Ministry of Education and Science of the Russian Federation
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Practice Task – Ch 4

Ant Algorithm
Discipline: Intellectual Computing
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Contents

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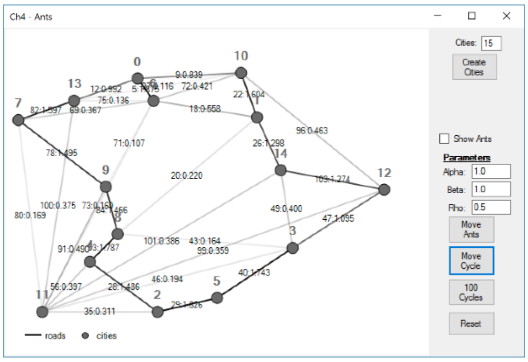
Introduction

Chapter 4 of "AI Application Programming" by M. Tim Jones is about the Ant Algorithm. This method is used for finding the most efficient/shortest path through a set of locations; in this example, the traveling salesman problem. A series of cities are created with random positions. Roads are then created between each of these cities and ants are created to test these routes. These ants deposit an even amount pheromone on the roads after completing a journey. Hence the shorter the path, the more the pheromone, and the more likely it will be taken by the next ant.

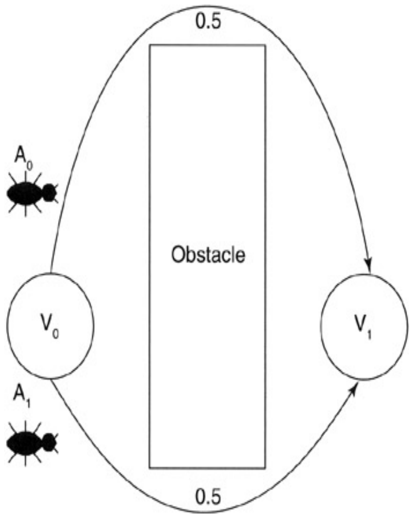


A sample C# program has been created to show this methodology. The program allows the user to specify the number of cities as well as the algorithm parameters (alpha, beta, rho). The effect of these parameters on the results is demonstrated.

Background

Algorithm

The main algorithm flow is explained using the figure to the right (borrowed from the book). This figure depicts two ants with different length paths which travel back and forth around an obstacle.



Processing Steps

1) Ants A0 and A1 travel from V0 toward the destination V1.
2) Ant A1 reaches first, while A0 is only half way.
3) Ant A1 returns to V0, while A0 finally reaches V1.
4) Ant A1 has deposited pheromone twice on the lower. Ant A0 only once on the upper path.
5) This process repeats one more time until ant A0 reaches V0. At this point ant A1 has deposited pheromone 4 times on the lower path, and ant A0 has deposited pheromone 2 times on the upper path.
6) The ant choses a path based on the amount of pheromone and random probability. The equation for this weighted probability is below. A probability is generated for each road and compared to a random number. If the weighted probability is greater than the random number, that path is taken.

$$P = \frac{\tau(r,u)^{\alpha} * \eta(r,u)^{\beta}}{\sum_k \tau(r,u)^{\alpha} * \eta(r,u)^{\beta}}$$

where

Numerator: the probability of the current road

Denominator: the probability of the combined roads

7) Finally, to prevent errors, a precipitation affect is included which slowly removes the pheromone. Hence, paths that are no longer traveled will eventually be forgotten completely.
8) This process then repeats until all ants take the same path, or a max number of cycle is met. This is to prevent infinite analysis for scenarios without a single solution.

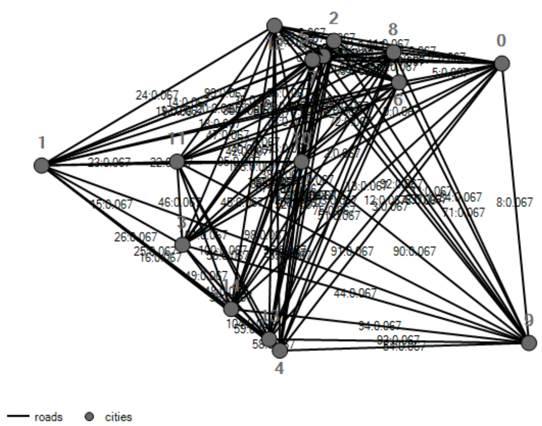
Parameter Testing

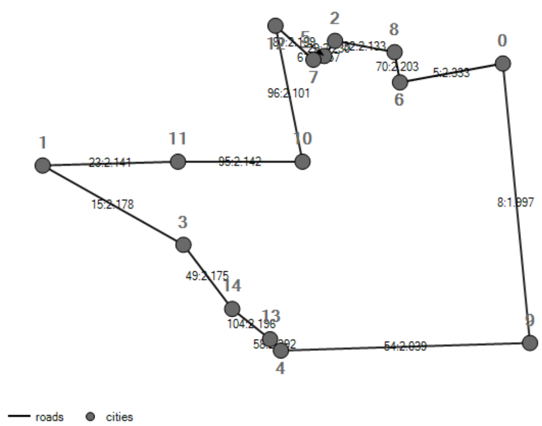
The algorithm allows for 3 simple adjustments which give more weight to different factors such as pheromone amount, path length, and evaporation rate. Below is a table of the parameters that have been tested. Each was tested seperately to show it's affect on the results. The comparison value is an image of the results as well as the number cycles needed to converge.

Test ID	Alpha (Pheremone)	Beta (Road Length)	Rho (Evaporation)
1	0.1	1.0	0.9
2	0.2	1.0	0.9
3	0.3	1.0	0.9
4	0.4	1.0	0.9
5	0.5	1.0	0.9
6	0.6	1.0	0.9
7	0.7	1.0	0.9
8	0.8	1.0	0.9
9	0.9	1.0	0.9
10	1.0	1.0	0.9
11	1.0	1.0	0.9
12	1.0	2.0	0.9
13	1.0	3.0	0.9
14	1.0	4.0	0.9
15	1.0	5.0	0.9
16	1.0	1.0	0.1
17	1.0	1.0	0.2
18	1.0	1.0	0.3
19	1.0	1.0	0.4
20	1.0	1.0	0.5
21	1.0	1.0	0.6
22	1.0	1.0	0.7
23	1.0	1.0	0.8
24	1.0	1.0	0.9

City Map & Expected Results

The left image shows a map of all the cities with roads connecting each city. These roads represent the possible routes an ant may take. The image on the right show the solved solution.

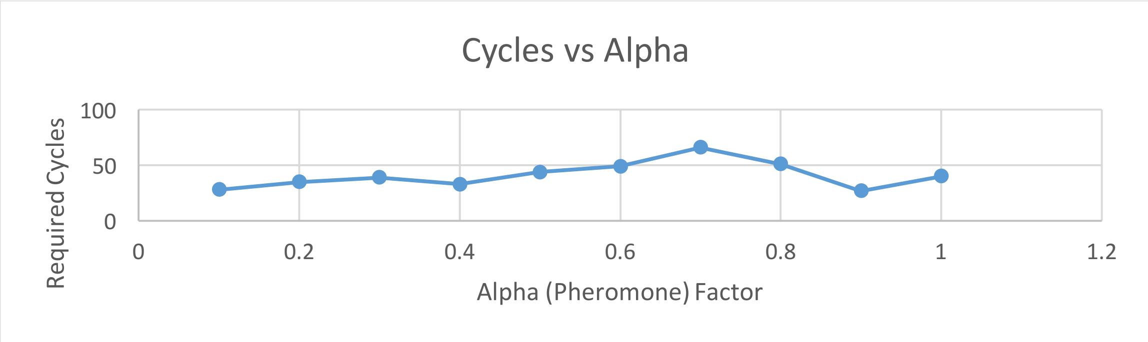


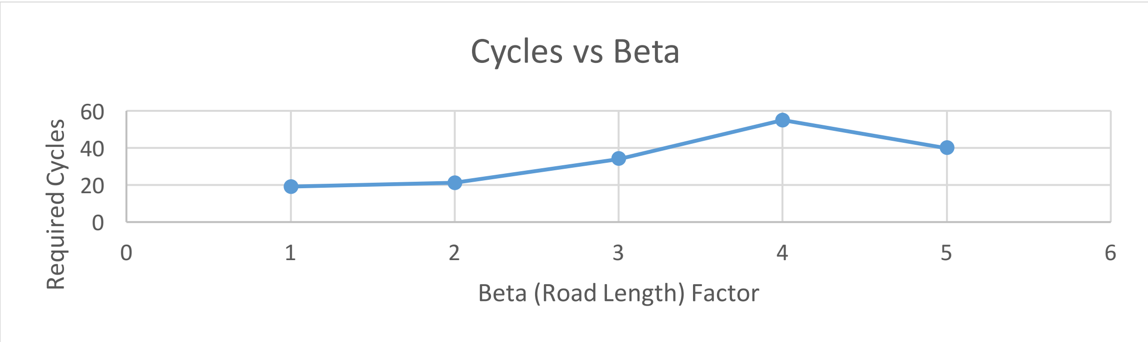


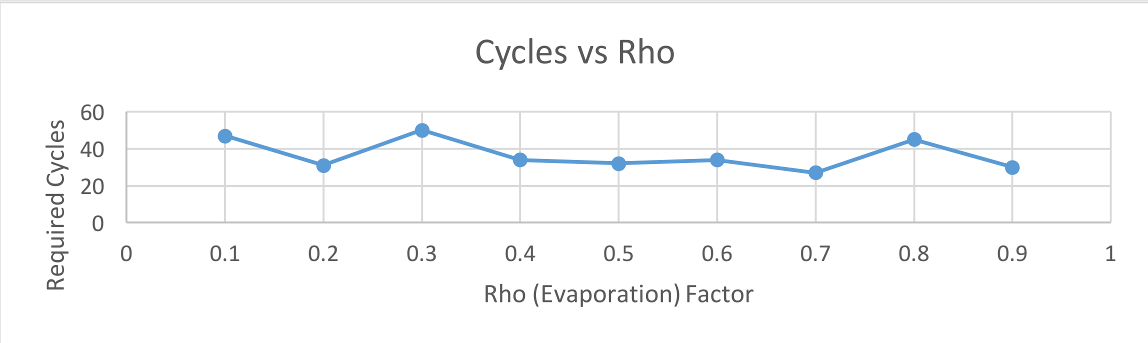
Christopher W. Blake

Results

Three graphs are presented which show the effect of each parameter (alpha, beta, rho) on the required number of cycles for a solution. It should be noted that this is not entirely reproducible as there is a randomness factor build into the algorithm. However, basic trends can be discovered and recommendations produced.







Conclusion

Only a partial study was performed, hence a full description of the effects cannot be described. Additionally, due to the randomness factor of the algorithm, results are not entirely repeatable. Hence a more accurate study would require many more permutations. However, given the above results, the following statements can be inferred. Note: All relations are relative to a value of 1.0 for other factors.

- Lower alpha factors (deposits of pheromone per cycle) appear to reduce the number of cycles required.
- Lower beta factors (road length) appear to reduce the number of cycles required.
- Low (0.0 < Rho < 0.4) and large (0.8 < 1.0) appear to create more uncertainty in finding a solution. Values between 0.4 and 0.7 provided more consistent results.