Nature Inspired Computing Ant Colony Optimisation Report

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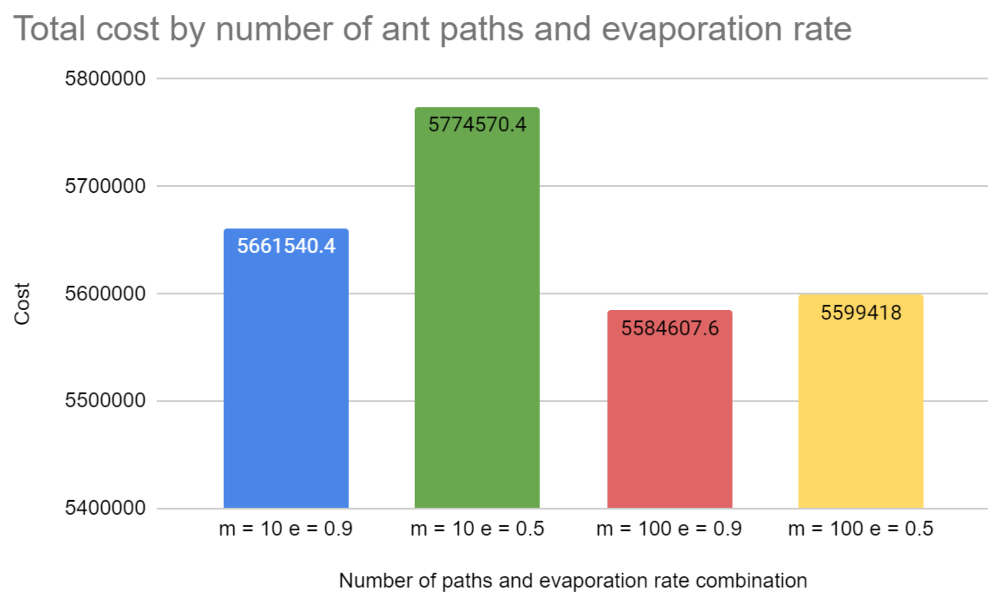
Each of these tables shows an experiment looking at five trials running an ant colony optimisation algorithm with four different parameter combinations. Table 1 shows the total best total cost for each of these trials and table 2 shows the percentage decrease of this best total cost compared to the baseline cost with the solution [0, 1, 2 … 49]. This is followed by the two graphs comparing the averages from these tables.

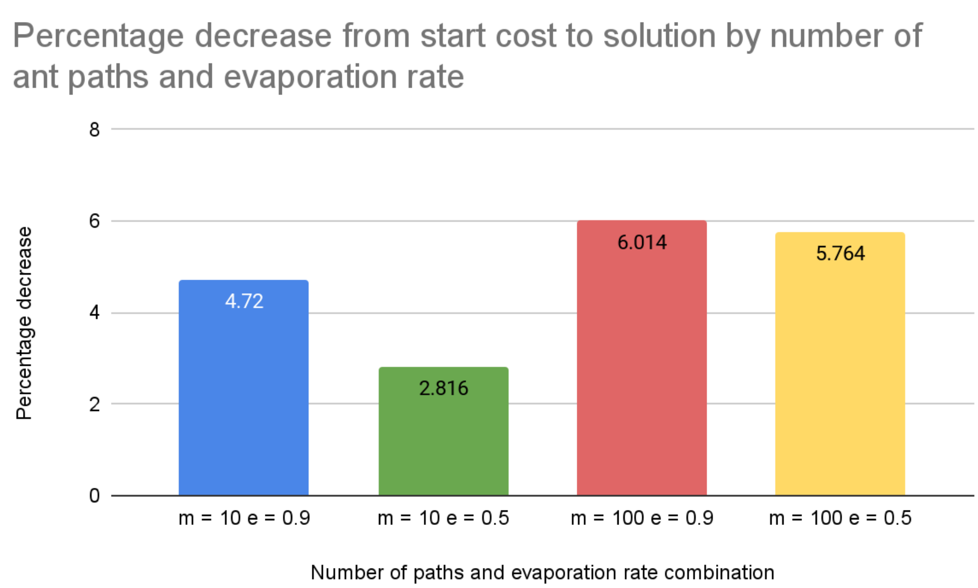
Table 1

						Average
m=10 e=0.9	5661090	5643140	5642150	5670210	5691112	5661540.4
m=10 e=0.5	5827642	5723108	5774970	5775840	5771292	5774570.4
m=100 e=0.9	5607554	5537174	5593174	5607346	5577790	5584607.6
m=100 e=0.5	5626844	5557266	5602302	5598870	5611808	5599418

Table 2

						Average
m=10 e=0.9	4.73	5.03	5.05	4.57	4.22	4.72
m=10 e=0.5	1.92	3.68	2.81	2.8	2.87	2.816
m=100 e=0.9	5.63	6.81	5.87	5.63	6.13	6.014
m=100 e=0.5	5.3	6.47	5.72	5.77	5.56	5.764





Which combination of parameters produces the best results?

The combination of m = 100 and e = 0.9 delivers the best results due to them generating the lowest average cost of 5584607.6 and the highest percentage decrease from the initial cost given, with the decrease being 6.014%.

What do you think is the reason for your findings in Question 1?

This parameter combination produces the best results due to its larger number of ant paths per iteration and the high evaporation rate. When comparing the number of ant paths generated, we can see that it is the most important factor with both experiments with m = 100 achieving significantly better results than those with 10. Only the experiments with this higher m value were able to achieve a cost value lower than 5600000 throughout all of the trials, suggesting that with more ant paths, a lower cost is more likely to be found. A wider range of possible solutions able to be found with the higher amount of ant paths and with a higher amount of pheromone on the edges it is more likely that the ants will be guided towards better solutions.

How does each of the parameter settings influence the performance of the algorithm?

A higher value m means that with more ant paths generated on each generation, there can be more exploration of the solution space. With the evaporation rate e being multiplied by the pheromones on the edges, a higher value means that the pheromones won't evaporate as fast. With the higher pheromone levels on the edges, it is more likely that an ant is going to take that route, meaning better routes are more favourable and won't be lost as quickly as can be seen with a lower e value.

From the data, it can be inferred that the number of ant paths plays a more important role in finding the best solution as with more paths there are more opportunities to find better solutions. Even with the preferred evaporation rate with the m = 10, e = 0.9 combination, a 1% difference in the decrease percentage can be seen between the combination of the more favourable ant path number and the lower evaporation rate. This is somewhat expected due to the random nature of the algorithm. With more paths generated and the choice between nodes being only slightly influenced by the pheromones being placed, the likelihood is significantly higher with a larger amount of paths explored that a better solution will be found.

Can you think of a local heuristic function to add?

A possible local heuristic that could be used would be the addition of a function that looks at the distance and flow of a given edge when finding the next node in the graph. This could still involve randomness to ensure that different paths are still explored but using these values as a bias to influence the decision could help the ants make a more informed decision about which edge may be best. This could potentially lead to a more efficient solution.

Can you think of any variation for this algorithm to improve your results? Explain your answer.

The implementation of a form of local search could help improve the results of this algorithm. For example, implementing a 2-opt or 3-opt algorithm to consider swapping edges could help in finding a better solution. This is because the current ACO algorithm frequently appears to get trapped in local optima. The use of a local search could help in getting closer to the global optima for the solution, as small changes to their current solutions can be made and evaluated to see if they result in improvement.

Do you think of any other nature-inspired algorithms that might have provided better results? Explain your answer.

A genetic algorithm is an example of another nature-inspired algorithm that may provide better results for this problem. This algorithm uses the ideas behind natural selection to form populations of solutions and select the best solutions for each population and then combine them with a crossover between 'parents' forming 'children', ideally taking the best attributes from each parent. Mutations can also be used to randomly adjust solutions which can help escape local optima. Using a genetic algorithm could be useful to solve this problem as they are more effective at finding global optima, which would be helpful to solve this problem.

It would also better reward the solutions with greater fitness as only these solutions would move between each generation. The current use of the ACO places small amounts of pheromone which helps guide the ants towards the correct path but can still lead them down less effective paths or cause them to be trapped in local optima quite quickly and relies on the chance of multiple ants taking an alternate route.

Further experiments

To further investigate the relationship between the two parameters, I ran an experiment with a high amount of ant paths (m = 100) with a much lower e value (e = 0.2), meaning the pheromones evaporated much faster. This was to see how important the number of ant paths is and whether it can outweigh the high evaporation rate. The graph below shows the average percentage decrease across the five trials and compares these results to the lower amount of ant paths with a higher e value as well as the higher amount of ant paths with the previously lowest e value.

These results show that while the high amount of ant paths is important to find a better solution, a significantly lower e value (high evaporation rate) will lead to poor results with a smaller percentage decrease than the lower amount of ant paths with higher e value. This is due to the pheromones evaporating too fast for them to affect the ant's decision in what path to take.