1-28

Evolutionary Algorithm with Immune and Infection for Traveling Salesman Problems

Takuya INOUE, Yoko UWATE and Yoshifumi NISHIO
(Tokushima University)

1. Introduction

In this paper, we propose Evolutionary Algorithm with Immune and Infection (EAII). Immune Algorithm[1] was proposed in the past and finds a optimal solution by updating antibodies. On the other hand, EAII is using infection algorithm to be based on Immune Algorithm. Thus, EAII finds a optimal solution in combinatorial optimization problems by updating antibodies and apart of the information of the antibody changing by infection. In this study, we apply proposing method of EAII to Traveling Salesman problems (TSP) and confirm that EAII obtains more effective result than others method.

2. Flow of EAII

In this section, we explain flow of Evolutionary Algorithm with Immune and Infection (EAII). Flow of EAII shows Step1-4. Step2 from Step4 is repeated until the set number of updating antibodies.

Step1 (*Initialization*)

Initialization is random route selection. We define random routes as antibodies.

Step2 (*Evaluation of antibodies*)

Where ax_i is level of affinity and is defined by the following formula. ca_j indicates the antigen, and N indicates number of city.

$$ax_i = \sum_{j=1}^{N} ax_{ij} \tag{1}$$

$$ax_{ij} = \begin{cases} 1(c_{ij} = ca_j) \\ 0(c_{ij} \neq ca_j) \end{cases} \tag{2}$$

Where c_i is concentration of specific antibody. S indicates number of antibody.

$$c_i = \frac{\sum_{j=1}^{S} ay_{ij}}{S} \tag{3}$$

$$ay_{ij} = \begin{cases} 1(ax_i = ax_j) \\ 0(ax_i \neq ax_j) \end{cases} \tag{4}$$

In using ax_i and c_i, we calculate e_i. $d_{total-i}$ indicates total distance of each route. α is coefficient. Where e_i is evaluation value, and is defined by the following formula.

$$e_i = \frac{1}{(d_{total-i})^{\alpha}} \times \frac{ax_i}{c_i} \tag{5}$$

High evaluation values organism survive, while low evaluation values organism become extinct.

Step3 (*Production of new antibodies*)

In surviving antibodies, this Step3 acts production of new antibodies by Crossover and Mutation. Crossover is to be mated the two routes, and Mutation is to change the route with a certain probability.

Step4 (*Infection*)

We define elements of each route as antigen, elements select the minimum route in obtaining and part of each route is infected by this antigen at random. Number of element selects is fixed probability.

3. Experimental Results

In order to compare the performance of EAII and others method. In this study, the number of updating antibodies is 2000 times, the number of simulation is 5 times, number of antibody is 1024 and *error rate* is defined by the following formula.

$$Error\ rate[\%] = \frac{(obtain) - (optimum)}{(optimum)} \times 100 \tag{6}$$

where *obtain* is minimum solution and *optimum* is optimum solution. When *obtain* value approaches *optimum* value, *Error rate* is low. For example, when *obtain* value is equally *optimum* value, *Error rate* is 0[%]. If *Error rate* is 0[%], we would obtain optimum solution. However, *obtain* is bad solution, *error rate* is high.

Table 1 shows result of EAII and others method. GA is Genetic Algorithm, AS is Ant System and GIACO[2] is Ant Colony Optimization Using Genetic Information. Using TSP types are 5 types. att48 is 48 cities, kroC100 is 100 cities, eil101 is 101 cities, gr120 is 120 cities and gr202 is 202 cities.

Table 1: result

Algorithm	Error rate[%]				
type	att48	kroC100	eil101	gr120	gr202
GA	5.54	13.34	13.34	12.32	10.01
AS	2.76	10.21	7.19	6.01	1.31
GIACO	2.41	9.50	**2.11**	4.64	**0.00**
EAII	**2.03**	**9.47**	6.61	**3.89**	9.08

In Table 1, EAII does not obtain the best solution in all TSP type, however EAII can obtain basically good solution.

4. Conclusion

We proposed EAII for TSP and applied it to lead approximate solutions. From the result, EAII was valuable to obtain of the good solution. In the future work, we would like to study the mechanism of *Infection* in detail. It is also our future work to investigate leading approximate solution for large number of cities in TSP.

References

[1] K. Mori and M. Tsukiyama, *"Immune algorithm with searching diversity and its application to resource allocation problem,"* Transactions on JIEE 113-C (10), 1993.

[2] S. Shimomura, H. Matsushita and Y. Nishio, "*Ant Colony Optimization Using Genetic Information for TSP,*" Proceedings of International Symposium on Nonlinear Theory and its Applications (NOLTA'11), pp. 48-51, 2011.