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Effect of Chaos Noise on City Placement with 2-Opt Algorithm for Traveling Salesman Problems

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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 the local minima. It is possible that the solutions become close to a good solution by avoiding the local minima.

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

2 Proposed method

As shown in Fig. 1, the 2-opt algorithm exchanges two paths, *a*-*b* and *c*-*d*, with the other two paths, *a*-*c* and *d*-*b*, where *b* and *d* are the cities next to *a* and *c*. If a trial exchange shortens total tour length, the exchange is really executed.

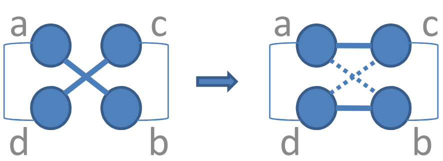

Figure 1: Example of 2-opt exchange.

After the 2-opt algorithm, the chaos noise is poured in the city placement. The city placement is changed by the chaos noise. Therefore, the 2-opt algorithm finds new candidates for exchange. These processes are iterated several times.

3 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.

$$x_n(t+1) = \alpha x_n(t)(1 - x_n(t)) \quad (1)$$

The chaotic sequence is normalized by

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

where $\bar{x}$ is the average of x_n and σ_x is the standard deviation of x_n. In this study, we use the intermittency chaos near the three-periodic window obtained from the logistic map with $\alpha = 3.828$. It is reported that the intermittency chaos near the three-periodic window obtained from the logistic map gains good performance for combinational optimization problems [1]. The chaotic sequence is shown in Fig. 2.

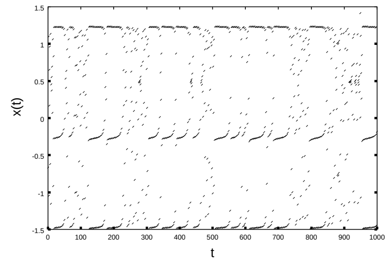

Figure 2: Intermittency chaos ($\alpha = 3.828$).

4 Simulated results

In this study, we use three problems, "bayg29", "lin105" and "kroE100" from TSPLIB[2]. The results are summarized in Table 1. Here, the number of iterations is 100 times. The results are average values of 10 trials.

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
kroE100	59030	62950	59847

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

5 Conclusions

We have investigated the effect of chaos noise poured in the city placement with 2-opt algorithms for the TSPs. By carrying out computer simulations for various problems, we have confirmed that the chaos noise had a good effect to avoid local minimum problems and achieved a good performance to find good solutions of the TSPs.

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

References

[1] Y. Hayakawa and Y. Sawada, "Effects of the chaotic noise on the performance of a neural network model for optimization problems," Physical Review E, vol. 51, no. 4, pp. 2693-2696, 1995.
[2] "TSPLIB," http://www.iwr.uni-heidelberg.de/groups/comopt/software/TSPLIB95/