Design and implementation of wireless sensor network nodes based on BP neural network

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ABSTRACT

Routing protocol for wireless mobile sensor networks can be active, can also be passive. The network all wireless sensor node is base station and the gateway for two-way communication. To complete the training parameters, which can be called the training function is used to train the BP neural network. The paper presents design and implementation of wireless sensor network nodes based on BP neural network. Experimental results show that the efficient use of practical BP network in wireless sensor network.

Keywords: BP neural network, wireless sensor network, nodes.

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INTRODUCTION

BP neural network is very sensitive to the initial network weight, with different weights initialization of network, which tends to converge to different local minimum, which is the fundamental reason for many scholars get different results of each training. The convergence speed of BP neural network algorithm is slow: because BP neural network algorithm is essentially a gradient descent method to optimize the objective function, which is very complex, therefore, will appear "sawtooth phenomenon", which makes the BP algorithm is inefficient; and because the objective function optimization is very complex, it will be close to neurons in the output of 0 or 1, some flat areas, in these regions, the weight error is little changed.

The nonlinear mapping of neural network can effectively realize the input space to the output space [1]. Seek input to the nonlinear relationship between the model output, is generally faced problem in engineering field. Most of nonlinear systems without model, neural network can well simulate. Therefore, the neural network has become an important tool for the nonlinear system research. From the above points can be seen, the advantages of the neural network, it is based on the traditional serial computer symbol operation reasoning difficult to achieve. Therefore, the neural network attention is inevitable.

The main task of sensor acquisition sensor output analog signal and digital signal conversion for the computer can recognize, and then sent to the computer to calculate and deal with accordingly, the required data. At the same time, get the computer to display or print the data, so that the monitoring and measurement of a physical quantity, the data will also be part of the production process computer control system used to control some of the physical. The design of the sensor acquisition system of traditional system was simplified, the collected data to the single chip microcomputer to calculate and process the corresponding, the required data and displayed through the display.

The sensor is the main ways and means to obtain information of nature and production. In modern industrial production, especially in the automatic production process, various sensors are used to monitor and control the various parameters in the production process; the equipment is in normal state or state, and to reach the best quality products. So we can say, without a large number of good sensors, the modernization of production will be lost.

1. Wireless sensor network data wireless
According to the environment and structure state monitoring, we design a wireless sensor network, the network consists of several sensor nodes, a wireless receiving function of the network control node and a computer. Wireless sensor nodes distributed in the monitoring region, performing data acquisition, processing and wireless communication, and network control receives the data from each sensor node and transmits the data to the computer in a wired mode.

The front sensor and GPS module -- signal acquisition: the part mainly constitutes the detection unit and the GPS module is composed of image, sound, vibration, and infrared sensor, responsible for the completion of the battlefield information monitoring tasks [2]. Information transmission part: mainly responsible for the collected information coding and long-distance wireless transmission. Command center control platform: the part mainly completes the remote control and signal to the monitoring unit receive tasks, all kinds of information and the collected fusion processing, analysis. The results provide the command center staff will handle, so that they can accurately grasp the battlefield situation, make the appropriate decision-making.

$$\sum_{i=1}^{N} z(kN+i)\phi_{M,i}(t) = \sum_{j=L}^{M-1}\sum_{m=1}^{2^j} d_{s,m}^{j}\psi_{j,m}(t) + \sum_{m=1}^{2^L} c_{s,m}^{L}\phi_{L,m}(t) + \sum_{i=1}^{N} v(kN+i)\phi_{M,i}(t) \qquad (1)$$

And the use of Matlab Link for CCS Development Tools connection with target DSP. Using the CCSLink tool, able to transmit data from CCS to Matlab work space, also can put in the Matlab data to the CCS, and by RTDX (real time data exchange technology), a connection can be established between the Matlab and the real-time DSP hardware, real-time transmission of data between them without being a program running on DSP stop, this function can provide an observation of DSP real-time operation state of the window for us at runtime, greatly simplifies the debugging work.

Firstly, the sensor module for receiving external signals, and then the external signal is sent to the data acquisition module. Data acquisition module receives the signal after amplifying and filtering and AD conversion into digital signals, then data acquisition modules to digital signal change and come to the main control module. Digital master control module will receive the analysis processing, the output module output. 4*4 matrix keyboard input module is used to set the sampling interval of time. Data is transmitted to the main control module input from the keyboard, the main control module according to the input data to control the sampling interval.

Classification of physical sensor working principle of sensor is the application of physical effects, such as piezoelectric effect, magnetostriction, ionization, polarization, thermoelectric, photoelectric, magnetoelectric effect [3]. The measured signal small changes in volume can be converted into electrical signals. Chemical sensors, including those by chemical adsorption, electrochemical reaction phenomenon as the sensor of causality, the measured signal small changes in volume can be converted into electrical signals, as is shown by Eq.2

$$\gamma(m+1) = \Phi_w(m)x(m,M) + \overline{w}_{\gamma}(m) \qquad (2)$$

The RF module is an important part of the node; the production of short distance RF transceiver chip RFW102, which is a RF physical layer transceiver, working at 2.4GHz, the antenna includes a printed on the printed circuit board, without external antenna. RFW102 uses the DSSS direct sequence spread spectrum technology; the working voltage is 2.7 ~ 3.6V wide, suitable for different power supply battery; low power consumption: the standby current is only 1 A, wake up time 20 s. Module provides a spread spectrum pulse tube through credit, rate reached 1Mbps.

Modem and PC interface is actually the interface circuit of W77E58 and PC single chip modems in support of W77E58, TTL level, and computer serial communication port RS 232C supports EIA level, so in the realization of serial communication between them, we must design level conversion circuit, in order to meet their own needs.

Routing protocol for wireless mobile sensor networks can be active, can also be passive. The protocol is realized through the routing table maintenance, maintain routing tables need to periodically exchange messages, so that it can have the new routing information, the relative mobility of high network is not suitable, but if taking into account the absolute mobility of wireless mobile sensor and relative stability, so proactive routing protocol is very suitable for communication between a group of sensors, and this group is the region. To determine the path of proactive routing protocol in what almost no delay, but the additional burden of periodic updating of routing information generated is larger [4].

The selected input signal is sent to an analog modulator based on programmable dedicated front-end gain. The filter output signal processing chip digital modulator. The cutoff point of on-chip control register adjustable filter and output the new rate, from the digital filter first notch programming. AD7705 is only 2.7 ~ 3.3V or 4.75 ~ 5.25V single power supply. The AD7705 is a dual channel fully differential analog input, when the supply voltage is 5V, the reference voltage is 2.5V, the two devices can be input signal range from 0 ~ +20mV to 0 ~ +2.5V signal for processing.

The static characteristic of sensor is refers to the static input signals, input and output. The sensor has the relationship. When the input and output quantity and time independent, so the relationship between them, namely the static characteristics of the sensor can be a free time variables algebraic equation, or to input as abscissa, the characteristic curve of output and its corresponding as ordinate and draw to describe. The main parameters of static characteristics of sensor are: linearity, sensitivity, hysteresis, and repeatability, drift and so on.

2. Research of BP Neural Network

Some neurons are connected into a network, a neuron which can accept a plurality of input signals, according to certain rules for the output signal conversion. The neurons in the neural network and the complex connection between neurons transmit signals nonlinear mode, input and output signal can build a relationship of sorts, so it can be used as a black box model, the expression of those with mechanism model can not accurately describe, but between input and output is objective, deterministic or ambiguity in the law.

Neural network learning methods change the weights of rules called learning rules or learning algorithm [5]. The learning algorithm of neural network is a supervised learning, for a class of unsupervised learning. Supervised learning in the training process needs to continue to provide a network of pairs of input patterns and a desired network correctly output mode, called "the teacher signal". The teacher signal when the output and the expected network do not match, then adjust the output weights, and it can produce the desired. Unsupervised learning needs constantly to network with dynamic input information, network according to the learning rule and the input information to adjust its weights. This model, the influence of network weights adjustment does not depend on the foreign teacher signal, the network learning, as is shown by equation(3).

$$I = -\sum_{t=0}^{T} q(t)\log q(t) - (-\sum_{t=0}^{T} p(t)\log p(t)) \tag{3}$$

Through the combination of neurons in layer, and it can be achieved between the same layers of neurons in the lateral inhibitory or excitatory mechanism. This limits in each layer can act at the same time the neural elements, or put in each layer of neurons can be divided into several groups, each group as a whole operation. For example, the lateral inhibition mechanism to select a layer has a maximum output neurons, thereby inhibiting other neurons, which is no output.

The BP network is simple, so it has been widely applied in industry. In the control system, BP network as a neuron control parts, can be used for device control system or information flow control system. Network performance advantages of the BP neural network in the classification and identification of the advantage, can be fast and efficient diagnosis of mechanical fault diagnosis, spectrum analysis of technical efficiency than traditional greatly enhanced [6]. Shortcomings: the robustness of network, it is difficult to guarantee the real-time online fault diagnosis, monitoring and forecasting accuracy. The BP algorithm convergence speed is slow, and the selection of network hidden layer node number is lack of unified and complete theory.

Biological neural system is not serious injury does not affect the whole function, BP neural network also has this property, network of highly connected means that few errors may not have serious consequences, some neurons damage does not undermine the overall, it can automatic error correction, as is shown by equation4.

$$\phi(s, 2^s l) = \sum_k h(k)\phi(s+1, 2^{s+1} l - k) \tag{4}$$

ART network structure, the expert system knowledge into neural network connection weights matrix using fuzzy model, system using hierarchical structure, system consists of several subsystems are integrated into the. Feasibility: the initial stage of training, the knowledge system is mainly based on the adaptive fuzzy ART network learning function of the fuzzy expert system (rules) to intensify or supplement, through the coordination mechanism based on fault sample template to supervise the fuzzy ART network.

The stability of the BP network training requirements of learning efficiency is very small, so the gradient descent method to make the training is very slow. Momentum method because the learning rate is usually higher than the simple gradient descent method to be faster, but in the actual application, or the speed is not enough, the two methods are usually applied only to the increasing training. Multilayer neural network can be applied to the linear system and nonlinear system, simulation for arbitrary function approximation. Of course, the perception and linear neural network can solve this kind of problems in network. But, although the theory is feasible, but in fact the BP network does not always have a solution.

3. Design and implementation of wireless sensor network nodes based on BP neural network
The sensor node sensor network system with low power microcontroller as the core, and it is the RF module of the RFW102 chip group communication, sensor selection of application specific integrated circuit. The use of battery powered nodes, the hardware and software design can achieve the greatest degree of energy saving, so as to prolong the service life of the nodes [7]. The experiments show that this system has good stability, the efficiency of communication.

A typical configuration of wireless sensor network node consists of two main components: the RF transceiver (analog, the frequency of 300MHz-2.4GHz ISM frequency band) and MCU (digital devices, usually working in low frequency band kHz-MHz). The RF transceiver usually with various external elements, such as inductance, and it is capacitance or surface acoustic wave filter. Because of these external components of large volume and high cost, so the RF circuit is very difficult to meet the size and cost requirements. With the rapid progress of CMOS technology, there are some small, and it is low cost and high integrated RF transceiver on the market.

$$u'(x_1, x_2) = \sum_{s=-n}^{n}\sum_{t=-n}^{n} w(s,t)u(x_1 + s, x_2 + t) \tag{5}$$

The program is divided into five parts, three main procedures: sender, receiver chip program microcontroller program and microcomputer receiving program; two subroutines: error processing subroutine, transmission delay subroutine. Collect, between both sides and single chip computer and PC software were used to contact "handshake" signal. All contact "handshake" signal is #0AAH, after receiving the correct response signal is received in response to the #00H, error #0FFH. A sensor in no data needs to be transmitted, make MSM7512B work in the power saving mode through the microcontroller programming control.

To modify a parameter or variable in Matlab, and to modify the value passed to the DSP is running, which can real timely adjust or change the processing algorithm, and through the observation of probe data to debug program. The CCSlink and Embedded Target for C2000 is DSP Platform. combination, can be directly generated by the Simulink model DSP2812 debugging good executable code, and loaded into the DSP target board, so that we can complete the system algorithm in the same environment of the Matlab design, simulation, debugging, testing, and finally run in the DSP2812 target board, as is shown by figure1.
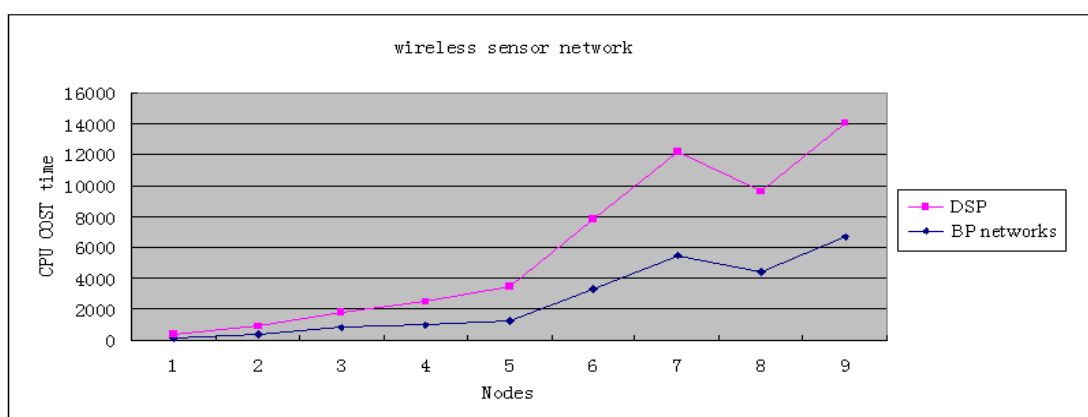

Fig. 1. Design and implementation of wireless sensor network nodes based on BP neural network

The architecture of wireless mobile sensor network has the high adaptability to highly dynamic, adaptive and highly mobile characteristics and low energy consumption constraints, the system structure of the concepts of mobility and energy together. In order to achieve this goal, we will introduce the mechanism of measure of relative stability and energy consumption. The relative stability of the dynamic model involves a node regional adaptability, as well as the

nodes can use of proactive routing protocol to determine the number of other nodes of the path.

CONCLUSION

Sensor and BP networks with network model are different, the neural network toolbox integration of a variety of learning algorithms, provides great convenience for the user. Matlab R2007 neural network toolbox contains many functions for the analysis and design of BP network.

An important advantage of the wireless sensor network is to get rid of the connection limit and cost problems of traditional network. However, if there is no wireless power supply suitable, this advantage can not be reflected, therefore the power efficiency is a key design considerations, because if you must often change the battery (such as weekly or monthly), then the associated labor costs will far outweigh the relative cable network cost savings.

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