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Detection of static life characteristic signals based on fuzzy neural networks

JianJun Li*, JianFeng Zhao
Information engineering college of Inner Mongolia Science and Technology University, Baotou, 014010, (CHINA)
E-mail : xidianjj@163.com

ABSTRACT

Life parameters signal has characteristics of extremely low frequency, low signal-to-noise ratio, and the easy submerged in strong clutter noises. How to extract the characteristic parameters of life is a problem. This kind of problem can be widely used in non-contact medical ward, and also puts forward a new direction for weak signal detection. The method for detecting life signal based on fuzzy neural network, which is proposed via taking full advantage of processing fuzzy information of the fuzzy pattern recognition and self-learning of the neural network (NN) pattern recognition. Simulated results show that the method not only can completely descript life signals in the time-frequency domain, but improve the signal-to-noise ratio and the ability of detecting algorithm. Moreover, the method is effective and practical.

KEYWORDS

Fuzzy neural network;
SNR;
Self-learning;
Feature detection.

INTRODUCTION

In signal processing area, people often used to hypothesis signals or noise to obey the Gaussian distribution, but Gaussian distribution is just one of the many distribution types, the non-Gauss signals is more general signal, in actual work, often have to face a lot of non-Gaussian, non-minimum phase, the cause and effect, the non-stationary with the problem.

The merit of fuzzy pattern recognition is the ability of fuzzy information processing or uncertain information processing, and the advantage of NN pattern recognition is the self-learning capability and the automatic recognition, so combining the fuzzy method and the NN, a new FNN pattern recognition method is proposed for automatic processing the fuzzy information. Because of the method can very well display their respective advantages. In this paper, a FNN pattern recognition method is put forward to recognize the noise signal, which need not assume the unknown signal with Gaussian distribution, can extract life characteristic signal.

The algorithm can to deal with the simulation experiments show that the method need not be waiting in the signal of the prior knowledge, can extract life parameters signal drown in strong clutter noises. A conclusion that the method is feasible and effective.

FUZZY NEURAL NETWORKS

Fuzzy neural network is usually defined as the NN

which introduce the fuzziness concepts and fuzzy reasoning, or the fuzzy system based on NN. The former introduce fuzzy element to NN, and it improves the ability and flexibility. There are two forms: fuzzy operator is introduced into the NN and the function of NN is further increased by fuzzy logic. The latter realize fuzzy system by the connection structure of NN; meanwhile according to self-study ability of NN, it will be used for the parametric learning of fuzzy system.

This paper adopts a FNN method: it expresses the fuzzy system by the connection structure of NN, meanwhile realize the parameter optimization of the fuzzy system rules by the self-learning function of NN. As mentioned above the NN is not a black-box, that all nodes and parameters of the NN have certain significance, that is to say that it has a correspondence with the membership function or reasoning process of fuzzy system. As shown in Figure 1.

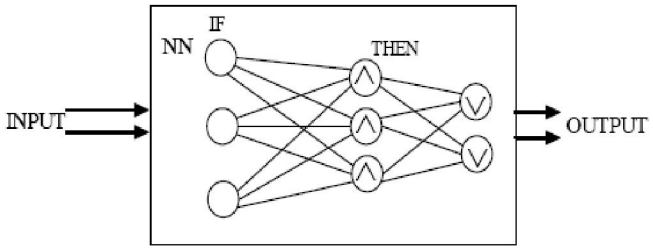

Figure 1 : The type of structure equivalence

An approach to construct structure equivalence NN based on fuzzy system.

Let the fuzzy system with n input and one output, whose input variables are $(x_i, i = 1, 2, ..., n)$ and output variable is y. Then fuzzy sets can be expressed as:

$$x_i : x_{i1}, x_{i2}, ..., x_{in} \quad i = 1, 2, ..., n$$

$$y : y_1, y_2, ..., y_{n_y} \tag{1}$$

Fuzzy rule is defined as:

$$x_1 \in A_1^j, x_2 \in A_2^j, \cdots, x_n \in A_n^j,$$

$$y \in B^j, j = 1, 2, \cdots, R, \tag{2}$$

Where $A_1^j, A_2^j, ..., A_n^j$ and B^j are fuzzy sets, and

$$A_i^j \in \{x_{i1}, x_{i2}, ..., x_{in}\}, i = 1, 2, ..., n; j = 1, 2, ..., R$$

$$B^j \in \{y_1, y_2, ..., y_{n_y}\} \tag{3}$$

Generally, we may choose the trapezium membership function as B^j, in other words, the value of the function is a constant in certain range. So based on the above description, the fuzzy rule may be defined as:

If $x_1 \in A_1^j, x_2 \in A_2^j, \cdots, x_n \in A_n^j,$

$$y \in y^j, j = 1, 2, \cdots, R, \tag{4}$$

Where $y^j \in \{y_1, y_2, ..., y_{n_y}\}$ and y_i is a constant.

The output value of the fuzzy system will be computed by the formulas as follows:

$$y = \frac{\sum_{j=1}^{R} \mu_j y^j}{\sum_{j=1}^{R} \mu_j} \tag{5}$$

Where $\mu_j = \mu_{A_1^j}(x_1)\mu_{A_2^j}(x_2)\cdots\mu_{A_n^j}(x_n)$ (6)

Based on the above description about the fuzzy system, we can describe the feedforward NN by Figure 2.

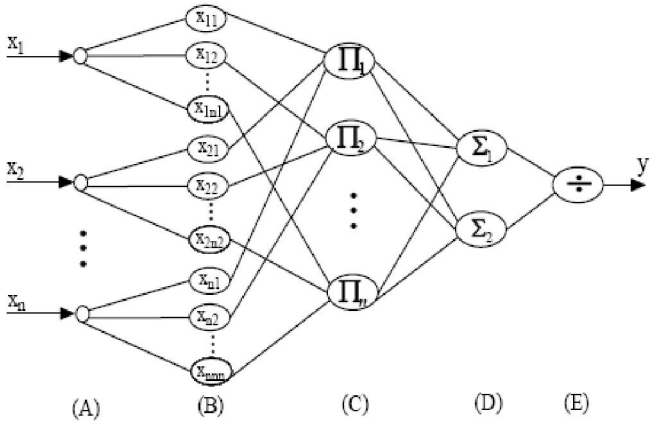

Figure 2 : The neural network of structure equivalence

Thus we may turn a fuzzy system into a NN. The NN is composed of five layers ((A)-(E)), which the (A) is input of layer, the (E) is output of layer. The (B) is corresponding to the fuzzy sets of the fuzzy system conditions, whose outputs are the corresponding membership degrees of the input variables. The (C) may realize the function of the fuzzy sets operators, whose output value is applicable extent of every rule with (2-6). The (D) will compute the value of the numerator and denominator by (2-5). It will realize the defuzzification of function along with (E).

The nodes in the network different form the usual neurons, which x_{ij} may be a usual neuron or a small network that is formed with more than one neuron. The node of $\prod_j$ is a multiplier, whose output value is the

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product of all inputs, and the node of ÷ is a division, whose output value is the quotient of two input quantities.

FEATURE DETECTION ALGORITHM BASED ON FNN

The realization of pattern recognition of static characteristic of life signal can be divided into the following steps:

Step1. Determine the characteristic vector for pattern recognition.

Step2. Determine the quantification levels for recognition.

Step3. Establish the fuzzy rules.

Step4. Establish fuzzy inference rules.

Step5. Determine the applicable extent of fuzzy infer ence rules.

Step6. Based on the formula (5) calculate the output result:

In this paper, the FNN pattern recognition system (as shown in Figure 3) contains two fuzzy system, whose fuzzy rules:

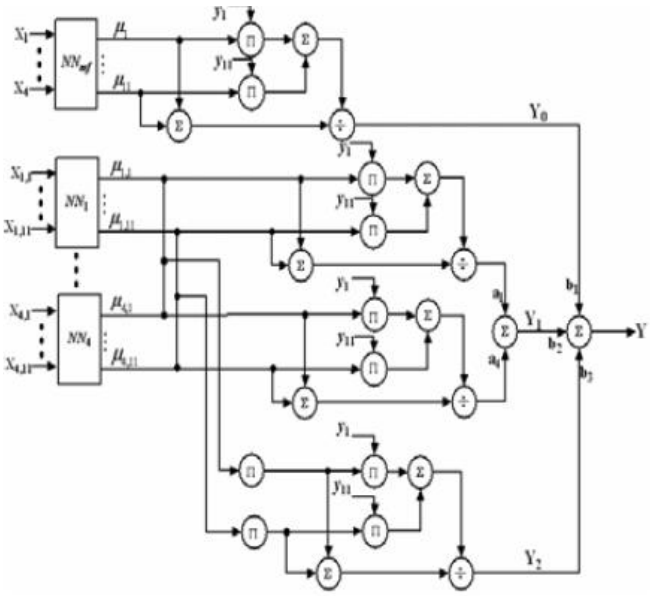

Figure 3 : The fuzzy system based on neural network

1) The inputs of first fuzzy system are four eigenvector, and the output is the degree of life characteristic vector. The degree of characteristic vector is recognized by four eigenvector as a whole in the fuzzy system. The output result of NN_{mf} is applicable extent of fuzzy rule $(\mu_1, \mu_2, \cdots, \mu_{11})$.

2) Every eigenvector as the input of second fuzzy system recognize the degree of life characteristic vector.

The aim of the fuzzy system is to study exact degree of the life characteristic vector recognition as the basis of weight value adjustment. The output results of NN_1, NN_2, NN_3 and NN_4 are applicable extent of fuzzy rule of every eigenvector, which is $(\mu_{1,1}, \mu_{1,2}, \cdots, \mu_{1,11})$, $(\mu_{2,1}, \mu_{2,2}, \cdots, \mu_{2,11})$, $(\mu_{3,1}, \mu_{3,2}, \cdots, \mu_{3,11})$ and $(\mu_{4,1}, \mu_{4,2}, \cdots, \mu_{4,11})$.

Based on BP networks in the five FNN systems, the inputs are different neuron, the numbers of the hidden layer and the neuron of hidden layer may be adaptively tuned. As mentioned above the applicable extent of fuzzy rule is actually the corresponding membership degrees of every life characteristic vector degree which y $(y_1 = 1, y_2 = 0.9, \cdots, y_{11} = 0)$ is the life characteristic vector degree level.

The recognition result of life characteristic vector degree is calculated through the formulas (5). The concrete calculation method is:

1) By four eigenvector as a whole, we can calculate the characteristic vector degree (Y_0) using output of NN_{mf} and the characteristic vector degree levels $(y_1 = 1, y_2 = 0.9, \cdots, y_{11} = 0)$.

2) Calculate the characteristic vector degree by the output results of four BP NN ($NN_1 0 NN_2 0 NN_3$ and NN_4), then adjust the weight values (a1, a2, a3 and a4), and obtain the characteristic vector degree (Y_1) by recognizing every eigenvector.

3) By doing multiplication for the output results of the four BP NN ($NN_1 0 NN_2 0 NN_3$ and NN_4), we can obtain the union of the fuzzy rule's applicable extent, then calculate the characteristic vector degree (Y_2).

4) In order to obtain the output (Y) of the FNN pattern recognition system, we should consider the important degree of three recognition results to adjust the weight values (b1,b2 and b3), then calculate the result (Y_3) of characteristic vector degree recognition.

ALGORITHM SIMULATION AND ANALYSIS

In the paper the two process simulation is tested. The first, we do pretreatment and mathematical model-

ing of vital signs by life radar detected. The second, the signal through parallel filter bank and the higher order statistics detection system for processing.

Signal modeling and analysis

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 detection.

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 2 is a sampling clutter signal histogram. Figure 3 is Clutter spectrum diagram.

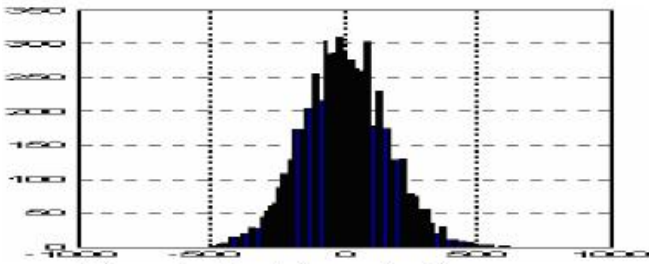

Figure 4 : Real clutter the histogram

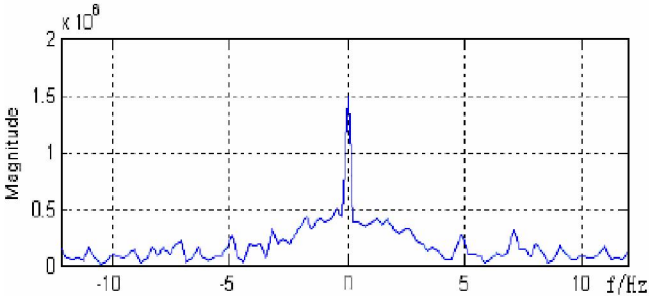

Figure 5 : Clutter spectrum diagram

Clutter spectrum diagram as follows:

FNN algorithm

Time domain and frequency pretreatment analysis is done to the sampling signal, we can gain signal containing the high frequency noise and clutter interference based on frequency analysis. The Figure 6 is the life signal time domain analysis. ThguFiu re 7is the life signal frequency domain analysis, among them the frequency -50 Hz and frequency 50 Hz place for a strong bumps clutter signal.

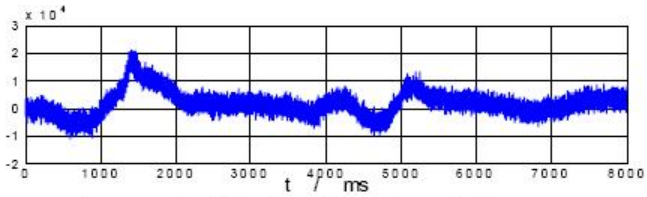

Figure 6 : The life signal time domain figure

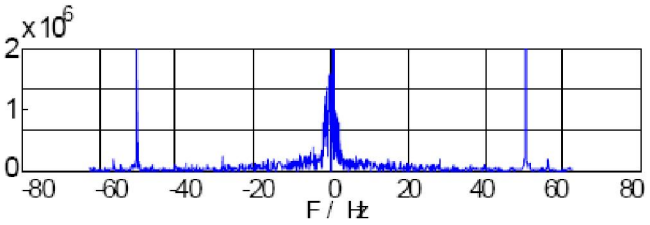

Figure 7 : The life signal frequency figure

In order to validate the FNN algorithm is effective. The following is a sampling rate for 1000 Hz, sampling points for 8000 point of life parameters signal data after parallel filter bank and the higher order statistics system simulation diagram:

Figure 6 about life parameters signal sampling data graphics, can see the signal completely submerged in strong clutter background. Figure 8 and Figure 9 is through FNN system of time domain and frequency domain graph, we can clearly see the algorithm can ef-

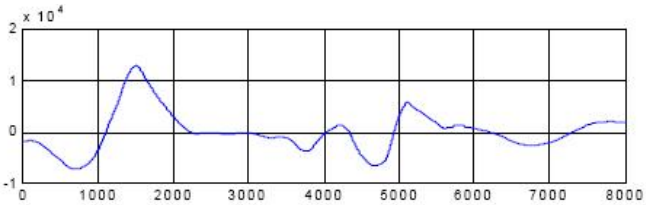

Figure 8 : Through the FNN system time domain

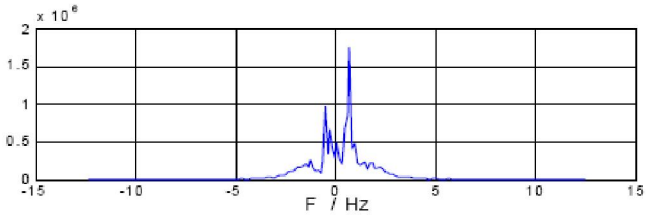

Figure 9 : Through the FNN system frequence figure

fectively and accurately realized the life signal detection and extraction of the characteristic signal in strong clutter.

The experiment result is shown the system can completely extract signal from the noise drown, and the amplitude basic unchanged and improve signal-to-noise ratio. This show, the design idea of FNN 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 the feasibility and availability.

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