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THE TECHNOLOGY OF DETECTION OF LIFE CHARACTERISTIC SIGNALS BASED ON ELMAN NEURAL NETWORK

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ABSTRACT

The article through the analysis of time domain and frequency domain to the radar non-contact life-parameter signals and gain its characteristics of extremely low frequency, low SNR, and the easy submerged in strong clutter noise. This paper presents the algorithm of dynamic life signal detection based on Elman neural network. The practice shows that the Elman neural network can stored state inside through the united way. Gain the function of the dynamic features by feedback network. And achieve the purpose of dynamic modeling. The simulation results show that the system has the ability to adapt to the time-varying characteristic. And the better generalization it is and the higher practical value it will be.

Keywords: -*Neural Network, Signal Noise Raito (SNR), Clutter Noise, Detection*

1. INTRODUCTION

Artificial neural network is constituted with many of the neurons with nonlinear mapping capability, which is connected by weight coefficient. Artificial neural network has self-organizing, self learning ability, fault tolerance and robustness.

Elman is a kind of dynamic recursion feedback type neural network, Due to the increase of the layer of coupling in feedback, which makes its input and output can express the delay , the network has a memory function , This combination structure can make it in limited time with arbitrary precision and any function approximation, So it can be applied to the sequence analysis, system identification and control field. On the basis of knowledge, this paper puts forward adaptive detection algorithm of vital signs based on Elman neural network , the experimental results show that the algorithm can extract the good vital signs, which can maintain the signal good nonlinearity and unsteady characteristics.

2. ELMAN NEURAL NETWORK

Elman neural network contains network layer, hidden layer, input layer, output layer and state layer. Topological structure is presented as follows:

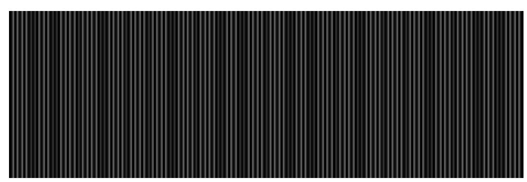

Figure 1 Elman Neural Network Topology Structure

The information need to identify from the input nodes into the network, and through calculation, from the variable weights into hidden layer node, the output of the hidden nodes should not only to output node and but also to state layer, finally from the output layer output recognition results, on the next moment, state layer will make the hidden layer node output value and the new input node output value to a hidden layer node. The state layer is a structure of the special unit. It is used to memory hidden layer unit before output value of the moment, which can be a delay operator. So, here the feed-forward connect can correct connection and fixed recursion part , namely which can't learn correction, to be specific, the output value of structure unit of K moment equals to the output of the hidden layer in K-1 moment and the output value of the K-1 moment of structure unit a times, namely.

$$X_{c,l}(k) = aX_{c,l}(k-1) + X_l(k-1) \quad l = 1,2,\ldots n \qquad (1)$$

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$X_{c,l}(k)$, $X_l(k)$ is the output of L structure layer unit and the L hidden layer unit, as the feedback gain factor of connection. The mathematical model of the network as follows:

$$y_k = \omega^3 x(k) \qquad (2)$$

$$x_c(k) = \alpha x_c(k-1) + x(k-1) \qquad (3)$$

$$y_k = g\left(\omega^3 x(k)\right) \qquad (4)$$

$f(x) = \dfrac{1}{1+e^{-x}}$, $g(x)$ is linear function.

Elman neural network learning rule: Set the K step of the output of actual as $y(k)$, $y_d(k)$ is output, error function as follows:

$$E(k) = \frac{1}{2}\left[y_d(k) - y(k)\right]^T \left[y_d(k) - y(k)\right] \qquad (5)$$

$E(k)$ as ω^1, ω^2, ω^3 respectively connection weights for partial derivative. Elman network algorithm by the gradient descent method:

$$\Delta\omega_{ij}^3(k) = -\eta_3 \frac{\partial E}{\partial \omega_{ij}^3(k)} = -\eta_3 \frac{\partial E}{\partial y_i(k)} \frac{\partial y_i(k)}{\partial \omega_{ij}^3(k)}$$

$$= \eta_3 \left[y_{di}(k) - y_i(k)\right] g_i(g) x_j(k) \qquad (6)$$

$$\Delta\omega_{jt}^2(k) = -\eta_2 \frac{\partial E}{\partial \omega_{jt}^2(k)}$$

$$= -\eta_2 \frac{\partial E}{\partial y_i(k)} \frac{\partial y_i(k)}{\partial x_j(k)} \frac{\partial x_j(k)}{\partial \omega_{jt}^2(k)}$$

$$= \eta_2 \left[y_d(k) - y_i(k)\right] g(g) \omega_j^3 f_j(g) u_t(k) \qquad (7)$$

$$\Delta\omega_{jl}^1(k) = -\eta_1 \frac{\partial E}{\partial \omega_{jl}^1(k)}$$

$$= -\eta_1 \frac{\partial E}{\partial y_i(k)} \frac{\partial y_i(k)}{\partial x_j(k)} \frac{\partial x_j(k)}{\partial \omega_{jl}^1(k)} \qquad (8)$$

$$= \eta_1 \left[y_d(k) - y_i(k)\right] g(g) \omega_j^3 f_j(g) x_{cl}(k)$$

$\Delta\omega_{ij}^3(k)$, $\Delta\omega_{jt}^2(k)$, $\Delta\omega_{jl}^1(k)$ respectively is hidden layer to the output layer, input layer to the hidden layer, connected layer to the hidden layer of the weights of change. i, j, t, l is defined as output layer respectively, hidden layer, input layer and connection layer neuron nodes number. η_1, η_2, η_3 is defined as Learning rate of ω^1, ω^2 and ω^3.

3. THE FILTERING SYSTEM

Elman neural network consists of the adaptive signal offset system structure as follows:

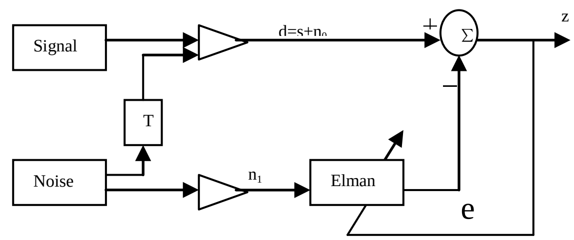

Figure 2 Elman Neural Network Adaptive Signal Offset System

In this system, d is the original input signal including useful signal s and noise signal n_0, the noise signal n_1 as reference signal. Hypothesis, the output signal is y through adaptive filter, So, The output signal based on neural network adaptive Elman offset system as follows:

$$z = s + n_0 - y \text{, so, } z^2 = s^2 + n_0^2 - y^2 \qquad (9)$$

Elman neural network design steps as follows:

1) Input and output layer

Use the Elman neural network model as recognition classifier, its input node number as the characteristic vector of the dimension. In this paper, the dynamic signal preprocessing living organisms, including short-term energy maximum, short-term zero rate maximum and MFCC parameters of the characteristic value, which is formed 12 features vector.

2) Hidden and link layer

Hidden layer node is one important parts of neural network design, too little hidden unit number can't produce accurate features samples. Poor fault tolerance, too much hidden unit number can lead to too big network size, complicated structure, and sometimes don't converge.

Hidden layer node will lead to divide carefully in the feature space, the network's decision surface will contain only the training sample, lead to the

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network without judgment, may reduce the training sample outside the recognition rate of samples, resulting in over training. After repeated experiments, hidden layer node number is elected 13.

3) The selection of initial weights

Before Elman network learning, network must be initialized due to the system is nonlinear, initial value of learning lies in the condition that whether it meets the local minimum, the length of time training and whether there is a convergence of the relationship and whether it is very big, and an important condition is that it is close to zero after the initial weighted each neuron output values. So that it can ensure each neuron weight can change to keep the most regulated in their S type activation function.

4) Learning rate Settings

Learning rate determines weights variation of the each cycle training produced, if learning rate is set too big to lead to instability. If learning rate is set too small to lead to network convergence speed slowly, training time increase greatly. But the small learning rate can guarantee network point error is not jump out error low surface, and finally tend to be the minimum error value. So, we tend to choose smaller learning rate to ensure the stability of the system in the application. In order to make neural network be generalization ability of strongest and most of ideal of weights and threshold, we will choose 5000 times to train in the paper. Training convergence curve as follows:

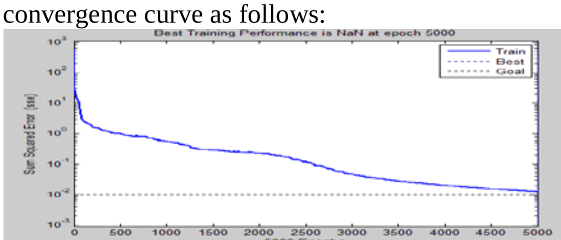

Figure 3 Training Convergence Curve

5) The choice of expect error

If expect error setting is too small to slow network convergence speed, even can't converge. If expect error setting is too large to speed network convergence, but wrongly convicted, rate will be increased. In neural network training process, expect error usually select the several different expectations error of training, and finally the effect of these networks contrast, should be used to determine the actual the expectations of the error.

4. ALGORITHM SIMULATION

In the paper the two process simulation are tested. First, we do pretreatment and mathematical modeling of vital signs by life radar detected. Second, the signal through Elman neural network is an adaptive offset system for processing.

The basic task of the moving object detection is to distinguish and restrain fixed clutter and detection target echo according to the difference spectrum of target of echo and clutter in the frequency domain and time domain. By establishing the reasonable signal model, make clear target signal and noise of the spectrum characteristics, so that, they can better detect.

Echo signal also include clutter and the objective existence of the signal noise and so on, on the analysis of energy of these signals in the time domain and frequency domain, Radar echo signal include two kinds of clutter and a fixed object moving objects clutter, including surface features, the sea, and the human impact and cloud interference, etc.

Analysis of clutter and noise data acquisition of radar exploration 40 cm thick across the wall through launched of electromagnetic wave. Do histogram to clutter signal, figure 4.1 is a sampling clutter signal histogram. Figure 4.2 is histogram of gauss random function which is produced by MATLAB simulation for 8000 points. Comparison chart 4.1 and 4.2, two figure waveform are basically the same visibly. We can also get the same result for more paragraphs clutter do the same experiment data. In conclusion, this paper studies clutter of function which is accord with the form of the Gaussian distribution.

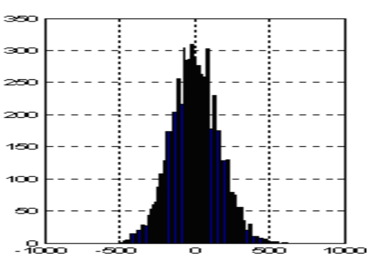

Figure 4.1 Real Clutter The Histogram

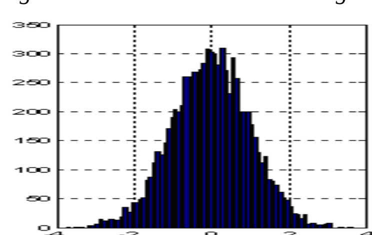

Figure 4.2 Gaussian Distribution Histogram

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Clutter spectrum diagram as follows:

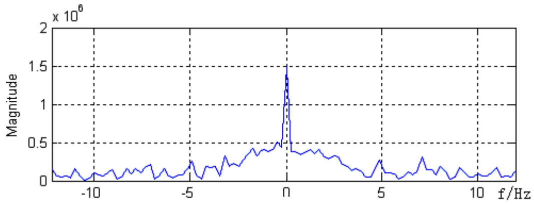

Figure 5 Clutter Spectrum Diagram

According to the above analysis, clutter model obey of Gaussian distribution, and the power spectral density function is the form of Gaussian noise expressed as:

$$C(f) = W_0 \exp(-\frac{f^2}{2\sigma^2}) \qquad (10)$$

The probability density obey of Gaussian distribution , the power density of Gaussian spectrum of clutter signal approximate can be seen as Gaussian white noise of variance σ_0^2 through a linear filter. The amplitude frequency characteristics of the filter as follows:

$$H(f) = \frac{1}{\sqrt{\sqrt{2\pi}W}} \exp(-\frac{f^2}{4W^2} + j\varphi) \qquad (11)$$

W Filter factor is corresponding to the clutter of the Gaussian form of power spectrum degree. Clutter the power spectral density function can be written as the following form:

$$c(f) = \sigma_0^2 \left|H(f)^2\right| = \frac{\sigma_0^2}{\sqrt{2\pi}W} \exp(-\frac{f^2}{2W^2}) \qquad (12)$$

Clutter power for expression as:

$$\begin{aligned} p_n &= \int_{-\infty}^{+\infty} c(f)df \\ &= \frac{\sigma_0^2}{\sqrt{2\pi}W} \int_{-\infty}^{\infty} \exp(-\frac{f^2}{2W^2})df \\ &= \sigma_0^2 \end{aligned} \qquad (13)$$

Analysis and mathematical modeling of the human body move signal through the radar detectors acquisition. Because of the individual's situation is different, walking around in the frequency of the signal range [10 Hz, 30 Hz], we can see signal containing the Gaussian distribution of high frequency noise and clutter interference based on frequency analysis.

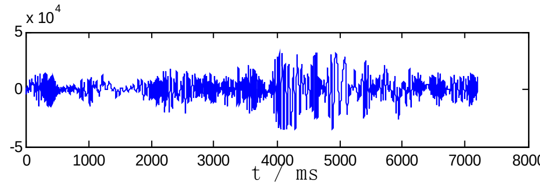

Figure 6 The Human Body Dynamic Signal Time Domain Figure

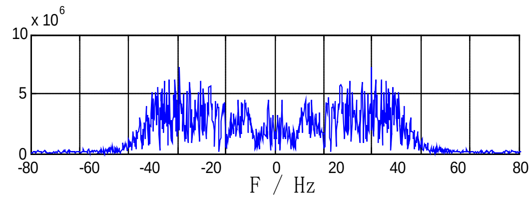

Figure 7 The Human Body Dynamic Signal Frequency Figure

In order to validate the adaptive Elman neural network algorithm is effective. The following is a sampling rate for 500 Hz, sampling points for 4096 point of human body dynamic signal data after Elman neural network adaptive cancellation system simulation diagram:

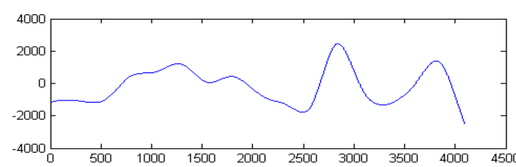

Figure 8 Through The Adaptive Elman System Time Domain

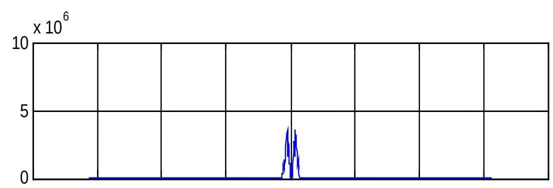

Figure 9 Through The Adaptive Elman System Frequence Figure

Figure 6 about human body signal sampling data graphics, can see the signal completely submerged in strong clutter background. Figure 8 and figure 9 is based on the Elman neural network adaptive cancellation system of time domain and frequency domain graph, we can clearly see the adaptive Elman neural network algorithm can effectively and accurately realized human body dynamic signal detection and extraction of the characteristic signal in strong clutter and low SNR.

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The experiment result shows system can completely extract signal from the noise drown, and the amplitude basic unchanged. This shows, the adaptive noise Elman of the design idea is completely feasible, and the de-noising effect is very satisfied. Signal detection provides a new train of thought and method for solve nonlinear time-varying online, and has some of the feasibility and availability.

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