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RESEARCH ARTICLE

An Effect and Analysis of Parameter on Ant Colony Optimization for Solving Travelling Salesman Problem

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Abstract—Ant Colony optimization has proved suitable to solve a wide range of combinatorial optimization (or NP-hard) problems as the Travelling Salesman Problem (TSP). The first step of ACO algorithm is to set the parameters that drive the algorithm. The parameter has an important impact on the performance of the ant colony algorithm. The basic parameters that are used in ACO algorithms are; the relative importance (or weight) of pheromone, the relative importance of heuristics value, initial pheromone value, evaporation rate, and a parameter to control exploration or exploitation. In this Paper we present the effect of parameter on ACO algorithm for solving Travelling Salesman Problem for 52 nodes.

Keywords— Ant Colony Optimization; Parameter tuning in ACO; Travelling salesman problem

I. Introduction

Combinatorial optimization problems are intriguing because they are often easy to state but very difficult to solve. ACO algorithm takes inspiration from the behavior of real ant colonies to solve combinatorial optimization problems. They are based on artificial ants, i.e. simple computational agent that work cooperatively and communicate through artificial pheromone trails. Ant colony optimization was firstly introduced in early 1990s by Dorigo and his colleagues [1]. The amount of pheromone deposited by the artificial ant is a function of the quality of solution found by each of them. The paper is organized as follows: section 2 describes travelling salesman problem. Section 3 illustrates ant colony optimization. Section 4 present effects of Parameter Selection. Section 5 presents the result at last Section 6 makes the conclusion of whole paper.

II. TRAVELLING SALESMAN PROBLEM

Its statement is quiet simple, but yet remains one of the most challenging problems. The problem state that there given a set of cities, a salesman needs to visit all cities without having any redundancy of city except the starting and finish city such that the traversed path is optimal. It comes under the set of NP Hard problem which means the problem complexity increases exponentially as the size increases. If salesman need to travel "n" cities then there are (n-1)! Different tours and it is known as asymmetric TSP. For the symmetric case there are many distinct solutions (n-1)! /2 for "n" cities[2]. The application range of TSP is very wide some of them are mentioned below:

- Distribution of goods and resources
- Planning Bus lines
- Machine Scheduling
- Integrated Circuits
- planning, logistics, and the manufacture of microchips

III. ANT COLONY OPTIMIZATION

Ant Colony optimization belongs to wider field of swarm intelligence. Swarm intelligence is a nature inspired approach which mimics the behaviors of insects and of other animals.

A. *Ant System*

Ant System is very first algorithm of ACO, it has its own historical importance. Ants deposit a certain amount of pheromone while walking, and each ant probabilistically prefers to follow a direction rich in pheromone [3] Initially, ants are put on randomly chosen city. In path construction step ant k currently at city i select the next city j by using probabilistic transition rule

$$\rho^{k}_{ij}(t) = \begin{cases} \dfrac{[\tau_{ij}(t)]^{\alpha}\,[\eta_{ij}]^{\beta}}{\sum_{k\,\varepsilon\,\text{allowed}} [\tau_{ik}(t)]^{\alpha}\,[\eta_{ik}]^{\beta}} & \text{if } j \in J_k(i) \\ 0 & \text{otherwise} \end{cases} \qquad (1)$$

η_{ij} is heuristic visibility, $\eta_{ij} = 1/d_{ij}$, α and β are two parameter which can be tuned to determine importance of the pheromone trail and heuristic visibility, $J_k(i)$ is the feasible neighbourhood of ant k which is not yet visited. The pheromone τ_{ij}, associated with the edge joining cities i and j, is updated as follows

$$\tau_{ij}=(1-\rho).\tau_{ij}(t)+\sum_{k=1}^{m}\Delta\tau^{k}_{ij} \qquad (2)$$

Where ρ denotes evaporation rate m is the number of ants, and $\Delta\tau^{k}_{ij}$ is the quantity of pheromone laid on edge (i,j) by ant k :

$$\Delta\tau^{k}_{ij} = \begin{cases} Q/L & \text{if } k^{th} \text{ant uses edge (i,j) in its tour(between time t and t+n)} \\ 0 & \text{otherwise} \end{cases} \qquad (3)$$

IV. EXPERIMENT AND ANALYSIS

For Experiment we take Berlin52 city problem and find out the solution, with the help of Matlab tool , the important parameter is tuned to observe the effect as well as to find the parameter for which solution is optimal. At last the deep analysis is done to understand the variation of parameter.

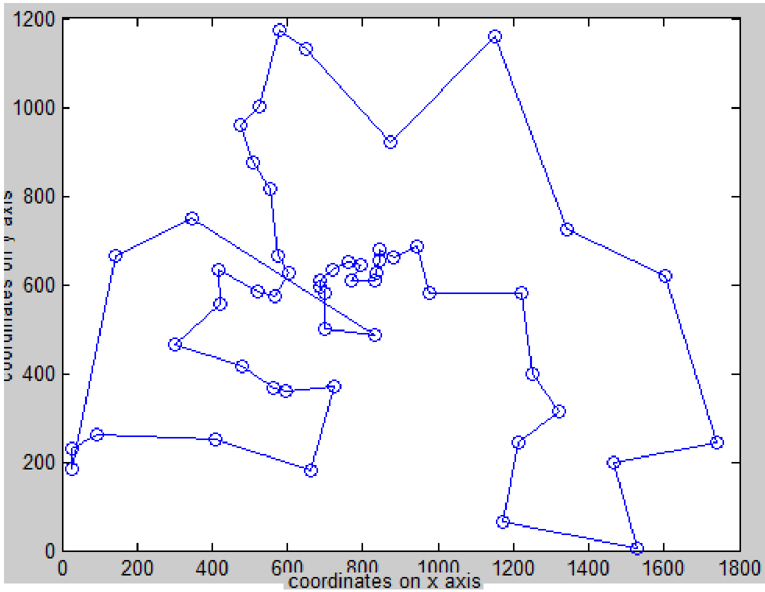

Fig. 1. Berlin 52 Node Problem

A. Pheromone Factor

Keep the other parameter still; adjust the value of α to get results

Table I. Simulation Result

TSP Instance name	Number of nodes	α	β	ρ	q	Best solution for AC
Berlin52	52	1	3	0.3	10	7663.585
		3	3	0.3	10	7773.006
		5	3	0.3	10	7984.400
		7	3	0.3	10	8048.261
		9	3	0.3	10	8172.4215

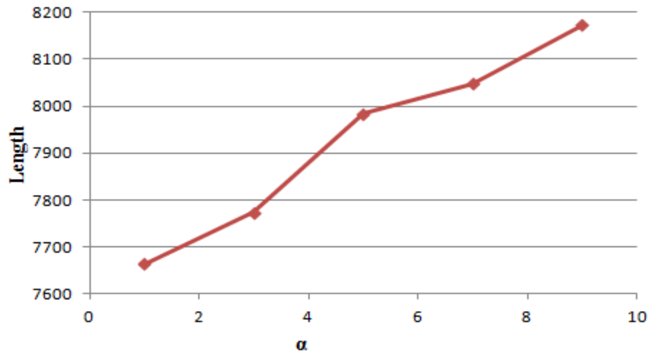

Fig. 2. Graph

The result obtained by experiments and graph it is clear that as α increase , the greater possibility of ants choose the path belong to the previous tour will be, in the new tour. In ant system α indicate the importance of collected pheromone on the edges.

B. Heuristic factor

Keep the other parameter still; adjust the value of β to get results.

Table II. Simulation Result

TSP Instance name	Number of nodes	α	β	ρ	q	Best solution for AC
Berlin52	52	1	1	0.3	10	8063.146
		1	3	0.3	10	7855.868
		1	5	0.3	10	7658.958
		1	7	0.3	10	7676.827
		1	8	0.3	10	7681.453

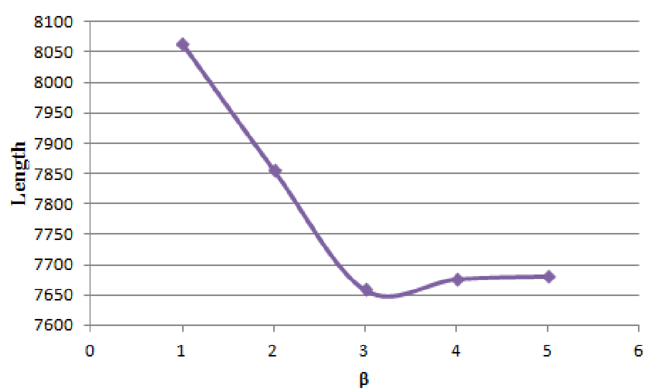

Fig. 3. Graph

As the increase of β, the possibility of ants choosing the local shortest path will increased the speed of convergence gets faster. To get optimal solution, algorithm must get balance between global optimization and fast convergence.

C. The Residue Coefficient of Pheromone

Keep the other parameter constant; tune the value of ρ to get results.

Table III. Simulation Result

TSP Instance name	Number of nodes	α	β	ρ	q	Best solution for AC
Berlin52	52	1	3	0.1	10	7659.2546
		1	3	0.5	10	7548.9927
		1	3	0.7	10	7549.289
		1	3	0.9	10	7663.8814
		1	3	0.99	10	7663.5851

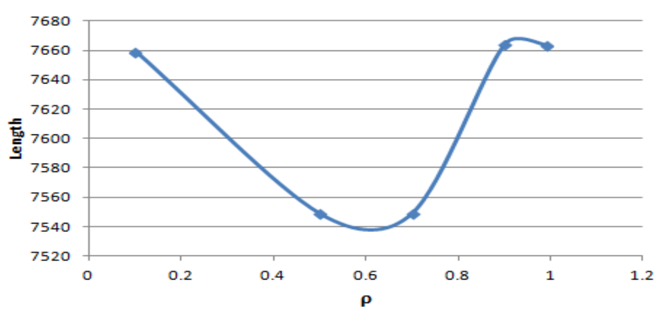

Fig. 4. Graph

The residue of pheromone left by ant on the edge evaporates with time. The parameter ρ directly effect the global search capability as well as randomness. When the number of nodes increases, the pheromones on the path which will never be traversed become 0.

D. The Amount of Pheromone

Adjust the value of q to get results. Keep other parameter constant.

Table IV. Simulation Result

TSP Instance name	Number of nodes	α	β	ρ	q	Best solution for AC
Berlin52	52	1	5	0.1	25	7663.585
		1	5	0.1	100	7663.585
		1	5	0.1	500	7598.442
		1	5	0.1	1000	7663.881
		1	5	0.1	10,000	7681.453

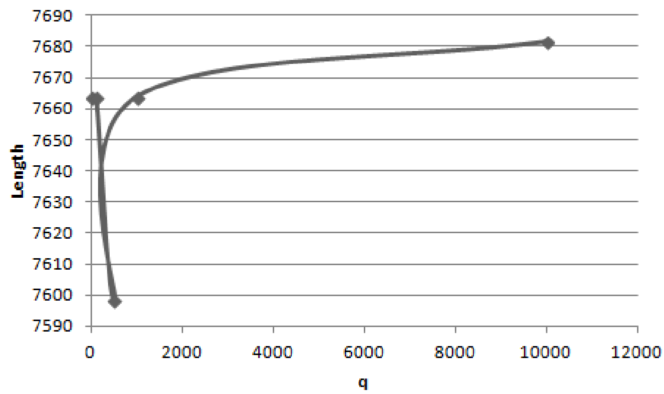

Fig. 5. Graph

By the above shown graph we can summarize that the effect of amount q to the performance depends on the three parameters (pheromone factor α, heuristic factor β and the residues coefficient of pheromone ρ)

V. Result

As the experiment result showed in the tables, the best ant colony model for the 52 node problem has the parameters as α=1 β=3 ρ=0.5 q=10

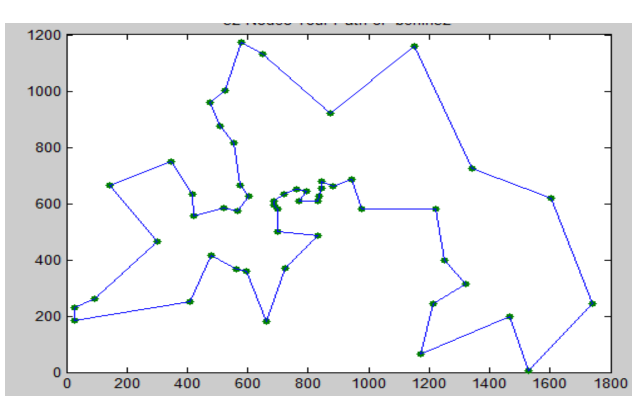

Fig. 6. Shortest Path Graph.

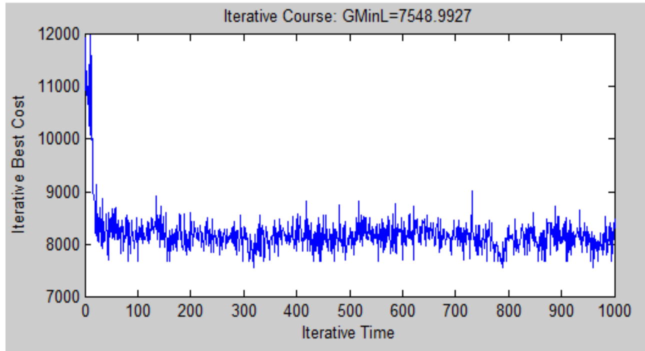

Fig. 7. Evolution of best length.

VI. TEST AND COMPARE

The performance of ACO was compared with the performance of other naturally inspired global optimization methods: simulated annealing (SA) genetic algorithm (GA), Particle Swarm Optimization (PSO) results as follows:

Table V. Comparison Table

TSP Instance Name	Number of Nodes	Genetic Algorithm	Simulated Annealing	Particle Swarm Optimization	Ant Colony	Best Known Solution
Berlin 52	52	7559	7554	7598	7548	7542

The Quality of the produced solutions is given in terms of the relative deviation from the optimum, that is

deviation (%)=100*(aco -opt)/ opt

Where ac denotes the cost of the optimum found by ant colony algorithm, and opt is the cost of the optimal solution. **Relative deviation for 52 nodes is 0.079**

VII. CONCLUSION

Ant colony algorithm is a good feedback mechanism. In this paper we have done a detailed analysis of main parameter. Although this algorithm has lots of positive point at the same there are some flaws. This algorithm requires a long search, at initial the edges contain different quantity of pheromone but after some time the edge which is marched more than other edges contain more pheromone. Parameter setting is important to performance of ant colony algorithm. This helps to have better starting point for the search of optimal path.

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