Research Article

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The application of neural network algorithm and embedded system in computer distance teach system

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Abstract: The computer distance teaching system teaches through the network, and there is no entrance threshold. Any student who is willing to study can log in to the network computer distance teaching system for study at any free time. Neural network has a strong self-learning ability and is an important part of artificial intelligence research. Based on this study, a neural network-embedded architecture based on shared memory and bus structure is proposed. By looking for an alternative method of exp function to improve the speed of radial basis function algorithm, and then by analyzing the judgment conditions in the main loop during the algorithm process, these judgment conditions are modified conditionally to reduce the calculation scale, which can double the speed of the algorithm. Finally, this article verifies the function, performance, and interface of the computer distance education system.

Keywords: neural network algorithm, embedded system, computer distance teaching system

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1 Introduction

Distance education is an educational behavior spanning geographical space. Teachers and students may not be in the same classroom, or even in the same region or country. Distance education includes a series of behaviors, such as course study and discussion. With the rapid development of computer technology, the application of computer in teaching is increasingly extensive, and it has become an important symbol of modern education [1]. At present, distance education based on Internet has become a research hotspot. Many countries have built their own education and scientific research networks one after another, enabling people to realize information exchange, resource sharing, scientific and technological cooperation, and distance learning through the Internet on a global scale, thus promoting the rapid development of national scientific research and education [2].

Modern distance education is relative to traditional distance education forms such as correspondence education and radio and television education. The development of online education has become a global trend [3]. To solve the shortage of educational resources and realize the sharing of resources, many governments take the development of online education as an important strategic decision, make special plans and organize their implementation [4,5]. Literature [6,7] studies the process of operating the Internet network to remotely operate the equipment and instruments in the teaching room, so that students can truly complete the teaching in different places. Literature [8] combines physical heat transfer process with virtual technology to vividly reproduce the whole process of heat transfer through virtual teaching.

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Literature [9] uses browser and server architecture to establish a remote virtual teaching room and uses customized LabVIEW virtual instrument software to simulate the operation of teaching equipment on the server side, thus realizing the virtual remote teaching function. Literature [10,11] established a remote robot teaching room based on Internet, and the operator can remotely control the robot's arm in real time. Literature [12] developed a set of remote control system, which realized the function of remote control of robot through network.

Distance teaching breaks the limitation of time and space and solves the problem of sharing teaching equipment resources, which not only saves costs but also achieves good results. However, at present, distance education also has some problems, such as imperfect management system, limited application level – it is mostly used for university teaching, and when the network is unstable, the client will disconnect from the server and interrupt teaching. Considering the above problems, this article is dedicated to designing and implementing a distance education platform based on neural network algorithm and embedded system technology.

The research results of this topic will support a variety of classroom modes and provide specific teaching functions and teaching for different teaching processes and contents, which not only saves the teaching management process, reduces the education cost, but also facilitates the choice of students and users, and provides a reference for the service modes of other distance education systems.

2 Radial basis function (RBF) neural network model

Generally, the basic RBF neural network is composed of three layers, and each layer has completely different functions [13,14]:

- (1) Input layer: it is composed of some sensing units, which connect the network with the external environment and transmit input signals to the second layer.
- (2) Hidden layer: it is the only hidden layer in the network, and its function is to make nonlinear changes from the input space to the hidden layer space. In most cases, the hidden layer space has a higher dimension.
- (3) Output layer: its function is to provide response to the activation mode of the input layer.

The structure of regularized RBF network is shown in Figure 1. It is characterized in that the network has N input nodes, P hidden nodes, and i output nodes. The number of hidden nodes in the network is equal to the number of input samples, and the activation function of hidden nodes is often Gaussian RBF. All input samples are set as the center of RBF, and each RBF takes a unified extension constant.

Let any node of input layer be represented by i , any node of hidden node be represented by j , and any node of output layer be represented by k . The mathematical description of each layer is as follows:

Input vector:

Figure 1: RBF neural network structure.

$$x = (x_1, x_2, \dots, x_N)^T. \quad (1)$$

Activation function of any hidden node:

$$\varphi_j(X), \quad (j = 1, 2, \dots, P). \quad (2)$$

It is called basis function, and Gaussian function is generally used.

Output weight matrix: W , in which $w_{i,k}$, ($j = 1, 2, \dots, P$, $k = 1, 2, \dots, l$) is the synaptic weight between the j th node of the hidden layer and the k th node of the output layer.

Output vector:

$$Y = (y_1, y_2, \dots, y_l). \quad (3)$$

The neurons in the output layer adopt linear activation function.

When a certain sample X^p in the training set is input, the corresponding expected output d^p is the teacher signal. To determine the P weights between the hidden layer and the output layer of the network, it is necessary to input the samples in the training set one by one. After the weights of the network are determined, the samples of the training set are completely interpolated, that is, the error of all samples is 0. For the input mode of nontraining set, the output value of the network is equivalent to the interpolation of functions, so the RBF network can be used as number approximation.

The regularized RBF network has the following three characteristics:

- (1) Regularized network is a general approximator, which can approximate any multivariate continuous function on a compact set with arbitrary precision only with enough nodes.
- (2) It has the best approximation property; that is, if an unknown nonlinear function f is given, a set of weights can always be found, which makes the approximation of regularization network to f better than all its possible choices.
- (3) The solution obtained by regularizing the network is the best, and the so-called “best” is reflected in satisfying both the approximation error of the sample and the smoothness of the approximation curve.

3 Application of neural network algorithm and embedded system in computer distance education system

3.1 System operation architecture

The computer distance education system connects many users, including teachers and students, and monitors the operation of each user for management verification [15]. Therefore, the running architecture of the system must mainly solve the following problems.

- (1) Computer distance education system is a multiuser and multiprocess concurrent system. Now, how to improve the concurrent management ability and efficiency of the system is the basic problem that the system must solve.
- (2) Computer distance education system runs according to a certain education and teaching plan. How to monitor all the systems to ensure the security of the system.
- (3) Computer distance education system is facing a steady stream of new courses and various new requirements. How to expand or upgrade new functions based on the existing operating framework is also a problem that must be considered.

To solve the above problems, our computer distance education system puts forward the running idea of “service driven” [16]. In process-driven, all teaching processes set up their own service modules, which are opposite to each other, perform their duties, and do not interfere with each other. A special monitoring process is set in the system to monitor the communication. Once a new service request is found, the service

request will be handed over to the service driver for processing, and the monitoring will continue. The operating architecture of the system is shown in Figure 2.

Figure 2: Operating architecture of the system.

3.2 Embedded architecture of neural network

In this article, various classical algorithms of neural network are combined into an algorithm library, which is introduced into the application field of embedded system, and the architecture of neural network embedded system is studied and discussed. On this basis, a kind of architecture is selected, the corresponding teaching model is designed, and RBF algorithm is used for function approximation as an example.

The architecture of shared memory consists of three modules [17,18]:

- (1) The plug-in processor and its peripheral modules, which are the main modules of system control, set corresponding peripheral modules according to different specific applications to complete specific functions.
- (2) Shared memory and different storage spaces are assigned to different algorithms, and the initial values, weights, and sample values of the algorithms are all placed in the shared memory.
- (3) Neural network processor module, in which all algorithms are put, and an algorithm library are established. The call of each algorithm is determined by the embedded processor through interrupt control, and the processed results can be output to the embedded processor for use by the main control module.

The system structure diagram is shown in Figure 3.

Figure 3: System structure of shared memory.

The bus architecture consists of two modules, namely master–slave module, with embedded memory as the master module and neural network processor as the slave module. All data exchange and control are completed through the bus. The peripheral modules of the embedded processor are the same as those in Figure 3. According to different control needs, the corresponding modules are increased or decreased. Different from Figure 3, the embedded processor has its own memory module.

When the system starts to work, the embedded processor transmits the initial values (including random weights) and sample values for the neural network algorithm to the memory and then starts to run the functions of other peripheral modules independently. The neural network processor obtains the corresponding parameters from the memory through the bus and can also directly take the values from the memory through direct memory access [19]. Similarly, the memory obtains parameter values from the neural network processor through the bus to update the weights and thresholds. The choice of algorithm is decided by embedded processor, and interrupt control is realized by the bus. The basic block diagram of the system is shown in Figure 4.

Figure 4: System model of bus structure.

The neural network operation module consists of two parts:

- (1) Neural network initialization module, which realizes the setting of some initial data of neural network, such as the number of neurons, the number of layers of neural network, the initial weight of network, and so on.
- (2) The weight training program is called as the interrupt subroutine of digital signal process (DSP). When the embedded processor writes the input data (neural network input) into the shared memory through the interface, it triggers the interrupt signal processing program. At the beginning of the program, the data should be read from the shared memory. When the neural network calculation is finished, the results should be written into the shared memory for the embedded processor to read [20].

The basic flow chart is shown in Figure 5.

Because the embedded system emphasizes real time, the whole software system is mainly based on interrupt mode. After the system is powered on, after necessary initialization, the main program enters the waiting state. When the embedded processor triggers interrupt 1, the DSP core accepts the interrupt and runs the corresponding neural network training program. Similarly, interrupt 2 is used to trigger the main program of embedded control. Among them, DSP initialization includes the initialization of the parameters of the chip itself, the number of neurons, the number of neural network layers, and the initial value of the network.

3.3 Intelligent algorithm based on embedded system

Embedded system is a product obtained by combining advanced technologies such as computer technology, communication technology, semiconductor technology, microelectronics technology, voice and

Figure 5: Basic flow chart of software design.

image data transmission technology, and even sensors with specific application objects. Therefore, the embedded system has the characteristics of technology intensive, high investment intensity, high dispersion, continuous innovation, and so on. It is a knowledge integration system, and its peripheral devices contain multiple embedded microprocessors, such as keyboard, hard disk, monitor, network card, and sound card, which are controlled by embedded processors [21,22].

In this study, the optimization algorithm is applied to embedded systems, hoping that the performance of the algorithm can be accepted by users. To solve this problem, we need to solve the following problems:

- (1) When solving specific problems, the optimization algorithm has considerable accuracy, which can meet the accuracy requirements of users.
- (2) The adaptability of the algorithm is strong; that is, the types of problems that can be solved should be as large as possible, and the scale of problems that can be solved should be as large as possible, so as to avoid being helpless as possible.
- (3) The time consumed by the operation of the method should be as little as possible. Although the time consumed by the algorithm can't be compared with the time spent running on a high-performance computer, it can't exceed the limits acceptable to users.

Some optimization algorithms are implemented on embedded systems, which are not aimed at a specific class of problems, but these algorithms cannot solve all learning problems. It is hoped that these optimization algorithms can solve a small number of learning problems, and this subset is preferably a common problem in engineering [23]. This is a problem that can give full play to the advantages of embedded systems.

Setting of RBF algorithm parameters:

Learning speed: $\alpha = 0.7$.

Charge coefficient: $\beta = 0.06$.

Threshold: -1 .

Conditions for algorithm convergence:

Mean square error is less than 0.06.

Or

The number of iterations is greater than 30 (default value).

η value: 0.6 (experience value).

Network structure: single hidden layer, the number of hidden layer units is the total number of samples/(sample dimension *4) + 1.

Network output: the number of neurons in the output layer is 1.

Setting of support vector machine (SVM) algorithm parameters:

Penalty factor: $\cos t = 1$.

Cross-validation: 3.

Gamma (γ): the reciprocal of the total number of samples; γ should be used in the following kernel function:

$$K(x_i, x_j) = \exp(-\gamma \|x_i - x_j\|^2), \quad \gamma > 0. \quad (4)$$

The parameter adjustment of SVM algorithm is simpler than RBF algorithm. When the penalty factor is L , the average performance on each sample set is quite good, so this factor is always L in this article.

4 Result analysis and discussion

4.1 Improve RBF algorithm to improve the speed of operation

Because the accuracy of the new exp function is not as good as the original exp function, the accuracy of the algorithm is high. Moreover, the realization of the new exp function is all realized by macros, which increases the space of the program to a certain extent. This section discusses how to trade the space of algorithm for speed and mainly discusses this problem according to RBF algorithm.

However, there is another way to improve the running speed of the algorithm by losing the prediction accuracy, that is, to select the appropriate iteration number control parameters. There are two main conditions to control the end of RBF algorithm:

One is iteration number control, and the other is training error value control.

If the training error required for the end of training is set to be small, it will be completed by iteration times in most cases; otherwise, it may fall into an infinite loop. Among these two conditions, the latter is difficult to judge and closely related to samples, whereas the first method is much easier to control.

Taking body fat as the training sample set, the number of iterations is 10, 20, and 50, respectively, and Table 1 shows the actual running results.

Table 1: Operational performance of hemorrhoids with different iteration times

Iterations	10	20	50
Time when the program runs (min)	0.93	1.55	2.93
Accuracy of program prediction (%)	92.1	93.6	95.2

It can be seen from Table 1 that the running speed of the algorithm is obviously improved by reducing the control conditions when the program runs, but the performance of the algorithm is not obviously reduced. It is worth noting that the influence of this method on the speed of the algorithm is obvious, but as for the accuracy of prediction, there will be great changes due to different sample sets, which should be decided according to the actual conditions.

This method needs to play an effective role under certain conditions; otherwise, it will inevitably lead to a great reduction in the generalization ability of the algorithm. The main limitations are as follows:

- (1) Batch learning algorithm should be used, so that the characteristic curve of error value is smooth and oscillation is less.
- (2) Using moderate learning speed, the error value can be quickly reduced to a smaller value, which can reduce oscillation.
- (3) The η parameter in the excitation function should be selected to be smaller, and the purpose is to reduce the oscillation in training.

4.2 Performance analysis of RBF neural network

Table 2 shows the color recognition results under different conditions.

Table 2: Color recognition results under different conditions

Each color is recognized 20 times in total. The following table shows the successful recognition times of each color						
Method	Red	Green	Blue	White	Total success rate (%)	
Threshold method	17	19	20	19	93.75	Natural light irradiation
Traditional threshold method	14	10	16	7	58.75	No natural light irradiation
RBF neural network method	20	20	19	19	97.5	Natural light irradiation
Artificial neural network method	19	18	16	20	91.25	No natural light irradiation

According to the teaching results, the recognition success rates of the two methods are similar under natural illumination, and the recognition success rate of the threshold method is slightly higher than that of the artificial neural network method. However, when the natural environment changes, the results are obviously different, and the success rate of RBF neural network hardly changes, but the threshold method drops by more than 28 percentage points, which can be said to be obviously different. From the results, it can be concluded that the threshold method is sensitive to environmental changes and the recognition results, whereas the artificial neural network is insensitive to environmental changes. The main reason lies in their different recognition mechanisms.

From Table 2, it can be seen that the threshold method mainly affects the success rate of recognition, which is the boundary between green and white. The intermediate state does not reach the changed threshold, so the recognition result is good, but the boundary value is very sensitive, and false recognition will occur if the environment changes. RBF neural network recognition is based on sample training. When training samples, the influence of environment will be considered. We consider the influence of the environment when training samples. For the input of samples, we input the sample values when the environment changes, so that the recognition success rate will not change greatly when the environment changes, so we can see that the RBF neural network method is more accurate and more practical.

4.3 System test analysis

After any software is written, it needs to be tested. Software testing is a means to verify the correctness, integrity, safety, and quality reliability of the software system. In other words, software testing is a process of comparing the actual output with the expected output and finding errors.

Software interface is the key to users' first impression of software. Simple and friendly user interface can guide users to find the functions they want to use and guide users to complete corresponding

operations by themselves. Beautiful interface can bring beautiful feeling to users. However, the failed interface will make users feel unable to start, unable to find a reasonable operation method, and bring frustration to users, and the software with perfect internal design and strong internal design will be abandoned by users. The users of distance education system are mainly students.

User interface testing includes testing whether the interface is clear and beautiful; whether the interface layout is reasonable; whether the interface font is easy to recognize; whether the interface navigation is clear and understandable, etc. The following four students scored the interface according to their satisfaction after using the APP operation, as shown in Table 3. The test chart is shown in Figure 6.

Table 3: Interface test item description table

Test number	Test item	Test index
1	Interface style	Is the interface clear and beautiful
2	Interface font	Is the interface font easy to recognize
3	Interface navigation	Is the interface navigation clear and easy to understand
4	Learning interface	Is the interface layout reasonable
5	Teaching interface	Is the interface layout reasonable

Figure 6: User interface satisfaction test chart.

Table 4: Test item description table

Test number	Test item	Test module	Operating procedure
1	Start response	System start up	Click the application icon on the computer to open the computer display startup screen and enter the application
2	Directory response	Directory display	After the user logs in successfully, it takes time for the system to read the data display directory
3	Show course responses	Course learning	The user clicks on the directory entry in the directory interface, and the system enters the course learning interface to display the time required for the course materials
4	Device connection response	Course teaching	The user clicks the menu tab at the bottom of the application to enter the teaching interface, and clicks the connection icon to query the idle equipment from the server first
5	Teaching response	Course teaching	The user adjusts the parameter submission for controlling the steering gear of the mechanical arm and observes the response time of the mechanical arm

Figure 7: Test chart of system response time.

Performance test will test the response of the application when it is used on computers with different performances. As shown in Table 4, the test results are shown in Figure 7.

5 Conclusion

This study puts forward a solution of computer distance teaching system based on neural network algorithm and embedded system. This connection mode can improve the transmission speed of network data and the stability of network connection. Optimization algorithm is the core of intelligent algorithm, so the embedded application of intelligent algorithm has similar problems, that is, the embedded application of optimization algorithm. At first, the RBF algorithm is improved when the satisfactory solution is obtained, and the running speed of the program is increased several times. Moreover, the same idea or method can be applied to SVM algorithm, which also verified that the optimization algorithm is the core of intelligent algorithm. From the example of RBF algorithm, it can be seen that the system scheme is feasible. The neural network algorithm is implemented by hardware and incorporated into the architecture of embedded system, which can meet the processing requirements of real-time systems and improve the artificial intelligence level of existing embedded systems.

Conflict of interest: Author states no conflict of interest.

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