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Effect of Chaos Noise on City Placement by Using 2-Opt Algorithm for TSPs

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Abstract

In this study, we propose the algorithm that pouring the chaos noise to the city placement for the traveling salesman problems. We investigate the effect of chaos noise poured in the city placement with 2-opt algorithm. By carrying out computer simulations for various problems, we confirm that the chaos noise has a good effect to avoid local minima and achieves a good performance to find a good solution of the TSPs.

1. Introduction

Although it would be possible to solve combinational optimization problems with a huge number of elements if we have infinite long time, it does not make any sense for practical problems. In the approximation method, the solutions get into local minima. Therefore, the solutions need to avoid local minima. It is possible that the solutions become close to a good solution by avoiding local minima.

Many researchers have proposed that the approximation method with the chaos noise [1]-[4]. The chaos noise is directly poured to the algorithm in these proposed method. In this study, we propose the algorithm that pouring the chaos noise to the city placement. It supports to find the good solution and avoid the local minima. We investigate the effect of chaos noise poured in the city placement with 2-opt algorithm for the traveling salesman problems.

By carrying out computer simulations for various problems, we confirm that the chaos noise has a good effect to avoid local minima and achieves a good performance to find a good solution of the traveling salesman problems.

2. Traveling Salesman Problems

The traveling salesman problems(TSPs) is one of the combinational optimization problems, which is described as follows: given city placements, find the minimum length tour which visits each city exactly once [5]. The TSP belongs to a class of NP-hard in the computational complexity. Solving for TSPs, it is reported that the good solution is achieved to used by neural network as other efficient method [6]-[9]. It is believed that it is almost impossible to obtain the optimal solution of the TSP in the limited time. Therefore, it needs the effective algorithm to find the near optimal solutions or approximation solutions for TSPs.

3. Chaos noise poured in the city placement with 2-opt algorithm

We proposed the algorithm that pouring the chaos noise to the city placement.

3.1. 2-opt algorithm

The 2-opt algorithm exchanges two paths for other two paths until no further improvement can be obtained. Figure 1 shows an example of the 2-opt exchange. In Fig. 1, the 2-opt algorithm exchanges two paths, *a*-*b* and *c*-*d*, with the other two paths, *a*-*c* and *b*-*d*, where *b* and *d* are cities next to *a* and *c*. If a trial exchange shortens total tour length, the exchange is really executed.

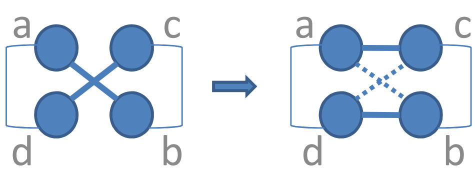

Figure 1: Example of the 2-opt exchange.

3.2. Proposed method

In the approximation method, the solutions get into local minima. Therefore, we poured the chaos noise to the city placement for solving this problem.

The proposed method is described as follows:

1. The initial tour is made at random. Figure 2 shows a initial tour.

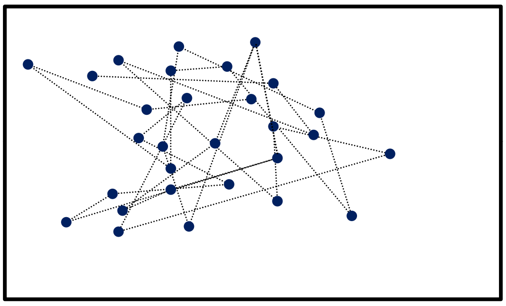

Figure 2: Initial tour

2. The tour is exchanged two paths with other paths by the 2-opt algorithm. Figure 3 shows the tour exchanged by the 2-opt algorithm.

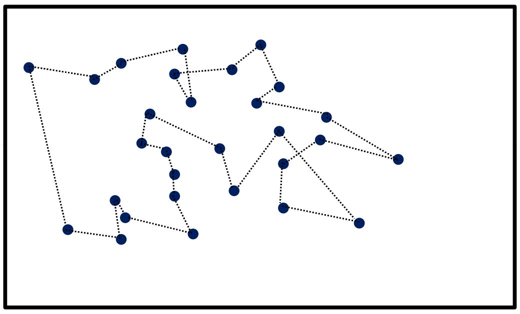

Figure 3: 2-opt algorithm exchanges

3. After the 2-opt algorithm, the chaos noise is poured in the city placement. The cities placement are slightly changed by adding noise. Figure 4 shows the city placement with chaos noise.

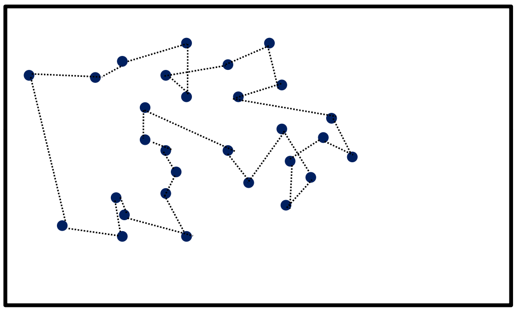

Figure 4: City placement with the chaos noise

4. Then, the 2-opt exchange executes when the 2-opt algorithm finds new candidates. In Fig. 5, the candidates are exchanged as the new paths by the 2-opt algorithm.

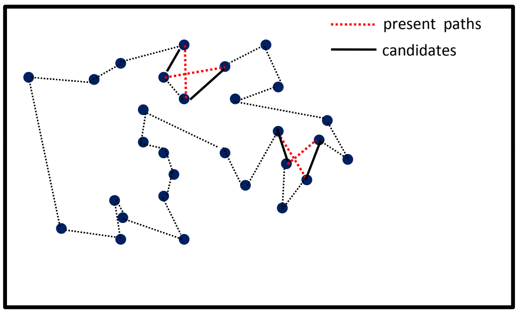

Figure 5: Candidates for 2-opt exchange

5. These processes are iterated several time.

4. Chaos noise

In this study, we use the time series of the chaos generated by the logistic map as a noise. The logistic map is given as following equation.

$$x_n(t+1) = \alpha x_n(t)(1 - x_n(t)) \tag{1}$$

where α is a bifurcation parameter. The behavior of sequences are changed by this parameter.

The chaotic sequence is normalized by

$$\hat{x}_n(t) = \frac{x_n(t) - \overline{x}}{\sigma_x} \tag{2}$$

where $\overline{x}$ is the average of x_n and σ_x is the standard division of x_n. In this study, we use the intermittency chaos near the three-periodic window obtained from the logistic map with α = 3.828. It is reported that the intermittency chaos obtained from the logistic map with α = 3.828 gains good performance for combinational optimization problems [1]. The chaotic sequence is shown in Fig. 6.

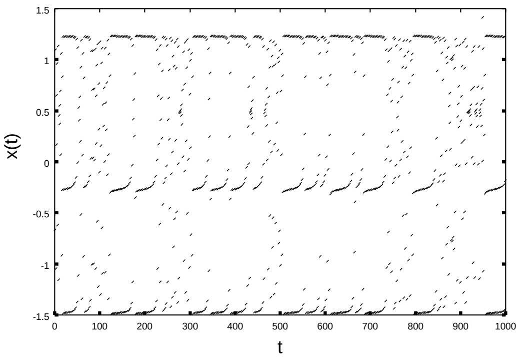

Figure 6: Intermittency chaos (α = 3.828).

5. Simulated results

In this study, we use four problems, “bayg29”, “lin105”, “pr124” and “KroE100” from TSPLIB[10]. The results are summarized in Table 1. Here, the number of iterations is 100 times. The results are average values of 10 trials with the different initial value.

Table 1: The results of the 2-opt algorithm (conventional method) and the 2-opt algorithm with chaos noise (proposed method).

Problem	Optimal solution	Conventional method	Proposed method
bayg29	9074	9416	9148
lin105	14379	15596	14728
pr124	59030	62950	59847
KroE100	22068	24303	23371

From this table, we can confirm that the 2-opt algorithm with chaos noise exhibits better performance than the 2-opt algorithm.

6. Conclusions

In this study, we have proposed the algorithm that pouring the chaos noise to the city placement. And we have investigated the effect of chaos noise poured in the city placement with 2-opt algorithm. By carrying out computer simulations for various problems, we have confirmed that the chaos noise has a good effect to avoid local minima and achieves a good performance to find a good solution of the TSPs.

As the future subject, we will investigate the effect to pour different noises to the city placement.

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