An Improved Ants Colony Algorithm for NP-hard Problem of Travelling Salesman

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Abstract. ACO (Ants Colony Optimization) algorithm has already obtained promising effect on solving many problems of combinatorial optimization due to its high efficiency, well robustness, positive feedback and the simultaneousness. Unfortunately the main defects of slow convergence and easy stagnancy in ACO low its applications. Fully employing the advantages of ACO, the paper proposes the novel tactics of updating the whole and local pheromone to avoid early stagnancy. Furthermore, the constraint satisfaction techniques are used to solve the problems of slow convergence by reducing the search space, accelerating search rate and enhancing efficiency. Finally, the case study for travelling salesman problem demonstrates the validation and efficiency of the improved ants colony algorithm.

Keywords: ants colony algorithm, constraint satisfaction, travelling salesman problem, NP-hard problem, combinatorial optimization.

1 Introduction

After 1980s, there was a rapid development of life science, the development of artificial intelligence has stagnated, so artificial intelligence began to turn the classic calculation way[1][2]. Many scholars have found that social individual with collective actions such as birds, fish, swarm tends to highlight the high intelligent behavior (such as its nest, foraging, and migration, etc.), these work behavior has caused wide public concern, biological heuristic computational research can develop and produce the swarm intelligence[3-7].

Ant colony System (Ant System, referred to AS) is widely used by Italian scholars Dorigo M, Maniezzo V and Colorni A proposed in the early 1990s, under the background of the computer technology and the changeable artificial intelligence algorithms to biological heuristic, and it is a new kind of intelligent optimization algorithm[8][9]. In the process of ant colony foraging and back to the nest, always can find a shortest path from the nest to food source, which has attracted the attention of Dorigo M, inspired by the behavior, Dorigo M and others put forward Ant colony system in artificial statement paper "Distributed Optimization by Ant Colonies", in the first artificial announcement meeting in 1991[10].

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2 Model of Travelling Salesman Problem Based on Ant Colony Algorithm

2.1 The Basic Ant Colony Algorithm

In the basic ant colony algorithm of ant system, ant select probability according to the pheromone intensity when there are many alternative paths. This probability is the two functions of d_{ij} (the path length) and (the pheromone on the path) τ_{ij} .When ant complete a cycle after choosing the path, the pheromone on the path is changed, will updating pheromone.State transition probability $p_{ij}^k(t)$ and pheromone updating equation τ_{ij} are:

$$p_{ij}^k(t) = \begin{cases} \dfrac{[\tau_{ij}(t)]^\alpha [\eta_{ij}(t)]^\beta}{\sum\limits_{s \in J_k(i)} [\tau_{is}(t)]^\alpha [\eta_{is}(t)]^\beta}, & If\ j \in J_k(i) \\ 0, & Or \end{cases} \tag{1}$$

Eq. 1 is the state transition probability. Among them, p_{ij}^k is the probability of ant k from i to j; α , β are the relative important degree of pheromone and heuristic factor; τ_{ij} is the pheromone on edge (i, j); η_{ij} is the heuristic factor; $J_k(i)$ is the allowing of ant k to select the next place.

$$\tau_{ij}(t+n) = \rho * \tau_{ij}(t) + \Delta\tau_{ij} \tag{2}$$

$$\Delta\tau_{ij} = \sum_{k=1}^{m} \Delta\tau_{ij}{}^k \tag{3}$$

$$\Delta\tau_{ij}^k = \begin{cases} \dfrac{Q}{L_k}, & If\ Ant\ k\ Through\ ij \\ 0, & Or \end{cases} \tag{4}$$

Eq. 2, Eq. 3 and Eq. 4 are the pheromone update equations. ρ is the coefficient of pheromone persistent; $\Delta\tau_{ij}$ is the current iteration pheromone of ant k staying on edge (i, j); Q is a normal number; L_k is the path length of ant k in the travel.

Dorigo M put forward three kinds of models in AS algorithm: Ant-cycle, Ant-quantity and Ant-density. Difference of the three is calculating the pheromone $\Delta\tau_{ij}^k$ left on edge (i, j) by ant k in the iteration: