DOI: 10.7763/IPEDR. 2013. V60. 18

Based on Improved Genetic Algorithm Optimized Neural Network Applications in the Intelligent Building Fire Detection System

Zhang Lijie[1+] and Angsheng[2]
[1]Ningxia Institute of science and Technology, Shizuishan, Ningxia, China
[2]Zhejiang University, Hangzhou, Zhejiang, China

Abstract. This paper proposes the fire signal detection based on improved genetic algorithm to optimize the neural network information processing method, By improving genetic algorithm the dynamic adjustment of the adaptive in the global solution space on the network topology and network parameters,thus ensuring the reliability of the network output,full range of monitoring and dealing with the fire signal. The algorithm is through a standard fire test. The results show that significantly improve the accuracy of the system alarm, increased network reliability and generalization ability.

Keywords: Genetic Algorithms, Neural Networks, Fire Detection.

1. General Instructions

Fire occurrence and development process is a complex physical and chemical process, and closely linked with the surrounding environment, especially for intelligent buildings and other public places, a higher demand on the fire detection and alarm system. The system needs to adapt to different environments according to the environmental change, automatically adjust operating parameters [1]. The traditional fire detection monitoring system intelligent degree is low; the processing of data is lack of gentleness [2]. This article aims to take advantages of the improved genetic algorithm optimized artificial neural network which has the human brain to self-learning, adaptive features, organic combination of the two used in fire detection systems, improving the system detection rate.

Combination of genetic algorithms and neural networks to seek the global optimal solution of its effect is superior to the single use of genetic algorithms or neural networks [3].In this paper, temperature, smoke, gas sensors constitute a three layer neural network for the fire signal to fire characteristics, through the introduction of real coded on the basis of the traditional genetic algorithm, the inheritance of competitive selection, multi-point crossover, adaptive mutation and other operations, fully integrate the strengths of the genetic algorithm and BP neural network adaptive network topology and parameters in the global solution space using a genetic algorithm, dynamic adjustment, thus ensuring the reliability of the network output..

2. Improved Genetic Algorithm

2.1. Genetic--Neural Network Optimization Mathematical Description is as Follows

$$\left.\begin{aligned} &\min E_1(w,v,\theta,\gamma)=\frac{1}{2}\sum_{k=1}^{N1}\sum_{t=1}^{n}\left[y_k(t)-\hat{y}_k(t)\right]^2 \\ &s,t,w\in R^{m\times p},v\in R^{p\times n},\theta\in R^p,\gamma\in R^n \end{aligned}\right\} \tag{1}$$

Where E1 is the total network error, $y_k(t)$ is the teacher signal, $\hat{y}_k(t)$ is the actual output for the network:

$$\hat{y}_k(t)=f\left\{\sum_{j=1}^{p}\cdot f\left[\sum_{i=1}^{m}w_{ij}\cdot xi(t)+\theta_j\right]\right\}+r_i \tag{2}$$

Set $E_2=\dfrac{1}{N-N_1}\sum_{k=N_1}^{N}\sum_{t=1}^{n}\left[y_k(t)-\hat{y}_k(y)\right]$ for the detection of example.

+ Corresponding author: Tel.: + 13995463001 0952-2210122; Fax: 0952-2210009.
E-mail address: dwkzlj@126.com.

E_2 said that estimated the reliability of data on the network output .The smaller E_2 is, the higher the reliability of the network output.

2.2. The Design of the Algorithm

This algorithm by using the EGA initially is identified by the BP network solution space (network connection weights and neuron threshold range). Samples of individuals continue to merit based evolution, the evolution of K on behalf of selecting individuals to adapt to the largest individual to determine the structure of the network and the network's initial weights and thresholds [4].

1) Gene encoding

Code generation code string is composed by two parts of the switch coefficient coding and weighting coefficient coding.The switch coefficient coded representation of the hidden layer neurons and the connection status of the input and output neurons, coded according to a certain order of cascading into a long string, each string corresponds to a set of network structure and connection weights.

2) The basic solution space

The three-layer BP network initially identified the fundamental solution of the space (network connection weights and neuron threshold range),first set the number of network training and network training error ε_1 .Input training samples for training, then get the error ε_2 input test samples, the maximum and minimum values in the connection weights are denoted by $u_{\max}$ and $u_{\min}$,in the interval$[u_{\min}-\delta_1,u_{\max}+\delta_2]$ (adjustable parameters) as the connection weights of the solution space.

3) Initialize the sample groups

The key to this step is to set the number of genes encoding combinations. Each individual in this paper consists of two parts.The first part of the string length is 0-1 string representation of the initial switch coefficient; l_2 uniformly distributed random numbers in the second part of the interval $[u_{\min}-\delta_1,u_{\max}+\delta_2]$ represents the initial weight value coefficient,said the initial weight value factor.

4) Fitness function calculation

A network error function as fitness function, and that a large error of the individual adapt to a small degree, specifically expressed as

$$F(W,V,\theta,\gamma)=10-\sqrt{\sum_{k=1}^{N1}\sum_{t=1}^{n}\left[y_k(t)-\hat{y}_k(t)\right]} \tag{3}$$

Calculate the fitness of each individual in the population; input the training sample calculated in accordance with (3), the adaptation of each individual degrees.

5) Select inheritance

Select purpose of inheritance in order to choose the good individuals from the current population. Adapt to the degree of individual genetic to the next generation, so that the problem solutions are more and more close to the optimal solution space.

6) Crossover operator and mutation operator

The cross is from the group the greater the probability of randomly selected two individuals to exchange these two individuals. The variation is a small probability to change some of the individual bits in the group, in real coded bits of some individuals to generate a random number (0,9) in instead of individual bits. Multi-point crossover genetic manipulation on the right weight coefficient coding and neuronal threshold encoding crossover and mutation operations on the crossover operator of the weight coefficient coding and neurons threshold coding, faster convergence to the desired accuracy.

7) Generate a new generation of groups**.**

8) Repeated 5-7 times, once for each group on the evolution of the generation, continuous evolution of the k-generation (evolution algebra).

9) Section K on behalf of the highest fitness individual decoding network connection weights and the number of hidden nodes, input the generalization ability of the test samples test model.

2.3. Parameter Optimization

This algorithm by using the EGA initially identified by the BP network solution space, the sample of individuals, merit based evolution to select individuals to adapt to the maximum degree of the individual to determine the initial weights and thresholds of the network structure and network.

System in this paper, the objective function is selected:

$$e_i = \frac{1}{2}\sum_{p=1}^{3}\sum_{q=1}^{3}\left(y_{pq} - \hat{y}_{pq}\right) \tag{4}$$

1) Membership functions to be modified as follows:

$$u = \begin{cases} 1 & |x| > c_i \\ 1 + \left(\left(x - c_i\right)/a_i\right)^{2b_i} & |x| \le c_i \end{cases} \tag{5}$$

So that it covers the entire domain.19 parameters using genetic algorithms, and these need to learn as 38 genes form a chromosome for optimization.

2) Take a genetic algorithm fitness function $F(w, v, \theta, \gamma) = 10 - \sqrt{\frac{1}{2}e}$, e is the error of the control objectives, the system error function, it is desirable to:

$$e = \sum_{k=1}^{N1}\sum_{t=1}^{n}\left[y_k(t) - \hat{y}_k(t)\right]^2 \tag{6}$$

Among them, $y_k(t)$ is the teacher signal, $\hat{y}_k(t)$ is the actual output of the network signal.

3. Fire Monitoring System Data Flow

Combined with systems network architecture, overall system data flow as shown below:

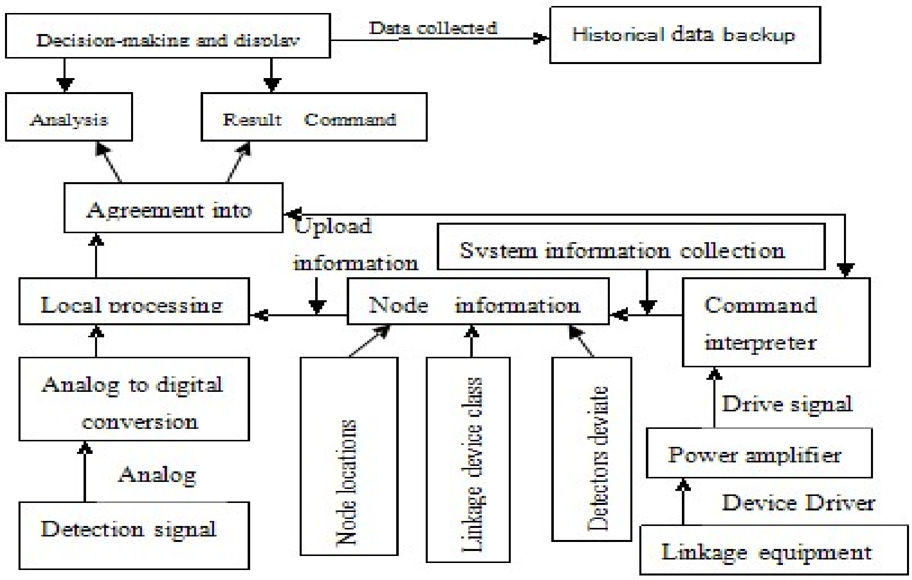

Fig. 1: the overall system data flow

4. Testing and Results Analysis

In the Intelligent building fire monitoring system, the terminal sensor networks fire signal is identified as a sample test. According to the provisions of Article 8.1 of the "automatic fire alarm system design specifications," the relationship between protected area, protected radius and other parameters. The business hall of a building buildings, for example, the lobby area 277.6m^2, lobby smoke detectors, heat detectors, gas sensors layout is as follows, A = 60 square meters, the protection of radius R = 5.8m, so the number of detectors in the business hall for N0101 ≥ 277.6 / (0.9 * 60) ≈ 5.14[5], take five detectors arranged as shown below.

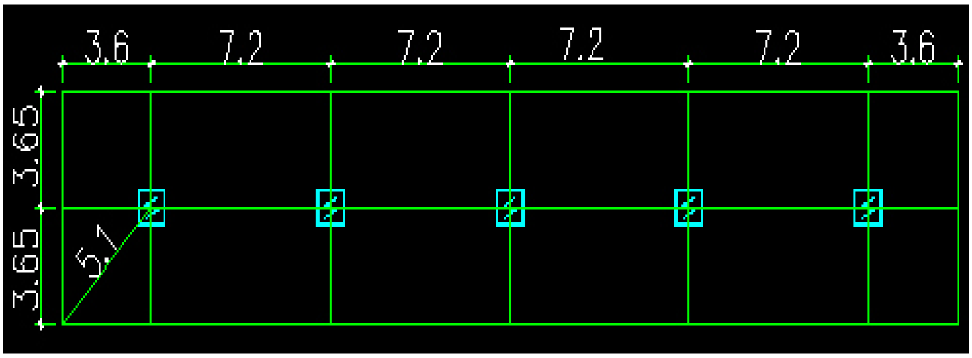

Fig. 2: Business lobby detector layout.

Using the SH1, SH3, SH4 three standard fire for the test fire. Terminal detection network is composed of three layers. Input layer is a time measurement to a fire signal parameters. There are three input nodes and output layer has three nodes, respectively expressed as the probability of SH1, SH3 and SH4 three standard fire.

Accordance with the steps to get $u_{\min}$ =10.7012 , $u_{\max}$ =14.9523, $\theta_{\min}$ = -9.5950, $\theta_{\max}$ =10.7953, connection weights of the solution space is initially set to [-10,16],the solution space of the threshold is initially set to [-9, 10], the number of hidden nodes search range of 3-16, and the evolutionary process of genetic algorithm initial population of L=30, the overall evolution of algebra K=100, crossover probability p_c =0.85, the rate of elimination r_d = 0.15, the maximum fitness in the current group $f_{\max}$=10,mutation probability p_m = 0.006.

Three-layer network structure of the preselected 8 typical data sample training sample set the connection weights of the neural network learning and training. To the network input layer and hidden layer, hidden layer and output layer optimal connection weight matrix as follows:

$$\begin{bmatrix} 0.16832 & -0.43307 & -0.10386 \\ -0.11929 & 0.21187 & -0.013139 \\ 0.14117 & 0.75841 & -0.19219 \\ -0.08859 & -0.80864 & 0.26925 \\ -0.08892 & -0.85066 & 0.20249 \\ -0.21823 & -0.14954 & 0.25268 \\ -0.23902 & -0.24594 & 0.54269 \\ -0.26484 & 0.36236 & 0.44538 \end{bmatrix}$$

Input layer and hidden layer connection weight matrix

$$\begin{bmatrix} 0.053488 & -0.38099 & 0.022125 & -0.44567 & 0.054134 & -0.44538 & 0.07683 & -0.57325 \\ 0.59068 & -0.057724 & -1.4073 & 2.0889 & -0.63229 & -0.20249 & 0.81223 & -1.5255 \\ 0.05603 & 0.9726 & -0.2795 & 0.0821 & -0.0914 & 1.36174 & 0.5729 & -0.1290 \end{bmatrix}$$

Hidden layer and output layer connection weight matrix

Through the training samples of the actual output and actual output of the test sample, we can s-ee that the training sample to identify the correct rate 98.3%, 89.95% correct rate for the test sam-ples were never trained. Prove that the algorithm is self-adaptable, has a good network generalizati-on.

5. Conclusion

From the network test results, the fire detection network trained to identify a very high rate, reducing the signal processing time, enhance the recognition capabilities. Reliability and credibility of the automatic fire alarm system has been enhanced, low false alarm rate and missing rate, to achieve the desired purpose.

6. References

[1] Shu Wang, Zheng Dou.*Fire detection and signal processing*. Huazhong University of Science Press, 1999.

[2] Thuillard M.*New Methods for Reducing the Number of False Alarms in Fire Detection Systems*.Fire Techno-logy, 1994, (2):250-268.

[3] Yi Cai, and Da-jie Li.*Adaptive optimization algorithm based on improved genetic algorithm BP neural network.* Chongqing University of Technology.2007, 35(4):102-105.

[4] Chi-Hau Wang,Han-Lei Liu,andChen-Teng Lin. *Dynamic Optimal Learning Rates of a Certain Class of Fuz-zy Neural Networks and its Applications with Genetic Algorithm.* IEEE Transaction on Systems, Man, and Cy-bernetics Part B: Cybernetics.VOL 31, NO.3, June 2001, 467-475.

[5] *Automatic fire alarm system design specifications.* GB 50116-1998, People's Press, 1999.