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Ant Colony Optimization with Intelligent and Dull Ants

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1. Introduction

Ant colony optimization (ACO) is an evaluational optimization algorithm inspired by pheromone effect of ants and is effective to solve difficult combinatorial optimization problems like the traveling salesman problems (TSPs)[1]. Meanwhile, there is a simulation result of ant's feeding action that the ants group, which contains the certain dull ants, can collect more foods than the group which contains only intelligent ants [2]. Because the intelligent ants collect the foods and the dull ants are searchers of new foods. Therefore, the dull ants increase the effectiveness of the feeding action. In this study, we propose Ant Colony Optimization with Intelligent and Dull Ants (IDACO), which is a new ACO algorithm. The important feature of IDACO is that two kinds of ants exist. We apply IDACO to two TSPs and confirm the effectiveness.

2. ACO with Intelligent and Dull Ants

In IDACO algorithm, the important feature of IDACO is that two kinds of ants exist; intelligent ants which exactly trail pheromone, and dull ants which do not trail the pheromone. S denotes the input space of N city positions as

$$S \equiv \{P_1, \cdots, P_N\}, P_i \equiv (x_i, y_i), \quad (1)$$

where the input area is normalized as the unit square and P_i is the i-th city position. M ants are deposited on each city at random. $d \times M$ ants are classified into a set of the dull ants S_{dull}. d is rate of the dull ants on all the ants.

[IDACO1](Initialization): Let iteration number $t = 0$. $\tau_{ij}(t)$ is the amount of pheromone trail on the path (i, j) between cities i and j at time t, and $\tau_{ij}(t)$ is initially set to τ_0.

[IDACO2](Find tour): For the k-th ant ($k = 1, \cdots, M$), the visiting city is chosen by probability $p_{ij}^k(t)$ and the k-th ant finds a tour according to the following equations;

$$p_{ij}^k(t) = \begin{cases} \dfrac{\eta_{ij}}{\Sigma_{l \in N^k} \eta_{il}}, & \text{if } k \in S_{\mathrm{dull}} \\ \dfrac{[\tau_{ij}(t)]^\alpha [\eta_{ij}]^\beta}{\Sigma_{l \in N^k} [\tau_{il}(t)]^\alpha [\eta_{il}]^\beta}, & \text{otherwise,} \end{cases} \quad (2)$$

where $1/\eta_{ij}$ is the distance of path (i, j). The adjustable parameters α and β control the weight of pheromone intensity and city information, respectively. As the dull ants do not trail the pheromone, set to $(\alpha, \beta) = (0, 1)$. Therefore, the equation of the dull ants does not include the amount of the pheromone trail $\tau_{ij}(t)$. N^k is a set of cities such that k-th ant has not yet visited any city in the set.

[IDACO3](Pheromone update): Compute the tour length $L_k(t)$ and update the number of the pheromone trail $\tau_{ij}(t)$ by

$$\tau_{ij}(t+1) = (1 - \rho)\tau_{ij}(t) + \sum_{k=1}^{M} \Delta\tau_{ij}^k(t), \quad (3)$$

$$\Delta\tau_{ij}^k(t) = \begin{cases} 1/L^k, & \text{if } (i, j) \in T^k(t) \\ 0, & \text{otherwise,} \end{cases} \quad (4)$$

where $T_k(t)$ is obtained tour by the k-th ant and $L_k(t)$ is its length. $\rho \in [0, 1]$ is the pheromone trail decay coefficient.

[IDACO4] Let $t = t+1$. Go to [IDACO2] and repeat until the maximum time limit $t = t_{\max}$.

3. Numerical Experiments

In order to confirm the effectiveness of IDACO, we apply IDACO to two problems, ulysses16 and att48. The total number of the ants of ACO and IDACO are 10, respectively. All the ants of ACO are the intelligent ants, and 10 % of all the ants of IDACO are the dull ants and other ants are the inteligent ants. We carry out the simulation 2000 times. The simulation results of ACO and IDACO are shown in Table 1. In this table, we can confirm that IDACO obtains better result than ACO for difficult TSP. In the real world, there is a simulation result of ant's feeding action that the intelligent ants collect the foods and the dull ants are searchers of new foods. From these, we think that the dull ants are inefficient, however, the dull ants increase the effectiveness of the feeding action. Therefore, we can see that IDACO has a good effect to escape local minima and achieves a good performance to find near optimal solutions.

Table 1: Results of ACO and IDACO for ulysses16 and att48.

		ulysses16	att48
ACO	AVG	80.9	56192
	Min	76.8	47276.3
	Max	91.5	56499.4
LACO	AVG	90.2	48635.3
	Min	80.4	44088.8
	Max	90.5	48953.9
	Optimal solution	72.9	33523.9

4. Conclusions

In this study, we have proposed Ant Colony Optimization with Intelligent and Dull Ants. We have confirmed that IDACO obtains better result than ACO for difficult TSP.

Reference

[1] M. Dorigo and L.M. Gambardella, "Ant Colonies for the Traveling Salesman Problem," BioSystems, vol. 43, pp. 73–81, 1997.

[2] H. Hasegawa, "Optimization of GROUP Behavior," Japan Ethological Society Newsletter, no. 43, pp. 22–23, 2004.