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 a popular method to solve the TSP. However, the GA has the characteristic that the convergence speed is slow.

In this study, we propose a 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 incorporates the standard GA with virus characteristics. GAVI is indicated by 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,

\[ f_i = \frac{1}{d_i} \]  

where \( d_i \) is the total distance of each route and \( f_i \) is evaluation value.

Step3 (Selection)
Route is selected with a probability of \( p_i \),

\[ p_i = \frac{f_i}{\sum_{i=1}^{n} f_i} \]

where \( n \) is the number of cities. Selection is the method of tendency 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.

\[ \text{error rate}[] = \left( \frac{\text{obtain} - \text{optimum}}{\text{optimum}} \right) \times 100 \]

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.

Table 1: The result for ulysses16

<table>
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<th>algorithm type</th>
<th>Mutation rate</th>
<th>error rate[]</th>
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<tbody>
<tr>
<td></td>
<td>Max</td>
<td>Min</td>
</tr>
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<td></td>
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<td></td>
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</tbody>
</table>

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