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The Research of Adaptive Noise Cancellation Technology Based on Neural Network

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***Abstract*—Noise cancellation technology is one of the major problems of signal processing. Adaptive noise cancellation technology, based on neural network, is a good kind of signal processing technology, which can eliminate noise from unknown noise resources. The technology shortage of the traditional adaptive noise cancellation is overcome. Noise cancellation technology becomes one of hot research topic in the field of the current signal processing technology. By studying multilayer feed-forward artificial neural network of the back-propagation learning algorism, an adaptive noise cancellation based on artificial neural network is established, combining traditional adaptive noise cancellation system of basic principle. Experiments based on the Matlab Simulink prove it has strong noise filtering ability. Finally, this paper puts forward the method and algorithm of further improvement.**

Keywords—Adaptive Filter; Noise Cancellation; Neural Network

Ⅰ. THE RESEARCH SIGNIFICANCE OF ADAPTIVE NOISE CANCELLATION AND ITS DEVELOPMENT

The noise cancellation is one of the important problems in signal processing. The paper outlines the basic principles of adaptive noise cancellation and neural network, studies the adaptive noise canceling based on BP neural network. On the basis of the noise canceling features and external factors, we will build noise offset forecast model and use MATLAB to simulate.

Ⅱ. ADAPTIVE NOISE CANCELLATION

A. Adaptive filter

The adaptive filter emergences since the 1960s and its theory is continuously developing and improving. The block diagram of the adaptive digital filter is shown in Fig 1.

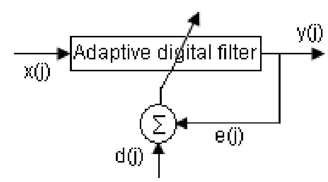

Figure 1 adaptive digital filter block diagram

B. The basic principle of adaptive noise canceling system

The system in Fig 2 is a typical adaptive noise canceling system, in which the original input signal d (k) is made up of the useful signal s (k) and the noise z (k).The reference input signal x (k) is noise c (k) which related to z (k) . Assume that S (k), z (k) and c (k) is zero-mean stationary random process and signal s (k) and z (k), c (k) is not relevant. As we known from Fig 2, the output z '(k) of the adaptive filter is the filtered signal c (k). So y (k) is the output of adaptive noise cancellation system.

$$y(k)=s(k)+z(k)-z'(k) \quad (1)$$

$$y^2(k)=s^2(k)+[z(k)-z'(k)]^2+2s(k)[z(k)-z'(k)] \quad (2)$$

$$E[y^2(k)]=E[s^2(k)]+E[(z(k)-z'(k))^2] \quad (3)$$

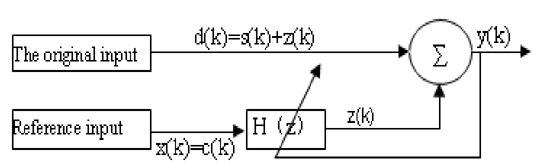

Figure 2 A typical adaptive noise canceling system

In the ideal state z(k)= z′(k), then y(k)= s(k).This time,

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the adaptive filter automatically adjusts its impulse response and c(k) is processed into z(k) and subtracts the z (k) of original input signal d (k).The output signal y (k) was completely offset by the noise and is equal to the useful signal s (k).

It can be proved that a necessary condition for the adaptive filter to accomplish the above tasks: the reference input signal x (k) =c (k) must be related to the signal (noise) z (k) that been offset.

C. The improvements of adaptive noise canceling system

In fact, a noise canceling system is more complex than that shown in Fig 2.The reason is that the input may also have a number of independent noise sources (noise and interference not related to the reference input),as is shown in Fig 3.

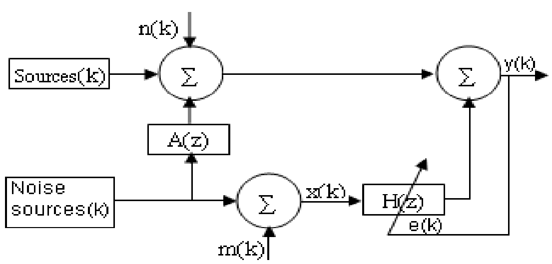

Figure 3 Adaptive noise canceling system

III. THE BASIC CALCULATION PRINCIPLE OF BACK-PROPAGATION LEARNING ALGORITHM

Back-propagation algorithm (BP algorithm) is the basic method of training artificial neural network and is been widely used. Take three-forward artificial neural network which the output layer contains only a neuron for example, the basic computing principles and processes [09] is shown in Fig 4.

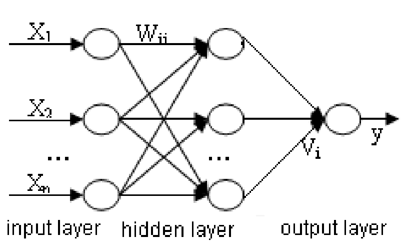

Figure 4 Output layer contains one neuron three-layer feed forward neural network

The input of each neuron of the hidden layer is Ii.

$$I_i = \sum_{j=1}^{n} W_{ij} X_i - \theta_j \,, \quad i = 1, 2, \cdots, m \tag{4}$$

Xi as the input of the neurons in the (4) and Wij is the connection weights between neurons i in the hidden layer and j in the input layer neurons. θi is the threshold of hidden layer neurons. Selecting Simoid function as stimulated function f () in the hidden layer neurons and then the hidden layer neurons output is O_i .

$$O_i = \frac{1}{1+e^{-I_i}} \tag{5}$$

Taking O as the output layer neuron threshold value from the (5) and taking a linear function as excitation function of the output layer neuron and namely the output of the output layer neuron or network output is y.

$$y = \sum_{i=1}^{m} V_i O_i \tag{6}$$

V_i is the connected the right between output layer neurons and hidden layer neurons i in the (6).

Has a learning sample (X1p,X2p,…,X1p;tp) (p = 1,2, ..., p is the number of samples), a sample (X1p,X2p,…,X1p;tp) and given network vector output value yp. For the sample p, define the network output error is the d_p .

$$d_p = t_p - y_p \tag{7}$$

And define the error function is the e_p .

$$e_p = \frac{1}{2}(t_p - y_p)^2 \tag{8}$$

The value of W is given randomly, therefore, after obtaining the network output value y_p, the error defined by the（7）is high, which means that the network's accuracy is not high. In case of determining the number m of network hidden layer neuron, only by adjusting the value of W, to gradually reduce the error d_p so as to improve the calculation accuracy of the network. The following gives specific calculation process that W is adjusted according to the information d_p. In the back-propagation algorithm, we change the value of W along the error function e_p with the negative gradient of W. Let W be the amendment of W.

$$\Delta W = -\eta \frac{\partial e_p}{\partial W} \qquad (9)$$

Ⅳ. NOISE CANCELLATION SYSTEM SIMULATION

A BP neural network learning and training based on the neural network toolbox

After 4000 times training, the error is to 0.001 shown in Fig 5. Function approximation curve can be seen that the output curve is very close to the target curve and proved that the network after the training has a better fit.

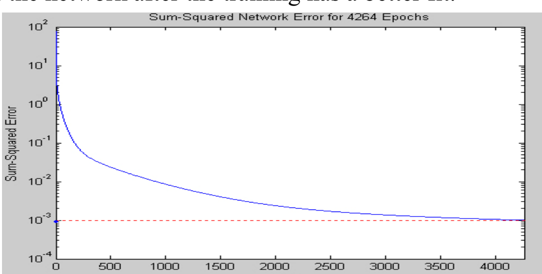

Figure 5 Error curve

The draw function approximation curve is shown in Fig 6.

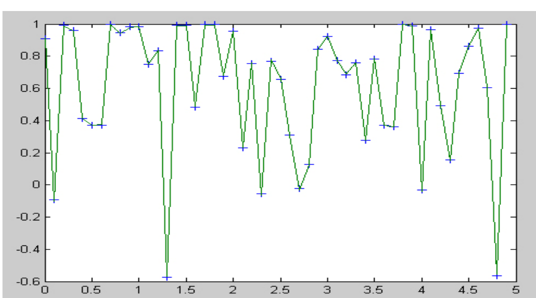

Figure 6 Function approximation curve

B. Based on the noise canceling system design of the simulink and dynamic simulation

We can observe the ideal signal with an oscilloscope , as well as the noise source signal and noise canceller output. The control input signal is shown in Fig 7 and the affected noise signal is shown in Fig 8 .The adaptive noise cancellation signal as shown in Fig 9 can be seen that adaptive noise canceling system has played a good role. Scope5 outputs noise signal shown in Fig 10 and scope4 outputs noise signal effected shown in Fig 11 and scope3 for the processed noise signal shown in Fig 10. It can be seen that Fig 11 and Fig 10 is similar.

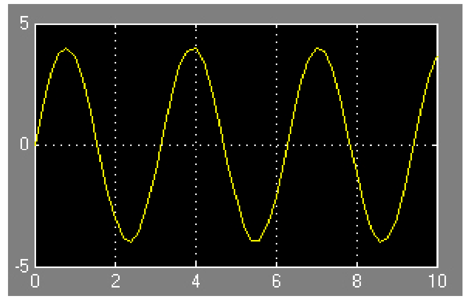

Figure 7 The ideal signal(scope)

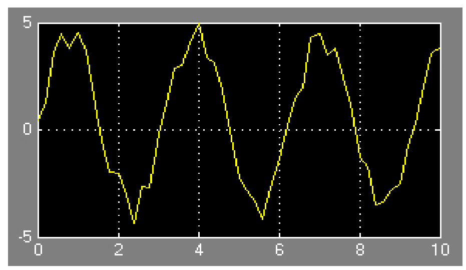

Figure 8 The noise source signal (scope1)

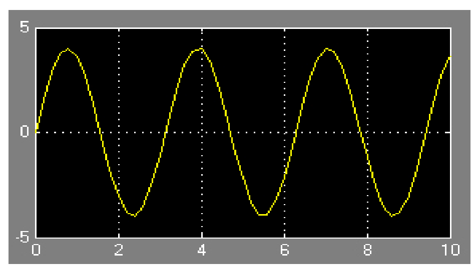

Figure 9 Noise offset output (scope2)

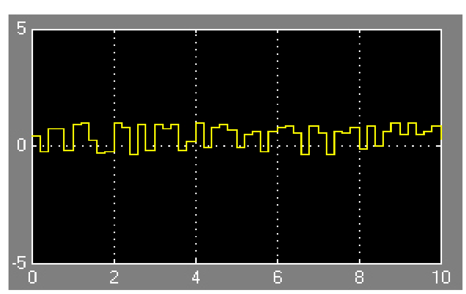

Figure 10 Condition Monitoring signal Scope3

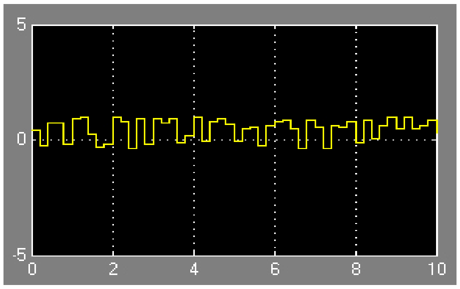

Figure 11 Status monitoring signal Scope4

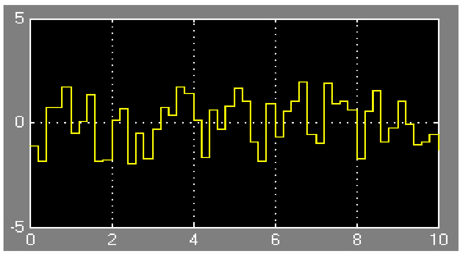

Figure 12 Status monitoring signal Scope5

Simulink constructed a comparison system of removing noise shown in Fig 13. Removal the network module (subsystem) shown in Fig 9.On condition that others is unchanged , scope output shown in Fig 7 remains unchanged. Scope1 output shown in Fig 8 remains unchanged and .Scope4 output shown in Fig 11 remains unchanged and Scope5 output remains unchanged, as shown in Fig 12. Scope3 output remains unchanged, as shown in Fig 12 .Scope2 output is shown in Fig 14. After contrasting the output image, we can find that in the case of no adaptive noise canceling system to process the signal is incorrect. Scope3 is very different from scope4.

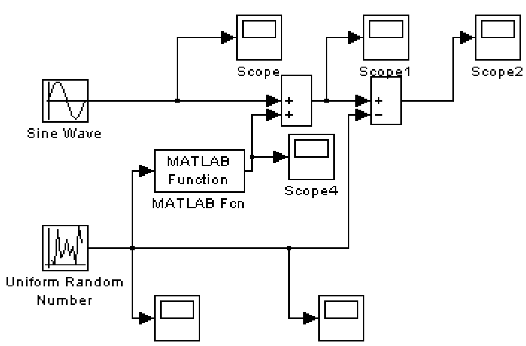

Figure 13 No subsystem

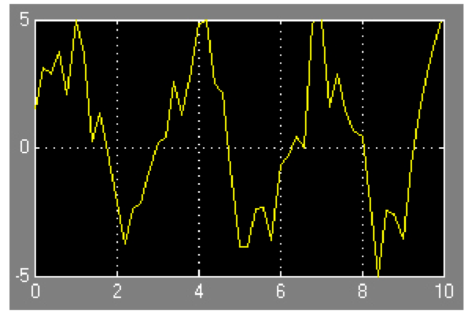

Figure 14 Contrast to noise offset the output of the BP network module（scope2）

By comparing the experimental results, adaptive noise canceling system based on neural networks achieves the desired results. It filters out the noise effectively to maintain the original characteristics, indicating that the application of neural networks in the field of adaptive noise cancellation is very meaningful.

Ⅴ. CONCLUSION

The paper demonstrates how to use the neural network function in the MATLAB for signal filtering processing. The experimental results show that the adaptive noise cancellation based on neural network can effectively remove the noise and have good performance. With the promotion of the ANC method in the application, there are also some improved methods.

Ⅵ. ACKNOWLEDGMENT

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REFERENCES

[1] Muhammad Ridyanto, and Hajimeno Buhara,“Improving recognition and Generalization capability of Back-propagation using a self-organized Network Inspired by Immune Algorithm,” Applied Soft Computing, vol.6, pp.72-84, June 2008

[2] Alexander ST,Adaptive Signal Processing．Newyork：SPinger —verlag，1996．

[3] R L HSU, M Abdel-Mottaleb, and A K Jain, “Face detection in color images,” IEEE Trans on Pattern Analysis and Machine Intelligence, vol.24,NO.5, pp.696-706, August 2002

[4] HOLENDA B.DOMOKOS E, REDAY, “Dissolved oxygen control of the activated sludge wastewater treatment process using model predictive control,”Computers and Chemical Engineering, vol.32,NO.6, pp.1270-1278,Dec 2008

[5] Zhang Pin-zheng, Shu Hua-zhong, “A neural networl and wavelet based face detection method,”Joural of Circuits and Systems, vol.12, No.1, pp.55-61,Februry 2007