A Novel Application of Neural Network Optimized Design Based on Immune Modulated Symbiotic Evolution

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Abstract

Optimized design of neural network based on immune modulated symbiotic evolution (IMSE) was proposed, which combines the adjustment of antibody of immune modulated theory so as to keep the individual diversity, eliminates effectively the premature convergence. The results of simulation experiment applied in AGC-ASC system of the two stands reversing tandem cold mill show that this method is suited to the complicated climate, and has good convergence and resists disturbance.
Keywords: immune modulate; symbiotic evolutional arithmetic; neural network; AGC-ASC system

1 Introduction

Biological immune adjustment can improve the variety of the antibody effectively. Biological immune system can produce antibody to resist antigen of outside invasion correspondingly, after the antibody is combined with the antigen. Destroy the antigen through the phagocytes or the special enzymolysis. Meanwhile, in order to keep the immunity balanced, there is suppression and facilitation among the antibodies.

It means calculating the evolution of the colony that is solved partly that the intergrowth evolves it make up the total solution. And it carries on operation with the traditional evolution algorithm to the colony that is solved completely, differents from disappearing and solves optimally in the overall situation finally. It is a kind of separation, search way of running side by side that the intergrowth evolves. Pay attention to the intergrowth among the individuals and cooperation relation further, operation is faster in speed. The ones are especially helpful to the solution of complicated environment.

On the basis of combining intergrowth evolving and immune adjustment, this text proposes Immune Modulated Symbiotic Evolution (IMSE), which is used in the neural network. IMSE adopts the improved immune algorithm, and it can guarantee the convergence property of the algorithm further.

2 Immune Modulated Symbiotic Evolution

2.1 IMSE Algorithm

The procedure of IMSE Algorithm is as Fig. 1 shows. In the Symbiotic Evolution, meet one degree of foundations appraised according to neuron behavior of participated in network as there are. The neuron with higher adaptation degree indicates that it helps to form the solving of the optimum network, having better cooperative ability with other neurons at the same time, and the immune adjustment that keeps on the basis of variety , even at the advanced stage evolving, can maintain the variety of the colony effectively too. Colony in this way produces at all with neuron that function shine upon through it may form and realize the solution of specific task.

2.2 The Neuron Individual's Adaptation Degree and Code

Because the individual neuron in the colony is solved partly, we need to choose a neural unit C at random from the colony, construct out the corresponding neural network (namely total solution). In order to adapt the degrees of value to test among environment network by this, we will meet degrees of value which form each adaptation of neuron of network at the degrees of variable to participate in to get to add, repeat the course of structure of the net and test course, until each neuron has participated in the test of certain number of times, then individual Ni pieces of adaptation of neuron one degree of value:

$$F(n_i) = \frac{\sum_{k=1}^{\Delta} V(\eta_k)}{\Delta}, n_i \in \eta_k \tag{1}$$

In the type: △—— the times of neuron participated in constructing the network;
V（η）——network η Adapt ion one degree of appraising value.

Neural network's input node and output node can not be changed which is up to the assignment generally, the neuron that the intergrowth evolves in the colony is used in building the latent layer of nodes. Each neuron should include all the definition of connections which are the neuron with outputted layer and inputting, take single latent layer of feed forwards network for example, number of connection of each neuron *Num* defines to be:

$$Num=(N+M)\times D \tag{2}$$

In the type: *M*——number of input layer nodes; *N*——number of output layer nodes ; *D*——connect density, generally the fetching value is[0.8,1]. Each connection includes two pieces of threshold, one is label threshold L_i, one is power threshold W_i, connecting the chromosome code which form a neuron of a lot of

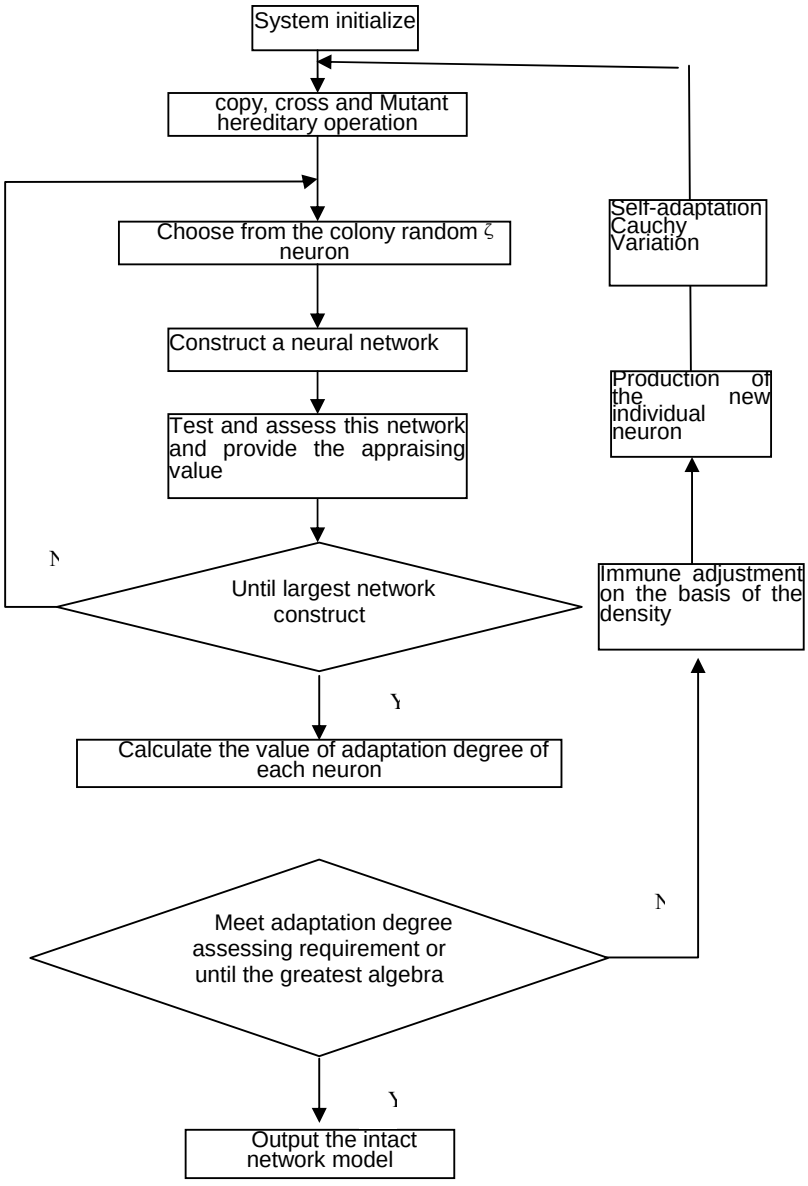

Fig. 1. IMSE arithmetic flow structure

connections, still include the threshold value of θ neuron in the code, the neuron individual's code scheme , the following one , shows:

L_1	W_1	L_2	W_2	…	L_{Num}	W_{Num}	θ

label threshold L_i is 8bits unsigned data, Representatives connect to specific nodes including input or output *Nod*.

$$Nod(i) = \begin{cases} L_i \bmod(M), & if\ L_i > 127 \\ L_i \bmod(N), & if\ L_i \le 127 \end{cases} \quad (1)$$

i pieces of connection according to grade value of threshold, through is it confirm it connect to some input or at the node that output to calculate, power threshold is 16 bit signed data, generally assigned as [-5，+5] Real number, their quantize precision can up to 0.00015 in adjusting power value, All power value of the connection initialized random number among[-1，+1].

As to the same network, if use the standard hereditary algorithm to the whole neural network code, the number of connection encoded is $Num=(M+N)\times D\times \xi$ make one bunch of codes obviously increase, thus make long to search, the calculating amount is heightened, therefore unable to do scale to expand to the network with more neurons and joining value. And adopting individual neuron method of code, number of unit in it increases length of code to increase with latent layer, and it is easy to carry on the expansion of scale.

2.3 Improved Immune Adjustment Algorithm

Regard the neuron individual as an antibody, utilize the density of the antibody to choose the mechanism, realize the function relation that is promoted and suppressed among antibodies, carry on variety to keep, improving and has not disappearing triply , improve the performance that the intergrowth evolves. But if operate improperly, will bring unfavorable influence to convergence property of the algorithm. To question this, improving the realization of immune adjustment algorithm in this text, narrate it as follows:

(1) **Several concepts**

Information entropy: algorithm for indicate variety of antibody of the colony, introduce information concept of entropy. There is an antibody of *N* (neuron), the length of code of each antibody is *L*. It adopts binary scale have the individual the codes character collects for {0, 1}, namely character collection of *S* =2, *N* piece antibody *j* information entropy $H_j(N)$ of location it defines to be:

$$H_j(N) = \sum_{i=1}^{S} (-p_{ij} \log p_{ij}) \quad (4)$$

Among them p_{ij} is represent *i* appear probability at *j* . Then get average information entropy $H(N)$ of an antibody of *N*:

$$H(N)=\frac{1}{L}\sum_{j=1}^{L}H_j(N) \tag{5}$$

Degree of kissing among the antibodies: kissing degrees among two antibody *u* and *v* of $A_{u,v}$ indicate similar degree of two antibodies, whether it defines to be:

$$A_{u,\upsilon}=\frac{1}{1+H(2)} \tag{6}$$

$A_{u,v}$ the fetching value range of *v* is (0, 1), $A_{u,v}$ heavy to show two antibody kiss or not similar. $A_{u,v}$ =1 which expresses the two code gene is self-same.

The density of the antibody: C_i is antibody density of *i* defined:

$$C_i=\frac{1}{N}\sum_{w=1}^{N}ac_{iw} \tag{7}$$

Among them: $ac_{iw}=\begin{cases}1 & ac_{iw}\geq\lambda\\ 0 & otherwise\end{cases}$ λ is a piece of kissing and one degree of constants confirmed in advance, generally the fetching value $0.9\leq\lambda\leq1$.

Choose probability: choosing probability to reflect the individual's adaptation degree, the individual's choice probability p is met one degree of probability p_f and density and suppressed probability p_d two parts to make up.Concrete definition as follows:

$$p_i=\alpha p_{fi}+(1-\alpha)p_{di}=\alpha\frac{F(i)}{\sum_{j=1}^{N}F(j)}+(1-\alpha)\frac{1}{N}e^{-\frac{c_i}{\beta}} \tag{8}$$

α and β The constant regulates the factor. (8)Type indicate individual meet degrees of $F(i)$ heavy to choose probability to be heavy , but individual density C_i heavy to choose probability to be little.

（2）**Calculation procedure of improved immune adjustment**

STEP1: Initialize: Produce an initial antibody of N at random;

STEP2: Appraise to an antibody of N, Calculate the density of the antibody according to type (7);

STEP3: Calculate the individual's choice probability according to type (8), through choosing the mechanism to carry on the promotion of the antibody and suppress regulating;

STEP4: Upgrade the colony: Use operator of crossing and make a variation operator , cross operator adopt simple single some cross methods , the individual mates at random and cross according to what has been scheduled probability is operated alternately ; it adopts adaptive Cauchy function perturbation making a variation method to operate on a variation, this method can survey optimum solve

close to the area at present effectively , have certain getting rid of some and extremely excellent ability, the concrete method as follows:

Through making a variation probability to choose a variation neuron corresponding weight increase on power value $\triangle x$：

$$W_i=W_i+\triangle x=W_i+T\cdot\tan（\pi\cdot R（-0.5，+0.5））\quad(9)$$

among the type R（-0.5，+0.5）is a random variable in the same size among the area [-0.5，+0.5].the function of density probability of $\triangle x$ is namely that Cauchy is distributed function:

$$f(\Delta x)=\frac{T}{\pi(T^2+(\Delta x)^2)}\quad(10)$$

In the type: T is an adaptive parameter ,defined as:

$$T=\frac{T_0}{F_{\max}-F_{avg}}\quad(11)$$

In type: $F_{\max}$——Adaptation degree of the optimum individual in some generation of colony; F_{avg}——Average adaptation degree of the colony; T_0——regulation constant.

The closer between $F_{\max}$ and F_{avg} ,the less difference of adaptation degree among the individuals in the colony, easier to fall into some regions which are extremely excellent. After adding self-adapting parameter, when group tends disappearing too early in the colony, it can change the distribution of Cauchy function, strengthen perturbation value, and regions which are extremely excellent can be surveyed out the new cyberspace and break away from.

3 Neural Thick Board Shape Control System of Network Board of Optimization on the Basis of IMSE Algorithm

3.1 Structure of the Control System

Thick board shape board integrated system with four inputs and 2 outputs, which uses the neural network controller of optimization based on IMSE, constitutes many variable control systems illustrated in Fig. 2:

r_1 protruding degree of establishing value , y_1（k）for the protruding degree of exporting value； r_2 curved regulating amount of roller strength of the job roller, u_2（k）is the roller that sews the regulating amount, e_1、$\triangle e_1$ is the thick deviation of the board and change amount of the deviation separately , e_2、$\triangle e_2$ is the shape deviation of the board and change amount of the deviation separately .

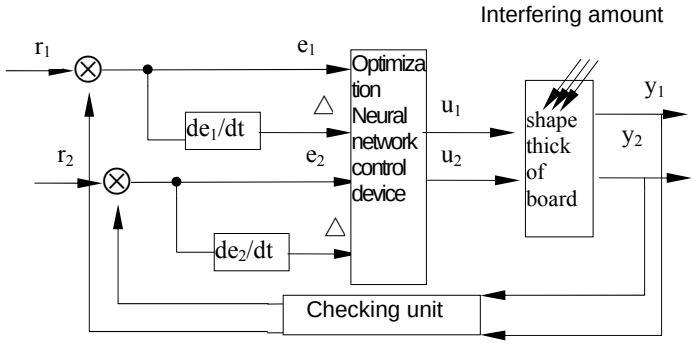

Fig. 2. AGC -ASC system

3.2 Emulation research of the control system

About two framework reversible cold calendar end lines of application illustrated in Fig. 2 based on IMSE optimization neural network board thick board shape comprehensive control system of group, as to this has carried on emulation research , considered the hardness of supplied materials and protruded degree fluctuate at the same time. It is that the amplitude is separately14Mpa（ $\frac{\delta K_0}{K}$ about 3%） and 0.002mm Sinusoidal wave is namely δK_0=14sin 10t（Mpa）, △CR=0.002 sin 10t （mm）.

Parameters of this emulation experiments: the neural network is the single latent layer of feed forwards network, the number of input layer is four, and the output layer is two , neuron colony N=120, kissing degree constants: λ =0.95， α =0.55， β=0.20，T_0=3.2, connect density is 1, one degree of appraising value of adaptation of the network is:

$$Val(\eta_i) = \frac{1}{\sqrt{\frac{1}{MK}} \bullet \sum_m \sum_k (Y_{mk} - \overline{Y}_{mk})^2} \tag{12}$$

In the type: Y_{mk} and $\overline{Y}_{mk}$ is m pieces of mode and k piece of sample which are expected export and actual export of output nodal separately, M=4 is count for the mode, K=2 is the number of output codes. Investigate the diversified performance of maintaining of the colony for the ration; define the variety degree φ value of the colony:

$$\Phi = \frac{2 \bullet \sum_{j=1}^{N} H_j}{N(N-1)L} \tag{13}$$

In the type: N colony size, L each code length of antibody, H_j N pieces of j message entropy of location of antibody. An initial colony adopting even random variable and emerging φ=0.5. IMSE emulation experimental result of this text and with standard hereditary algorithm (SGA), intergrowth evolves the comparative result of the method (SE) as Fig. 3 shows. 3 Fig. provide IMSE, SGA, SE meet comparison curve of degree on the basis of network. 4 Fig. provide two framework reversible cold calendar end lines of application based on IMES optimization neural network board thick board shape of group comprehensive board of control system thick the shape of the board controls the curve.

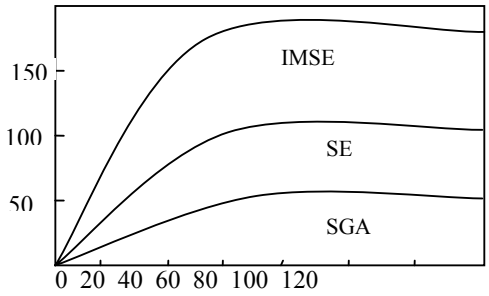

Fig. 3. IMSE、SE and SGA astringency curve

Result of emulation analysis can be found out by Fig. 3, in weighing overall convergence property and restraining the speed index synthetically, the performance of IMSE is the best. 4 Fig. And it indicates that optimization neural network controller based on IMSE control panel thick and the board shape have better control results, adjusting time within 50ms.

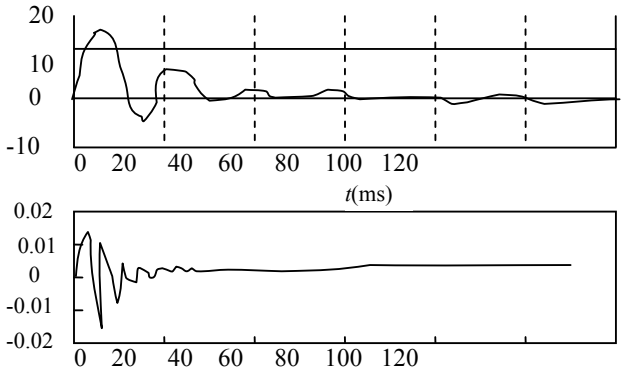

Fig. 4. System simulation curve

4 Conclusions

It has been proved that through the application instance above, on the basis of optimization neural network design method of IMSE, with combining evolved intergrowth algorithm and density of immune principle suppress regulation mechanism together, system have shortened the individual's length of code and lightened the calculating amount by solving the evolution of the colony to the neuron part. Meanwhile, system adopted the improved immune adjustment algorithm, which improved the variety of the colony effectively. The neuron that produced in the colony in this way can quickly get and realize the network, which is controlled by the thick and shape of the board.

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