a and b represent the coefficients.

(2) Amplitude, it is the biggest difference between peak and valley of radar signal.

$$z_{\max} = \max_{y=n_1}^{n_2} \left\{ \max_{x=m_1}^{m_2} \{z_{xy}\} - \min_{x=m_1}^{m_2} \{z_{xy}\} \right\} \tag{2}$$

Radar signal depth affects the signal amplitude directly, it is the depth feature, and it is related to the length and width of the radar signal.

(3) Feature of radar signal:

$$E = \sum_{x=n_1}^{n_2} \sum_{y=m_1}^{m_2} z_{xy}^2 \tag{3}$$

The feature of radar signal E can reflect the three-dimensional size of radar signal comprehensively.

1.2 High resolution radar signal feature clustering analysis

In order to obtain the precise analysis of the characteristics of broadband high resolution radar signal, the concepts of λ horizontal characteristic quantity accumulation is introduced, and it can describe the characteristics of radar signal with resolution and sensitivity, the feature model of radar signal is created [5].

Assumed the wideband high resolution radar signal is $x(t)$, windowing operation is operated on the signal, and the local feature variable feature is obtained. $x(t)$ is sampled, and the discrete signal $x(n)$ is obtained, the width of rectangular window function $h(t)$ is $T = (2d+1)T_s$, $F_s = 1/T_s$ is used to describe the sampling frequency of radar signal, through the discrete operation, it can obtain $h(n) = 1, (n = -d, \ldots -1, 0, 1, \ldots, d)$. The power $\frac{1}{2d+1}\sum_{n_i-d}^{n_i+d} x^2(n)$ of $x(n)h(n-n_i)$ is the d scale power $E(n_i, d)$ of radar signal $x(n)$ at point $n_i T_s$.According to the setting step, the position of point $n_i T_s$ is adjusted, it makes the d scale power slide on the axis, the radar signal features are searched fully in the domain.

For a given wideband high resolution radar signal $x(n)$, the scale is d, assumed all d scale power of $x(n)$ can be represented by $\bar{E}(n_i, d)$ in average, the maximum value is $\max\{E(n_i, d)\}$, they are shown as E_0 and E_1 respectively, for real value $\mu \in [0,1]$,if $E(n_{i_0}, d) \geq (1 - f(\mu))E_0 + f(\mu)E_1$,

then, $E(n_{i_0}, d) \geq (1 - f(\mu))E_0 + f(\mu)E_1$. And $\lambda = \sup\{u \,|\, E(n_{i_0}, d) \geq (1-\mu)E_0 + \mu E_1\}$.

It shows that the point $n_i T_s$ is a λ level feature clustering point of radar signal $x(n)$ in scale d, $f(\mu)$ is the

variable μ ,it is from $[0,1]$ to $[0,1]$, it is a monotonically increasing function.

The function $f(\mu)$ can modify the level signal λ, the aggregation degree of signal characteristic is improved, point $n_{i_0}T_s$ is a level feature λ, $E(n_{i_0},d)\geq E_0$, at the same time, $E(n_{i_0},d)$ is large and close to the level value, in the range of radar signal partial characteristic quantity, it can ensure that the set point $E(n_{i_0},d)=E_0$, the radar signal $x(n)$ is a top level features, then $\lambda=1$, d scale feature clustering point can reflect the quantity accumulation qualification, the λ value is higher, the point features more gathered around.

According to the radar signal feature, the radar signal feature point shape model is constructed, and the operational radar signals are clustered in the high feature aggregation area, the wideband high resolution radar signal can extract the characteristic frequency band of signal, the process analysis of radar signal quantity accumulation and feature extraction can be expressed as follows:

(1) Compute the spectrum $p(\omega)$ of radar signal $x(n)$.

(2) Select the scale d, calculate the d scale power average value E_0 of power spectrum radar signal, the maximum value is E_1, the average value is E_0.

(3) In accordance with the requirements, the horizontal feature λ_0 of λ is selected, and the λ_0 horizontal feature clustering point of radar signal $p(\omega)$ is calculated.

(4) According to horizontal feature of λ_0, the feature model of radar signal is established in the frequency domain.

As above analysis process, the wideband high resolution features of radar signal are extracted, and the concept of level characteristic quantity accumulation is proposed, the scale factor and factor can control the signal characteristic quantity, it can improve the sensitivity and resolution of radar signal. According to the feature clustering radar signal feature analysis method, the feature relationship of high resolution radar signal is analyzed, and the artificial neural network algorithm is used to realize the detection of radar signal.

1.3 Artificial neural network algorithm and realization of detection algorithm

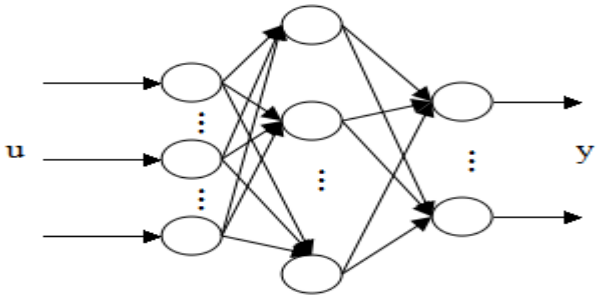

Fig. 1 Schematic diagram of the neural network

Neural network detection model takes three layers of BP neural network to realize the nonlinear mapping function of radar signal, it is shown in Figure 1, which is composed of input layer, hidden layer, output layer, each layer of the neural network realizes the connection of different layers. The input / output sample way is used to obtain the backward propagation learning algorithm. If the output layer obtain the expected output result, ending. Conversely, reverse propagation is carried out. By connecting the reverse operation error signal, the gradient descent method is used to modify each layer neuron weights and threshold, the error of radar signal is reduced. The algorithm process is expressed as follows:

(1) Assume that the initial weight $W(0)$ is the less random non-zero value.

(2) Given input / output signal samples, and thus the network output is obtained, the radar signal detection results are obtained. Assuming that the input / output results of p th sample are:

$$u_p=(u_{1p},u_{2p},\cdots,u_{np}),\ d_p=(d_{1p},d_{2p},\cdots,d_{np}),\ p=1,2,\cdots,L \quad (4)$$

When the P sample input, the output of node i is:

$$y_{ip}(t) = f[x_{ip}(t)] = f[\sum_j w_{ij}(t) I_{jp}] \quad (5)$$

Where, I_{jp} is used to describe the group p input, and jth output of node i is obtained, the function $f(x)$ get the S type function as the objective function, it is:

$$f(x) = \frac{1}{1+e^{-x}} \quad (6)$$

Through the hidden layer and output layer, the radar detection result is obtained, and the output of the network output layer nodes is optimized.

(3) Calculation of objective function J.

Assume that E_p is used to represent the objective function of p sample, L_2 is the norm, then:

$$E_p(t) = \frac{1}{2}\left\|d_p - y_p(t)\right\|_2^2 = \frac{1}{2}\sum_k [d_{kp} - y_{kp}(t)]^2 = \frac{1}{2}\sum_k e_{kp}^2(t) \quad (7)$$

Wherein, $y_{kp}(t)$ is the Pth sample in the input layer, after t weights adjustment, the network output is obtained, and the objective function of the total network is:

$$J(t) = \sum_p E_p(t) \quad (8)$$

2.4 *Experiment and result analysis*

In order to verify the validity of this method, we need the related experiments analysis, a stealth plane is selected as the target, the radar incident wave is horizontal polarization, and the radial radar signal resolution is 10cm, the length of the target is 2.1m. The wideband high resolution radar signal detection is taken with new method and traditional method, the wideband high resolution radar signal detection efficiency is shown in Figure 2.

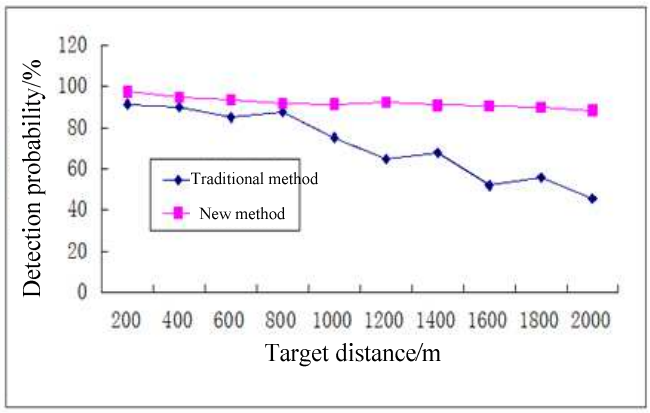

Fig 2 Signal detection performance

From figure 2, we can conclude that the detection efficiency of new method is better than the traditional method, the detection probability reach to 99%, and it has higher performance of radar signal detection. The detection performance results are expressed in Table 1. It shows that the new method is better than the traditional method, and it has good application value in practice.

Table 1 Detection results comparison

Method	Detection speed	Average error rate /%	Average detection rate /%	Average miss rate /%
Proposed method	Fast	3.7	95.8	4.2
Traditional method	Slow	7.6	72.5	13.5

CONCLUSION

In this paper, an improved high resolution wideband radar signal detection method is proposed based on feature analysis. A group of full range of wideband high resolution radar signal features is extracted for analyzing the wideband high resolution features of radar signal accurately, the concept of level feature quantity accumulation point

is proposed, the scale factor and level factor can control the signal feature quantity, the resolution and the sensitivity of the radar signal are improved, feature cluster analysis method is used in analyzing the radar signal, the feature relationship of high resolution radar signal is analyzed, the artificial neural network algorithm is used to realize the detection of radar signal. Experiment results show that the new method can improve the radar signal detection efficiency and accuracy.

Acknowledgments
The authors wish to thank the National Natural Science Foundation of China for contract 61001049, the foundation Research Funds for the Central Universities (ZYGX2011J013) and Opening Topic Fund for Key Laboratory of Computer Architecture(CARCH201103). And this work was also supported by Technology Project Foundation of Chongqing Education Committee(KJ131110),and Key Laboratory of signal and information processing Chongqing Three Gorges University, under which the present work was possible.

REFERENCES

[1] Liu Xiangdong. *Bulletin of Science and Technology*, 30(2): pp.161-163. **2014**
[2] GAO Zhichun, CHEN Guanwei, HU Guangbo, et al. *Computer & Digital Engineering*, 42(1): pp.14-18. **2014.**
[3] GUO Xiao-yan. *Computer Simulation*, 31(3):pp118-121. **2014**
[4] ZHENG Zhen, WANG Liyuan, ZHOU Yong. Chaos *Ship Electronic Engineering*, 33(5):pp 48-50. **2013**
[5] ZHANG Yan, REN An-hu. *Science Technology and Engineering*,; 12(22): pp.5645-5648. **2012.**