

# Study Actuality of Immune Optimization Algorithm

**Abstract.** In this paper, an optimization algorithm base immune principle is expatiated, explain its basic theory and process. And discuss immune algorithm's advantage than other heuristic algorithms, such as: genetic algorithm and evolution strategy. And introduce several better algorithms base immune algorithm, present application in optimization problems. At last we propose immune algorithm's further development in optimization problems' application.

**Streszczenie.** W artykule przedstawiono algorytm optymalizacji oparty na układzie odpornościowym. Opisano podstawy teoretyczne i zasady działania. Dokonano porównania z innymi algorytmami heurystycznymi, jak genetyczny i ewolucyjny. Omówiono także potencjalne zastosowanie algorytmów bazujących na proponowanym rozwiązaniu. (**Badanie algorytmu optymalizacji odpornościowej**).

**Keywords:** Immune Algorithm; Genetic Algorithm; Evolution Strategy; Optimization Problem.

**Słowa kluczowe:** algorytm odpornościowy, algorytm genetyczny, strategia ewolucji, problem optymalizacji.

## Introduction

The nature immune system is one of the most intricate bodily systems. It is a very important effect in make sure living healthy. In so complexity nature, immune system protects the body from a large variety of bacteria, viruses, and other pathogenic organisms.

## Several Improvement Optimization Algorithms

(A) Base on vaccine extraction immune optimization algorithm

### (1) Algorithm description

Vaccine inoculation is a very important aspect on the immune memory clinic application. Vaccinal defend immunity already destroy many serious infection diseases in worldwide, for example, smallpox, measles and infantile paralysis etc. Base on sufficiency knowledge researching the epidemic virus, people develop vaccines to prevention and cure the epidemic pertinence. Utilizing the concept of vaccine to improve the immune algorithm performance. Extraction vaccine from problem's basal and obvious characteristic or knowledge, make problem to solved more pertinence. Base on article [1], take vaccine concept introduce the immune algorithm, utilize the ancestor knowledge, design a new immune optimization algorithm base on vaccine inoculation. The algorithm flow chart shows fig. 1.

### (2) Algorithm characteristic

Extraction vaccine in reason is the key in immune operate number. Generally speaking, there are two methods to selective vaccine, the one base on problem's character information, the one is analyses the problem, and reduce original problem's size, increase some local constraints to predigesting problem.

### (3) Algorithm application

Article [6] has carried on the simulation experiment using this method to the TSP (Traveling Salesman Problem) question, compares with general genetic algorithms, This kind of immune optimization algorithm can solve the degenerated phenomenon well which in the existing algorithm appears, and also enable the convergence rate to have the remarkable enhancement. Result demonstration: the vaccine choice has the tremendous influence to the algorithm performance, but it cannot affect the algorithm the astringency, this algorithm has the good search ability and the auto-adapted ability [3].

(B) Immune Optimization Algorithm Base on the Information Entropy

Toyoo Fukuda design immune algorithm base on the information entropy.

Algorithm introduce

The algorithm's procedures are same to the normal immune algorithm. The difference is introduce the information entropy in evaluate diversity procedure. The following several paragraphs are explain the feasible solution diversity. The data structure of the genes can be depicted as shown in Fig. 2. According to Fig. 2 there are N antibodies with M genes in the antibody pool N is presented as the number of antibodies (candidates for unit commitment) in a generation, and M is the number of units.

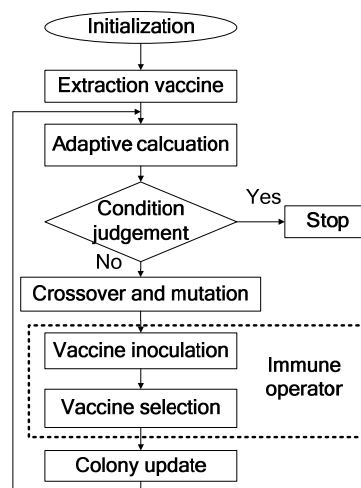


Fig.1. Base on vaccine inoculation immune optimization algorithm flow chart

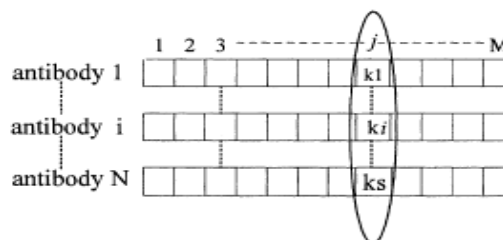


Fig.2. the model of antibody

Assume that antibody pool is composed of N antibodies having M genes. From the information entropy approach, we can get

$$(1) \quad H_j(N) = \sum_{i=1}^N -P_{ij} \lg P_{ij}$$

$H_j(N)$  is the number  $j$  information entropy in number  $N$  antibodies.  $P_{ij}$  is the probability of the  $k_i$  allele coming from the  $j$ th gene. The mean of the information entropy  $H(N)$  is defined as:

$$(2) \quad H(N) = \frac{1}{M} \sum_{j=1}^M H_j(N)$$

where  $M$  the size of the gene in antibody. The entropy can illustrate the diversity of the antibody population.

The expression observes the diversity between two antibodies as follows:

$$(3) \quad a_{vw} = \frac{1}{1 + H(2)}$$

where  $a_{vw}$  is the affinity between two antibodies  $v$  and  $w$ , and  $H(2)$  is the information entropy of only antibodies  $v$  and  $w$ . The larger  $a_{vw}$ 's value, the more matcher between antibodies  $v$  and  $w$ . Calculate the concentration  $c_v$  of antibody  $v$ .

$$(4) \quad c_v = \frac{1}{N} \sum_{w=1}^N a_{vw}$$

where  $a_{vw} = \begin{cases} 1 & a_{vw} \geq T_{ac} \\ 0 & \text{otherwise} \end{cases}$ . The expected-breeding ratio

$e_v$  of antibody  $v$  guides promote or suppress antigens.  $a_{v0}$  express affinity between antibody  $v$  and antigen.

$$(5) \quad e_v = \frac{a_{v0}}{c_v}$$

The more greater unit adaptation, the more higher expected-breeding ratio. The more greater unit's concentration, the more lower expected-breeding ratio. The advantage of utilizing information entropy is keeping units that have higher adaptation, at the same time, making units diversity, and improving the speed of convergence.

2) The characteristic of the immune algorithm base on the information entropy

① Adopt information entropy evaluate similarly of the colony solution, the information entropy is more impersonality than Hamming distance.

② Base on the concentration selection mechanism, encourage higher suitable feasible solution, and suppress higher concentration solution, make sure algorithm convergence and solution colony diversity. The algorithm suitable to resolving optimization function problem that have many peak values.

③ Introduce the threshold value function. Utilizing immune recognize diversity, namely BALDWIN domino effect (encourage the antigen reproduce that has higher matching) and improve the algorithm performance.

3) Based on information entropy immune algorithm application

Article [7] utilizing information entropy immune algorithm solves the Rosenbrock function overall situation maximum value computation question, and draws the conclusion: This algorithm enhanced the overall situation and the partial search ability, improved the flaw of immaturely convergence, and enhanced the convergence rate.

### (C) Immune algorithm base on immune recognition

Article [8] reference nature immune recognition mechanism, design a immune algorithm base Negative Selective modal. The algorithm called IAIR (Immune Algorithm Based on Immune Recognition). IAIR theory make solution space corresponding the whole space, non-excellent solution corresponding the self space, the complement corresponding non-self space; In find solution process, using the self space to checking the non-self space continuously, reduce the non-self space. Finally, only excellent solutions are kept in non-self space. Using the negative selective to exclude the non-excellent solution and find the excellent solution. IAIR base flow can be depict as show in Fig.3. IAIR base process is similar to Genetic algorithm and it can deal with the solution data directly, via coding express as gene string structure data. Normally utilize binary-code structure, we regard elements of the problem as gene fragment, and take all feasible values initializing the gene library. Therefore, all combination results germ library equal to all solution space. The finding solution process of IAIR needn't other exterior information, just using function value to evaluating antibodies or solution, according as evaluating result to process the immune operation.

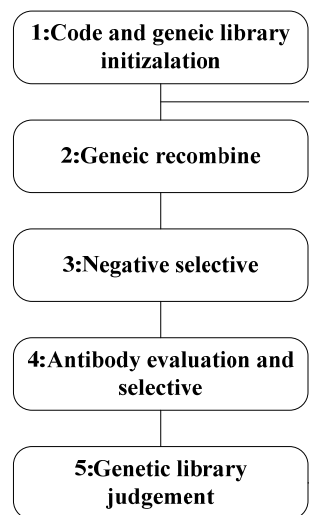


Fig.1. IAIR base flow chart

Genetic rearrangement, negative selective and gene library adjust are 3 main immune operation number of IAIR.

(1) Genetic rearrangement: Each gene fragment select corresponding allele randomly from gene library, composing a legal antibody (solution of the problem). The objective of the genetic rearrangement can improve the whole search capability.

(2) Negative selective: Utilizing genetic rearrangement produce new antibody, the antibody maybe a better solution, but it maybe a worse solution. NS can exclude the worse solution via self-selective, improve the search speed and algorithm time performance.

(3) Gene library adjust: Utilizing mature antibody to modify concentration of corresponding gene in gene library, increase concentration of the better antibody gene, and decrease concentration of the worse one. And improve probability of produce the better antibody in next gene rearrangement.

Article [2] via experiment prove the algorithm having better time complex degree, so the algorithm suitable resolve complex and huge practice problem.

## Several Improvement Optimization Algorithms

### (A) Conclusion

Article [5] via experiment prove base immune algorithm lack convergence characteristic. Analyze the reason, the antibody evaluate manner and utilize memory library are main problem. Immune algorithm base vaccine inoculation and information entropy improve on the antibody evaluate manner, encourage high matching degree antibody, at the same time, suppress high concentration antibody, make sure the diversity of group, improve the algorithm efficiency; Base on immune recognition and immune evolution, the algorithm improve on the memory library (gene library), make memory library keep and update optimization all the time, algorithm can find more suitable antigen, at the same time spend less time.

The immunity evolution algorithm improved the basic immunity algorithm to have the strong overall importance thick search, lacked carries on the high accuracy search ability in the partial region. It carries on overall large adjacent field search, finds evaluate value high area, and then carries on the local accuracy search in this area. Through from thick to accuracy the two adjacent field search, had achieved guaranteed its overall search optimize solution and local seek accuracy solution. Immune genetic algorithm has inherited the immune algorithm and genetic algorithm merit, can more effective find the overall situation optimal solution. Article design a improvement immune genetic algorithm, introduced the pattern memory library, causes a memory cell more effective renewal, has solved the problem which the general immunity genetic algorithms is short of memory function.

### (B) Development and prospect forecast

According to immune algorithm research experience, external violation examination and internal study mechanism optimized become two big difficulties. At present uses the external violation examination algorithm extremely simple, has the very big disparity with organism function, can't satisfy need of the actual optimized question application. Present immune algorithm general establishment in precise mathematical model or in formula foundation. The mathematical model no doubt simple, is easy to realize, but the function is not strong, the result often distorts, intelligent is not high, also is not advantageous for the improvement.

Although the immune algorithm development has many difficulties, but the immune algorithm prospects for development are still extremely optimistic, the application immune algorithm carries on optimized the example to be

more and more in the real life. Along with the immune algorithm mature, gradually becomes hot spot of the artificial immunization system the application.

The next immune optimization algorithm research will approximately concentrate with emphasis in: discriminate self and non-self capability; immune optimization algorithm intellectualization and several other aspects. Along with the immune optimization algorithm development and the consummate, will open the new development space for the stochastic optimized method.

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