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Ant Colony Optimization Changing Reaction to Pheromone

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1. Introduction

Recently, nature-inspired metaheuristic optimization algorithms such as Ant Colony Optimization (ACO) is developed. ACO is based the feeding behavior of ant herds. We suggest the new ACO for Traveling Selesman Problem (TSP).

In this study, we propose ACO in which the pheromone's response improves by increasing at the number of repetition. We compare the accuracy of the solution with ACO and the proposed method.

2. Ant Colony Optimization

Ant Colony Optimization (ACO) was developed by Marco Dorigo in 1992. We use the following two idealized rules:

- All ants leave volatile pheromone on the route from a nest to place of the bait;
- All ants choose the strong pheromone route.

Implementation steps of the algorithm are summarized below:

Step1. Initialize the total number of ants k, reaction of pheromone α, responding to heuristic information β and evaporation rate of pheromone ρ.

Step2. Calculate the evaluation value Eq. (1) when each ant moves from city i to city j. Then, select a route according to the probability based on it.

Step3. Add pheromone to the route that the ant visited. The value of pheromone can be obtained by Eqs. (2) and (3).

Step4. Repeat steps 2 to 3 and output the solution.

Pheromone values τ and evaluations value a are given by following equations:

$$a_{ij}^k(t) = \frac{[\tau_{ij}]^\alpha[\eta_{ij}]^\beta}{\sum_{l\in N_k}[\tau_{ij}]^\alpha[\eta_{ij}]^\beta} , \quad (1)$$

$$\tau_{ij}(t+1) = (1-\rho)\tau_{ij}(t) + \sum_{k=1}^{m}\Delta\tau_{ij}^k(t) , \quad (2)$$

$$\Delta\tau_{ij}^k(t) = 1/L_k(t)(if\ i,j\in L_k) , \quad (3)$$

where, L_k expresses the length of the route that each ant visited.

3. Proposed method

We propose a improved ACO (IACO). The reaction of pheromone is constant value in the standard ACO. IACO is that the pheromone's response improves by increasing at the number of repetition. Therefore, IACO changes α by Eq. (4)

$$\alpha \mathrel{+}= h/t_{max} \quad (4)$$

We continue adding it until α becomes 1 and calculate all α as 1 at time beyond 1. We expect that the convergence rate of the solution is improved by gradually increasing α. We compare the solutions of 4 kinds of h (h = 0.5, 1.0, 1.5, 2.0).

4. Simulation result

We compare the result of Traveling Salesman Problem(TSP). TSP sets the coordinate of all cities. The purpose of this problem is to find the shortest route which is visited once to all cities. We performed an experiment using TSP benchmark eil51 (optimal solution is 426). Averages of 10 solutions of IACO of each h are obtained and are compared it afterwards. We express the constant value to use for similation in Eqs. (5), (6).

$$k = 51,\ \beta = 2.0,\ \rho = 0.02,\ t_{max} = 2000 \quad (5)$$

$$\alpha = 1.0\ (ACO),\ \alpha_0 = 0.001\ (IACO) \quad (6)$$

Table 1 tells the length of the route by the difference in h.

Table 1: Solution according to the change of h

h	best	worst	average
0.5	539	604	568
1.0	434	456	442
1.5	435	451	438.1
2.0	435	454	439.1

Table 1 shows that the average of h = 1.5 is best. The results of IACO and the standard ACO are compared in Table 2.

Table 2: Simulation results

	best	worst	average
ACO	435	463	444.5
IACO	435	451	438.1

From the Table 2, it is clear that the average of IACO is better than the average of ACO.

5. Conclusion

This study introduced the improved Ant Colony Optimization. We tried improvement of ACO, where reaction to pheromone is reinforced according to the number of repetitions. We compared the average values of IACO and the standard ACO. As a result, IACO performed better than ACO. In the future work, we will make the cause of this result clear.

Reference

[1] K. Yosuke and K. Hitoshi, "Solution to Traveling Saleman Problem by Ant Colony Optimization Applying Local Optimum Solutions to Initiazation," MPS, vol. 19, pp. 109-112, 2007.

[2] M. Dorigo and L. M. Gambardella, "Ant Colonies for the Traveling Salesman Problem," BioSystem, vol. 43, pp. 73-81, 1997.