2/12/2016

A solution for the Capacitated Vehicle Routing Problem (CVRP) using the Ant Colony Optimization algorithms

Pan Xiaodong(xp16434)

Why chose the algorithm

When I searched the keyword about efficient solution of CVRP on the web page, there were a lot of academic papers introducing about Ant Colony Optimization (ACO), and the ACO combined with heuristic approached that act as the strategies of route improvement can deal with the CVRP problem efficiently and effectively, it is inspired by the real-life behavior of ants finding food laid a chemical substance named pheromone trail. Thus, the higher amount of pheromone which often accumulate faster on the shorter path will attract more ants to walk on this way. Because of these reasons, this algorithm can calculate the best path in a short period rather than waste plenty of time on converging.

Detail processes

Because of this idea is inspired by the social behaviour of any colonies, it means that the quantity of pheromone and distance between two stores play a key role in selecting the path（Tan, 2012). Initially, each ant departure from the depot and the list of the unavailable customer is empty. And the ant chooses the next store according to the available customer and its capacity, then updating its unavailable set when it arrives at one store. The ant return to the depot when the capacity constraint of the condition is met or all of the customers are visited, and then the rest of ants will do the same action like before until all of the customers are been visited . Moreover, each ant should build a vehicle path via select next customer ***j*** according to the following formula:

$$\begin{cases} j = \arg\max\{(\tau_{i0})^{\alpha}(\eta_{i0})^{\beta}\} \quad if \quad q \le q_0 \quad Otherwise & (1) \\ p_{ij} = \dfrac{(\tau_{ij})^{\alpha}(\eta_{ij})^{\beta}}{\sum_{j \notin M_k}(\tau_{ij})^{\alpha}(\eta_{ij})^{\beta}} \quad if \quad j \notin M_k \quad Otherwise & (2) \\ p_{ij} = 0 \end{cases}$$

Where $\tau_{ij}$is the quantity of pheromone between the current location ***i*** and possible location ***j***, and the amount of pheromone on the shortest path should be increased in one generation, and decreasing the longest path. The updating equation of pheromone is related with a coefficient μ,which is displayed on the below:

$$\tau_{ij} = \mu * \tau_{ij} + \tau_o$$

The$\tau_o$equals initial pheromone value dividing the distance from current location ***i*** to next location ***j***. The η is depended on the reciprocal of distance from ***i*** to ***j***. Furthermore, the ***α*** , ***β*** and ***q*** will be updated during the different stages, which can prevent ant to fall into local optimal solution. After few generations, the best solution will be produced through the action of ants.

Initialization parameters setting

In the early generation, the ant should find randomly find the customer, the ***α*** and ***β*** can equal 10 in order to improve influence from pheromone and distance. And ***q*** should be large enough to decrease the proportion of regular route. After that, decreasing a little number of ***α*** and ***β*** can guarantee ants to find relatively best solution. Finally, the ***α*** equals 1 and ***β*** equal 10 can support ants find anther shortest route instead of working on the same path. The small number of ***q*** can replace some random paths as regular routes. The compare of inverse parameter setting is shown as below picture:

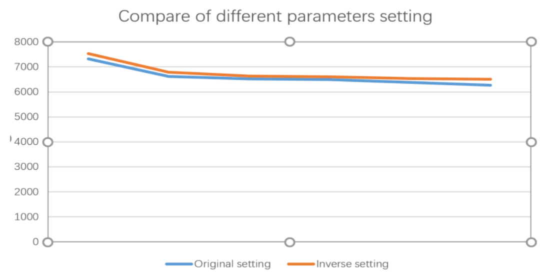

Figure1 Compare of different parameters setting

This picture proves that the original parameters setting has better performance on the convergence than anther one. Lastly, because of the ACO has the high speed of convergence, the number of generation only need to be 6000, which just run about 3 minutes.

Algorithm Limitation

However, the interval of convergence in the ACO is smaller than other algorithms in order to improve the efficient. But there are some approaches to solving above problem, like utilising 3-opt heuristic function to swap the route and selecting the ant which has the best distance to update pheromone, while it cannot absolutely be coped with the limitation. What is more, the iteration in the ACO is so redundant that the computer has to spend a lot of time to run it. But the ACO is also a viable alternative for solving the CVRP.

Reference

[1]Tan, W. L. L. Z. M. a. H. S., 2012. Ant Colony Optimization for Capacitated Vehicle Routing Problem. *Journal of Computer Science,* 8 (6), pp. 846-852.

[2]Yu Bin, Y. Z.-Z. Y. B., 2009. An improved ant colony optimization for vehicle routing problem. *European Journal of Operational Research,* p. 171－176.