Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia Engineering 29 (2012) 2754 – 2758

Procedia Engineering

www.elsevier.com/locate/procedia

2012 International Workshop on Information and Electronics Engineering (IWIEE)

Improved Danger Model Immune Algorithm

Qingyang XU[a]*

School of Mechanical, Electrical & Information Engineering, Shandong University at Weihai, Shandong, 264209, China

Abstract

Danger Model Immune Algorithm (DMIA) is an algorithm based on the danger theory of biological immunology. In the framework of the algorithm, the danger area is fixed in the process of optimization. In this paper, an improved algorithm is proposed which are different from the framework of the algorithm. In the new algorithm, the danger area will be changed gradually according to the iterations automatically. And two kinds of method (linear and nonlinear) are adopted to adjust the danger area. Complex function is used to test the algorithm. Through the comparison test, the results denote that the nonlinear method is more effective than the linear one, and has better optimization capability.

Keywords: Danger Model Immune Algorithm; Danger area; Linear; Nonlinear; Optimization

1. Introduction

The research of Artificial Immune Systems (AIS) is generally considered to have been initiated in 1986 with the publication of a paper about immune system application by Farmer et al. [1]. Then researchers begin to do some researches on AIS since then. The early researches about AIS are almost based on "self-no self" immunity mechanism. With the development of medical research, researchers found that the "self-no self" discrimination cannot explain some problem reasonable. Therefore, Mat zinger Polly who is an immunologist in NIH proposed the Danger Theory in 1994 [2, 3]. The core concept of Danger Theory is that the biological immune system reacts to danger signal instead of responding to "self-nonself". It provides a new method of 'grounding' the immune response. It affects the construction of AIS

* Corresponding author. Tel.: +86-0631-5688338; fax: +86-0631-5688338.
E-mail address: xuqy1981@163.com.

doi:10.1016/j.proeng.2012.01.385

correspondingly. Up to the present, there are many experts and scholars apply themselves to this, and proposed their research subject and result and apply to many fields [4-7].

The research of artificial immune algorithm based on danger model theory is almost talking about the realization of danger signal, and danger area and other operations *etc*. Through this, a framework of Danger Model Immune Algorithm is designed according to the characteristic of danger model theory. [8] But the danger area is fixed in the algorithm and it is difficult to define. So in this paper we adopt two different measures to improve the algorithm and realize a new Danger Model Immune Algorithm. The danger area is variable in the iteration process. The simulation results show that the improved algorithm has better performance than the basic algorithm.

2. Danger area

The danger area is a very important parameter in DMIA. It is fixed in the previous algorithm. However, there is a problem that how to define the size of danger area. The danger area is too wide to express the advantage of this algorithm. Inversely, if the danger area is two small, the searching result will be not very well. So we adopt two different methods to adjust the danger area automatically in the algorithm. The radius of danger area will be changed according to the iteration steps. At the beginning, there is a bigger danger area, and then the radius of danger area is degressive gradually. Linear and nonlinear methods are adopted to adjust the danger area as following.

2.1. Linear type

Linear adjustment method can be described as follows.

$$R = \frac{RS(n_{max} - n)}{n_{max}} = -\frac{RS}{n_{max}} n + RS = -kn + b \quad (1)$$

$K = RS / n_{max}$ is the absolute value of the slope. $b = RS$ is the initial radius of danger area. n is the iteration step. n_{max} is the max iteration step. The radius of danger area is adjusted according to the linear transformation formula.

Suppose that max iteration steps are 100, and the initial radius of danger area is 5 and the final radius of danger area is 0. The transform equation is as following.

$$R = -\frac{1}{20} n + 5 \quad (2)$$

2.2. Nonlinear type

The root index equation is adopted as the nonlinear adjustment method.

$$R = \frac{RS}{\sqrt[a]{n}} \quad (3)$$

R is the current radius of danger area. RS is the initial radius of danger area. n is the iteration step. a is the root index.

2.3. Linear type and nonlinear type comparison

Figure 1 shows the comparison of danger area changes under linear method and nonlinear method. The radius of danger area is adjusted quickly in 20 iterations for nonlinear method, but it is changed slowly after 20 iterations. So there is a change from fast to slow for the danger area adjustment which is suitable for optimization.

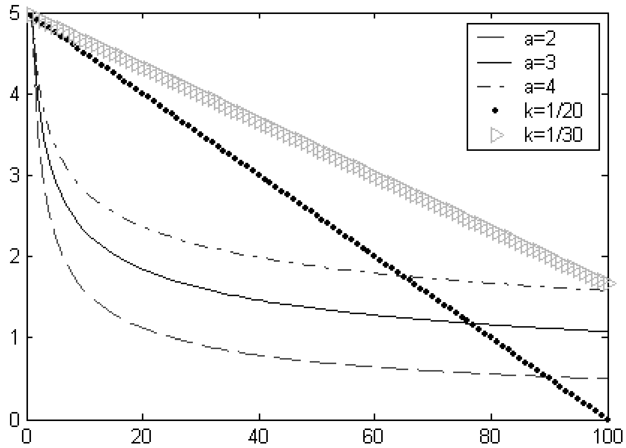

Fig. 1. the comparison chart of radius of danger area

3. Algorithm

In the algorithm, there are two main parts. The first one, divide the antibody set into danger and safe antibody set according to danger area. Second, adopt danger operator to operate the danger antibody. The algorithm of DMIA is shown as following. The following figure 2 is the flowchart of improved DMIA.

The concrete algorithm steps of DMIA as following:

Step1: initialization. Iteration step k = 0, and set mutation probability Pm, and then generate initial antibody population.

Step2: decode the antibody, and calculate the affinity.

Step3: obtaining the danger signal 0 and 1, if there is no danger signal, the optimization is end, otherwise send danger signal.

Step4: obtaining the optimal individual op_k*, send co-stimulate signal 2, calculate the danger area according to iteration steps. The danger area calculation is the main point of the improved algorithm. The radius of the danger area will be defined by the following equations, and changed gradually.

Linear type: $R = \frac{RS(n_{max} - n)}{n_{max}} = -\frac{RS}{n_{max}} n + RS = -kn + b$

Nonlinear type: $R = \frac{RS}{\sqrt[a]{n}}$

Step5: divide the antibody into safe antibody and danger antibody according to the danger area.

Step6: danger operation. In this paper, the danger operator is the same as the framework of DMIA.

Step7: adopt basic mutation operator and conventional selection operator to update population.

Step8: $k = k + 1$, return Step2.

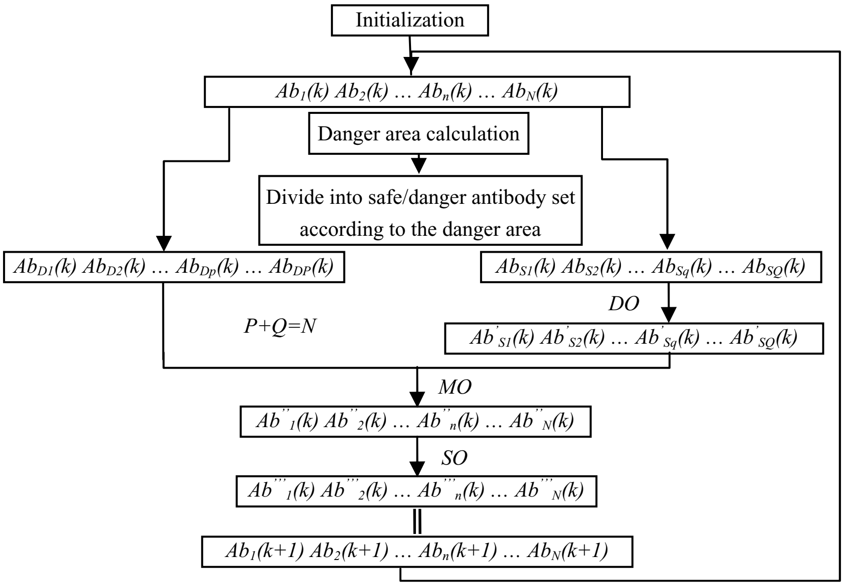

Fig. 2. the flowchart of improved DMIA

4. Simulation

In the simulation, binary string is adopted to encode the antibody. The binary string length is 20, and the population size is 50, and the mutation probability is 0.03, and the maximum iteration is 100. The initial radius of the danger area is 5, and it is adjusted according to the iteration steps. To testify the validity of the algorithm and also compare the linear method with the nonlinear method, a complex function are used for testing.

$$f = \left(\frac{3}{0.05 + (x^2 + y^2)^2}\right)^2 + x^2 + y^2, \; x,y \in [-5.12 \;\; 5.12] \quad (4)$$

f is a local peak function, and the maximum value is 3600 at point (0, 0) [9]. This can be used to test the optimization capability of improved algorithm.

Figure 3(a) is the contrastive error curves of DMIA and improved algorithm. The "*" line is the error curve of R =5. The danger area is almost the domain of x and y. The optimization result is very bad in 100 iterations. The algorithm degenerates into a simple genetic algorithm actually. The "— - " Line is the error curve of R =3, the optimization error is convergent to zero in 100 iteration steps. The final error is close to 0.005. It has better optimization capability than R=5. The " - - " line, "—" line and "—•" line are the error convergent curve of improved algorithm. At the beginning, it has the same initial value as R =5 for the improved algorithm, then the error is convergent with the increase of iteration steps and also the radius of danger area is changed according to the iteration steps, the error is convergent to zero finally. From these error curves we can see that the improved algorithm has better optimization capability than the basic DMIA. Figure 3(b) is the amplification of figure 3(a) from 70 steps to 100 steps. From this figure we can see that the nonlinear method is more effective than linear method for algorithm improving. It has faster convergence rate.

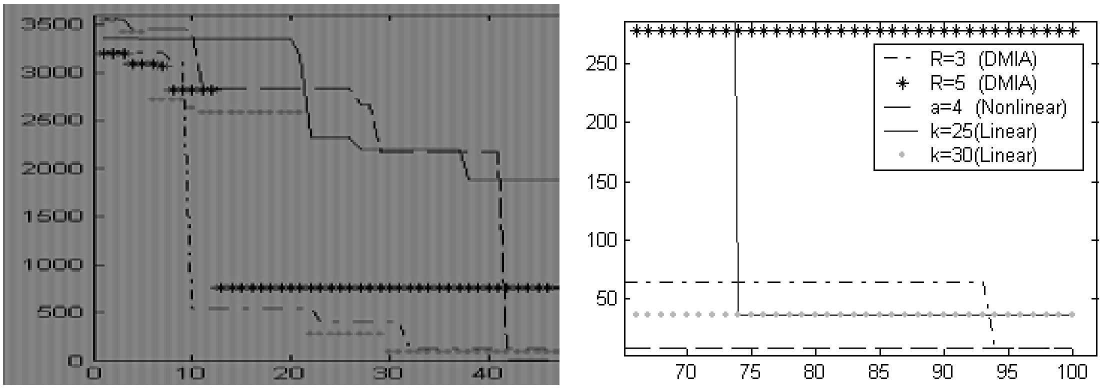

Fig. 3 (a) error convergence curves of DMIA and improved algorithm; (b) the amplification of (a)

5. Conclusion

The radius of danger area is a very important parameter in DMIA. It is an experiential parameter and difficult to define. So an improved algorithm is proposed to solve the problem. The danger area is variable according to the iteration steps in the improved algorithm. Linear and nonlinear methods are adopted to adjust the danger area separately. The simulation results indicate that the nonlinear method is more suitable for the optimization, and it has higher efficiency and accuracy. So the nonlinear method can be used to improve the DMIA for the optimization problem.

Acknowledgements

This paper is supported by Shanddong province science and technology development plan of China (No.2011GGE27053).

References

[1] Farmer JD, Packard NH, Perelson AS. The Immune System, Adaptation and Machine Learning. *Physica D* 1986; 22:187–204.

[2] Matzinger P. Tolerance Danger and the Extended Family. *Annual reviews of Immunology* 1994; 12:991-1045.

[3] Matzinger P. The Danger Model: A Renewed Sense of Self. *Science* 2002; 296:301-5.

[4] Aickelin U, Cayzer S. *The Danger Theory and Its Application to AIS*. 1st International Conference on AIS. Canterbury:UK; 2002.

[5] Swimmer M. Using the danger model of immune systems for distributed defense in modern data networks. *Computer Networks* 2007; 51:1315–1333.

[6] Musilek P, Reformat A LM, Wyard-Scott L. Immune programming. *Information Sciences* 2006; 176:972-1002.

[7] Secker A, Freitasa A, Timmis J. *A danger theory inspired approach to Web mining*. proceeding of International Conference on Artificial Immune Systems. Springer; 2003.

[8] XU Q, MENG X. Research on danger model theory based artificial immune algorithm. International Conference on Computational Intelligence and Software Engineering. China: Wuhan; 2009.

[9] DU H, GONG M, LIU R, JIAO L. Adaptive chaos clone evolutionary strategy algorithm. *Science in china series E: information science* 2005; 35:817-29.