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Effect of Chaos Noise on City Placement with Local Search Algorithm for TSPs

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1 Introduction

Although it would be possible to solve combinatorial optimization problems with a huge number of elements if we have infinite long time, it does not make any sense for practical problems. In several approximation methods, the solutions are trapped 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 propose an algorithm that pouring the chaos noise to the city placement. It supports to find good solutions and avoid local minima. In the past study, we investigated the effect of chaos noise poured in the city placement with 2-opt algorithm [1], hence in this study we extend the idea to more strong Or-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.

2 Proposed method

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

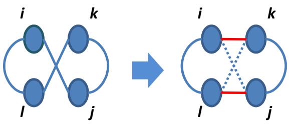

Figure 1: Example of 2-opt exchange.

The Or-opt algorithm exchange multiple paths in a similar way. In this study, after the Or-opt exchanges, the chaos noise is poured in the city placement. Because the city placement is changed by the chaos noise, the Or-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 bifurcation parameter $\alpha = 3.5, 3.828, 4.0$. The bifurcation parameter $\alpha = 3.828$ is the intermittency chaos near the three-periodic window obtained from the logistic map. It is reported that the intermittency chaos near the three-periodic window obtained from the logistic map gains good performance for combinatorial optimization problems [2].

4 Simulated results

In this study, we use three problems, "bayg29", "lin105", and "rat575" from TSPLIB [3]. The results are summarized in Table 1. Here, the number of iterations is 100 times. The results are average values of 10 trials. The Table 1 shows the Or-opt algorithm without chaos (conventional method), the Or-opt algorithm with chaos noise of the bifurcation parameter $\alpha = 3.828$ (proposed method 1), $\alpha = 3.5$ (proposed method 2), and $\alpha = 4.0$ (proposed mthod 3).

Table 1: The results of conventional method, proposed method 1, proposed method 2 and proposed mthod 3.

Problem	bayg29	lin105	rat575
Optimal solution	9047	14379	6773
Conventional method	9141	14790	7150
Proposed method 1	9074	14425	7111
Proposed method 2	9107	14459	7101
Proposed method 3	9074	14535	7116

From this table, we can confirm that the proposed algorithms with chaos exhibit better performance than the conventional method without chaos. Although the averaged values are similar for all three proposed methods, the intermitency chaos seems to be more effective to find the best solution.

5 Conclusions

We have investigated the effect of chaos noise poured in the city placement with Or-opt algorithm 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. Yoshida, S. Aono and Y. Nishio, "Effect of chaos noise on city placement by using 2-Opt algorithm for TSPs," Proc. of NCSP'09, pp.357-359, Mar. 2009.

[2] 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.

[3] "TSPLIB," http://www.iwr.uni-heidelberg.de/groups/comopt/software/TSPLIB95/