Combination of Immune Algorithm and Virus Theory of Evolution for TSPs

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Abstract— **We propose Evolutionary Algorithm with Immune and Infection (EAII). EAII is using Virus Theory of Evolution 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 Virus Theory of Evolution. We confirm that EAII obtains more effective result than others method.**

I. Introduction

In daily life, there are many optimization problems. One of these optimization problems is Traveling Salesman Problem (TSP) [1]. TSP is known as one of combinatorial optimization problems. When salesman is given a set of number N cities, TSP is the problem of finding minimum total between each city distance. When the number of N increases, the total route number explodes. Therefore, exploring total route number needs amount of time in finding approximate solution. It is necessary to solve the TSP in other ways except exploring total routes. There is a variety of methods to find approximate solution by TSP [2]-[4].

Immune Algorithm (IA) [5], [6] is one of method to solve the TSP, and modeling behavior of updating antibodies in organism. In repeating these updating antibodies, antibodies group changes efficient group for fighting antigen. IA finds optimal solution by using these behavior.

However, IA considers only updating antibodies group. Thus, we focus attention on acquiring the Virus Theory of Evolution (VTE) by antigen besides updating antibodies group. We propose Evolutionary Algorithm with Immune and Infection (EAII[1]). EAII is using VTE algorithm to be based on Immune Algorithm. We confirm that the proposed algorithm achieves better performance than other methods.

II. Virus Theory of Evolution

Organic evolution is theory based on natural selection. In natural world, high fitness individuals organism survive, while low fitness individuals organism become extinct. Over the years, only higher fitness individuals survive. We call it Evolution. Thus, evolution needs to overlay generations.

On the other hand, Virus Theory of Evolution (VTE) [7] has proposed aside from organic evolution. This theory is based on the evolution by Lateral Gene Transfer (LGT) [8] in Virus infection. Without evolution inherited from parent cell to child cell, genes can evolve. Low fitness individuals possibly evolve into high fitness individuals in just one generation by LGT in Virus infection. Algorithms of using VTE was proposed in the past [9]. We assume using VTE algorithm leads the approximate solution in less time and VTE theory is efficient in TSP.

[1]We are submitting the same content to IEEE International Symposium on Circuits and Systems (ISCAS'14).

III. Evolutionary Algorithm with Immune and Infection

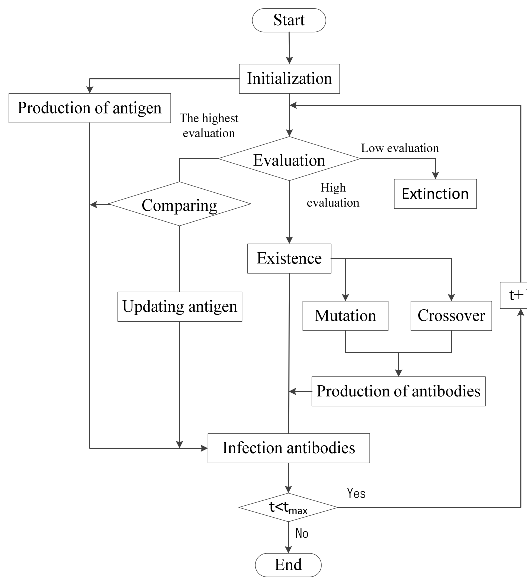

Fig. 1. Flow chart of EAII.

In this section, we explain flow of Evolutionary Algorithm with Immune and Infection (EAII). Flow chart of EAII is shown in Fig. 1. Flow of EAII shows Steps1-4. Step2 from Step4 is repeated until the set number of updating antibodies (t_{max}). t means the number of repeating times.

Step1 Initialization

We prepare a number of random route selection. We define the number of random routes as antibodies. The number of random route selection is U.

Step2 Evaluation of antibodies

Where ax_i is level of affinity and is defined by the following Eq. (1). ca_j indicates the antigen, and N indicates number of city.

$$ax_i = \sum_{j=1}^{N} ax_{ij} \quad (1)$$

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

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

$$c_i = \frac{1}{S} \sum_{j=1}^{S} ay_{ij} \quad (3)$$

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

By 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 Eq. (5).

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

Equation (5) means that high evaluation values organism survive, while low evaluation values organism become extinct.

Step3 Production of new antibodies

In surviving antibodies in Step2, new antibodies is produced by Crossover and Mutation.

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. Part of antibody changes the information held in this Virus like the Fig. 2. We call it $Infection$.

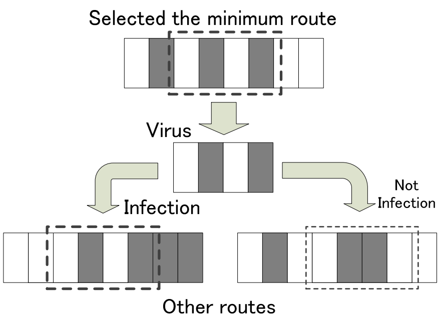

Fig. 2. The mechanism of $Infection$.

IV. Simulation Results

In order to compare the performance of EAII and other algorithms, we apply to find approximate solutions in TSP. In this study, the number of t is 2000 times, the number of simulation is 5 times, U is 1024, applying TSP are 4 kinds and $error\ rate$ is defined by the following Eq. (6).

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

where $obtain$ shows obtained solution and $optimum$ shows optimum solution.

Table I shows result of EAII, GA and ACO. GA is Genetic Algorithm [10], ACO is Ant Colony Optimization [11]. GA and ACO are same the number of t and U for comparing performance of EAII. In Table I, result of EAII is the best of three methods.

TABLE I

The result of simulations

	att48	kroC100	eil101	gr120
GA	5.54	13.34	13.34	12.32
ACO	2.76	10.21	7.19	6.01
EAII	**1.29**	**9.47**	**6.61**	**3.89**

V. Conclusion

We proposed EAII for TSP and compared the performance of EAII and other algorithms to lead approximate solutions. From the result, the result of EAII was better than other methods. Thus, it was efficient to use VTE based on IA in TSP. Furthermore, we expect that EAII has technological application possibility.

In future work, we would like to study the mechanism of $Infection$ in detail. We expect to obtain a better solution by studying mechanism of $Infection$.

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