Research of Improving Temperature Measurement Accuracy based on Neural Network

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Abstract

A new method is adopted in this paper. In order to improve the measurement precision, Radial basis function(RBF) neural network and Intelligent Temperature Sensor DS1822 is used to compensate the temperature in the pressure measurement.RBF network has a good nonlinear mapping ability, self-learning and generalization ability of the collected sample data training constitute a double-ended input, single-ended output network model, using an improved algorithm to achieve the measurement accuracy.

Keywords

temperature compensation, RBF neural network, DS1822.

1. Introduction

Temperature measurement and compensation in various fields of engineering, agriculture and national defense construction is great of significance in the industrial automation monitoring and control site, the ambient temperature change is impermanent, and most of the sensor has high sensitivity to temperature, so ambient temperature the changes will cause the sensor offset and sensitivity to be affected by a measurement error, so the temperature detection and compensation issues is an important part of industrial automatic control system.

With the development of science and technology, temperature measurement and compensation become more intelligent, and a variety of sensors with temperature compensation requirements.

This article describes the use of digital temperature sensor for temperature measurement and compensation of AK-4 pressure sensors, and the use of radial basis function to form a neural network, so as to achieve more accurate measurements.

The digital temperature sensor DS1822 digital temperature sensor chip based on single-bus technology, which is a signal line and a return line for Internet communication ICs. Use it to constitute a mini-LAN system, which is characterized by rapidity and low cost. Suitable for on-site implementation to use.

2. DS1822 Bus Interface Circuit

DS1822 digital sensor to measure temperature direct conversion frequency, and then use the clock to count thermometry, the count clock is generated by the low temperature coefficient oscillator stable, working state, while the count gate cycle is a high temperature coefficient oscillatordecision. The gates open during the count state, when the count value reaches 0, the temperature register by 1, while on the clock counting, pulse nonlinear correction to obtain a higher resolution temperature measurement. Also changed the number of temperature quantify the level of size, to obtain different resolution. DS1822 bus interface circuit shown in Figure 1.

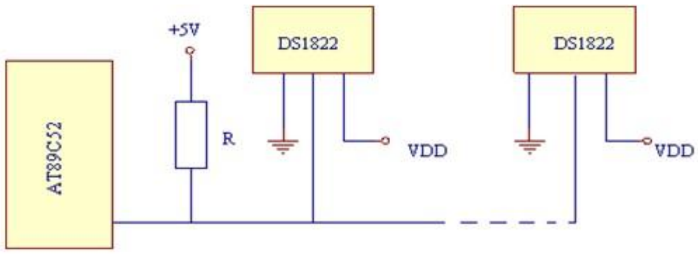

Figure 1 DS1822 bus interface circuit

DS1822 bus interface circuit working current is 1.5 mA, do not need to external components, this experiment in order to ensure that the measuring precision and reliable method of the external power supply.

3. RBF neural network

RBF is the radial basis function neural network, and its structure is shown in figure 2.

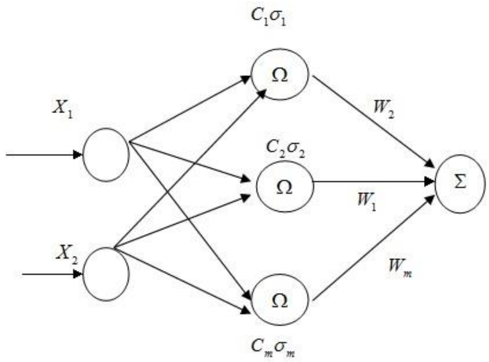

Figure 2 Radial RBF neural network structure

It is very easy to be extended to multi-output point of the case, consider an output in this situation. RBF has an input layer, one hidden layer, an output layer of the simplest model is a good performance to the network, with the best approximation capability of neural networks. The structure of the output of a right to a straight line relationship between the training method is fast and easy, there is no local optimum characteristics. Consider the current state of the time change, the network parameters of the previous time k-1 included. Set up the network input nodes, hidden layer node m output nodes is 1, the algorithm flow is as follows:

$$y = f(x) = w_0 + \sum_{j=1}^{m} w_j \Phi(\| X - C_j \| \sigma_j) = \sum_{j=1}^{m} w_j l_x p(-\frac{\| X - C_j \|^2}{2\sigma^2}) \qquad (1)$$

where, m is hidden node number, ‖.‖ is Europe norm. w_0 Is a replacement. X , $C_j \in R_n$, w_j is the first j a base function and output the weights between nodes.

The error function produced for:

$$J = \frac{1}{2}\varepsilon(wk)^2 = \frac{1}{2}(Y(k) - Y(w,k))^2 \qquad (2)$$

$Y(k)$ is the hope that the output value, $Y(w,k)$ for network real output, w for the network of ownership of the vector.

Hidden layer-output layer weights between the adjustment of the matrix algorithm for:

$$w(k+1) = w(k) + \mu(k)(-\frac{\partial J(w)}{\partial w}) \mid w = w(k) + \alpha(k)(w(k) - w(k-1)) \qquad (3)$$

Hidden layer for the adjustment of the center matrix algorithm:

$$C(k+1)=C(k)+\mu(k)(-\frac{\partial J}{\partial C})\,|\,c=c(k)+\alpha(k)(c(k)-c(k-1)) \quad (4)$$

Hidden layer of standard deviation matrix algorithm adjusted for:

$$\sigma(k+1)=\sigma(k)+\mu(k)(-\frac{\partial J}{\partial \sigma})\,|\,\sigma=\sigma(k)+\alpha(k)(\sigma(k)-\sigma(k-1)) \quad (5)$$

Where, $\mu(k)$ as learning rate, $\alpha(k)$ as momentum factors , Momentum factor is trained in the learning of the network, which is equivalent to the damping force ,when training error increases rapidly, it makes the network divergence more and more slowly, finally it make the network changes tend to be stable, advantageous to the network convergence.

4. Training methods

In the experiment, the AK-4 pressure sensors, for example, the pressure measurement value of the pressure sensor and the DS1822 output value as the input of the network input nodes, corresponding to the output layer node output.

RBF neural network used in a three-tier network architecture, in which the input layer has two nodes, the hidden layer has eight nodes, one node in output layer. By adjusting the adjustable parameters of the RBF network training and testing of the network, using the RMS (root mean square) to calculate the training accuracy and testing accuracy. Collected sample data 120, including 48 as a network sample test sample of 72 group as the network training. -5 ℃ ~ 75 ℃ ambient temperature range, according to laboratory data obtained by the best RBF neural network training accuracy of 0.046%, the test accuracy of less than 0.063%.

5. Conclusion

Pressure in the training test system, digital temperature sensor DS1822 only as an auxiliary measurement sensor, since only the temperature compensation due to the advantages of single-bus technology line is simple, low cost of hardware, software designed to be simple, the DS1822 temperature field in the futureis bound to have unparalleled prospect, widely applied to various fields.

RBF neural network parameter adjustment is the use of gradient descent algorithm with forgetting factor. This algorithm has a good nonlinear mapping ability, self-learning and generalization ability, robustness and rapid convergence, suitable for the sensor to establish the mathematical model, the measurement accuracy than the least-squares fitting and compared to single-chip interpolation Compensation Act, the accuracy 3-5 times to achieve high-precision measurement.

Reference

[1] Shang yupei, Shi linsuo,Zhang zhengren, Application of least square method in temperature measurement with high accuracy[J].Journal of transducer technology, Vol.19, No.1, pp.47-48, 2000.

[2]DallasCorp.DS18B20-PAR[EB/OL].http://pdfserv.maxim-ic.com/en/ds/DS18B20-PAR.pdf

[3] Tian Sheping, Wei Hongyu, Wang ZhiWu, Yan Guozheng.Application of Back Propagation Artificial Neural Networks on Dynamic Compensation of Measurement Systems[J]. Journal of Test and Measurement Technology, vol. 19, no. 4, 2005, pp. 453-458.

[4] Wu Baoyuan.Xu Dezhang.Research on the method of power supply for bridge circuit of strain type sensor[J],Process Automation Instrumentation, vol. 27, no. 1, 2006, pp. 9-13.

[5] Wen Dianzhong, Zhao Xiaofeng. The sensor principle and application. Sensor Principle and Its Application,2013.7

[6] ZhongYiXin. PanXinAn. Yang yixian. A intelligence theory and technology, artificial intelligence and neural network[M]. Beijing: people's posts and telecommunications publishing house, 1992