1-16

Genetic Algorithm with Virus Infection for Traveling Salesman Problem

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1. Introduction

Traveling Salesman Problem (TSP) is known as one of the combinatorial optimization problems. The Genetic Algorithm (GA) [1] is popular method to solve the TSP. However, the GA has characteristic that convergence speed is slow.

In this study, we propose Genetic Algorithm with Virus Infection (GAVI). One of the characteristics of the virus infection [2] is to be spread out around at once. This characteristic seems to be useful to find the optimum solution quickly. Therefore, we consider that the virus will help to solve the TSP. We carry out computer simulations for various parameter values and confirm that the proposed algorithm achieves better performance than the conventional GA.

2. Flow of GAVI

Selection, *Crossover* and *Mutation* are the main functions of the GA. GAVI is a method that incorporate the standard GA with virus characteristic. GAVI algorithm is indicated the following Step1-7. Step2 from Step7 is repeated until the set number of *Crossover* times.

Step1 (*Random route selection*)
The number of *Random route selection* is the same as the number of cities. For example, in the case of 16 cities, *Random route selection* makes 16 routes at random.

Step2 (*Evaluation*)
Evaluation is defined by the following formula,

$$f_i = \frac{1}{d_i} \qquad (1)$$

where d_i is total distance of each route and f_i is evaluation value.

Step3 (*Selection*)
Route is selected with a probability of p_i.

$$p_i = \frac{f_i}{\sum_{i=1}^{n} f_i} \qquad (2)$$

where n is the number of cities. *Selection* is the method of tends to be chosen high evaluation route.

Step4 (*Crossover*)
Crossover is to be mated the two routes.

Step5 (*Infection*)
It defines Virus that the shortest distance between the cities in route. For example, 1 from 6 is route numbers and between adjacent elements is defined distance. $3, 5$ is a virus and has infected the route of $1, 6, 3, 5, 2, 4$ in Fig. 1(a). The route replace to $2, 3$ $1, 4$. We call it *Infection*. *Infection* is incorporating partial optimum solution

Step6 (*Destruction*)
We calculate the longest distance between the cities in route in every generation. For example, $6, 1$ is the longest distance between the cities in route of $3, 6, 1, 4, 2, 5$ in Fig. 1(b) and swap the order of the route. The longest distance disappear in this route. We call it *Destruction*. *Destruction* is avoiding partial bad solution.

Step7 (*Mutation*)
Mutation is to change the route with a certain probability and less likely to fall into local minimum.

3. Experimental Results

In order to compare the performance of GAVI and GA, we apply GAVI and GA to a TSP such as ulysses16(16 cities). Table1 shows simulation result for ulysses16. In this study, the number of generation is 5000 times, the number of simulation is 100 times and *error rate* is defined by the following formula.

$$error\ rate[\%] = \frac{(obtain) - (optimum)}{(optimum)} * 100 \qquad (3)$$

where *obtain* is minimum solution. *optimum* is optimum solution. In Table1, Ave is the average, Max is the maximum value and Min is the minimum value in the results of simulation 100 times.

GAVI obtains better result than GA in Table1. GAVI can find a good solution by *Infection* and *Destruction*. We assume that *Infection* and *Destruction* were effective processes to escape from local minimum similar with *Mutation*.

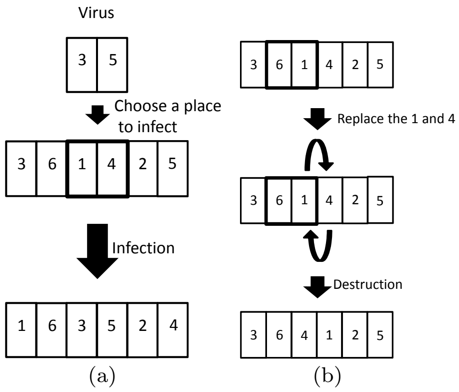

Figure 1: The mechanism of two functions.
(a) Infection (b) Destruction

Table 1: The result for ulysses16

algorithm type	Mutation rate	error rate[%]		
		Max	Min	Ave
GA	0.02	55.267	14.404	37.251
	0.05	57.794	4.395	**30.386**
	0.10	66.844	18.109	39.506
GAVI	0.02	28.347	3.852	**10.858**
	0.05	34.503	2.204	11.937
	0.10	41.190	2.818	10.972

4. Conclusion

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

References

[1] Jean-Yves Potvin, *"Genetic algorithms for the traveling salesman problem,"* Annals of Operations Research 63, pp.339-370, 1996.

[2] Naoshi Nakaya, Akinori Kanasugi and Kunio Kondo, *"An Evolutionary Algorithm Based on the Virus Theory of Evolution,"* Information Processing Society of Japan Vol.40, No.5, 1999.