1 Analysis of ACO Variants

Comparative performance analysis of Ant Colony optimisation (ACO) variants is crucial to understand their optimisation capabilities under different parameters. The following figures illustrate the effectiveness of various ACO strategies, including Basic ACO, Min-Max Ant System (MMAS), and Elitist Strategy. Each subplot in the figures shows how the best solution cost evolves with the number of fitness evaluations, highlighting the distinctive optimisation behavior of each variant in response to diverse conditions. This analysis aids in discerning the most efficient ACO variant and parameter combination for specific optimisation problems.

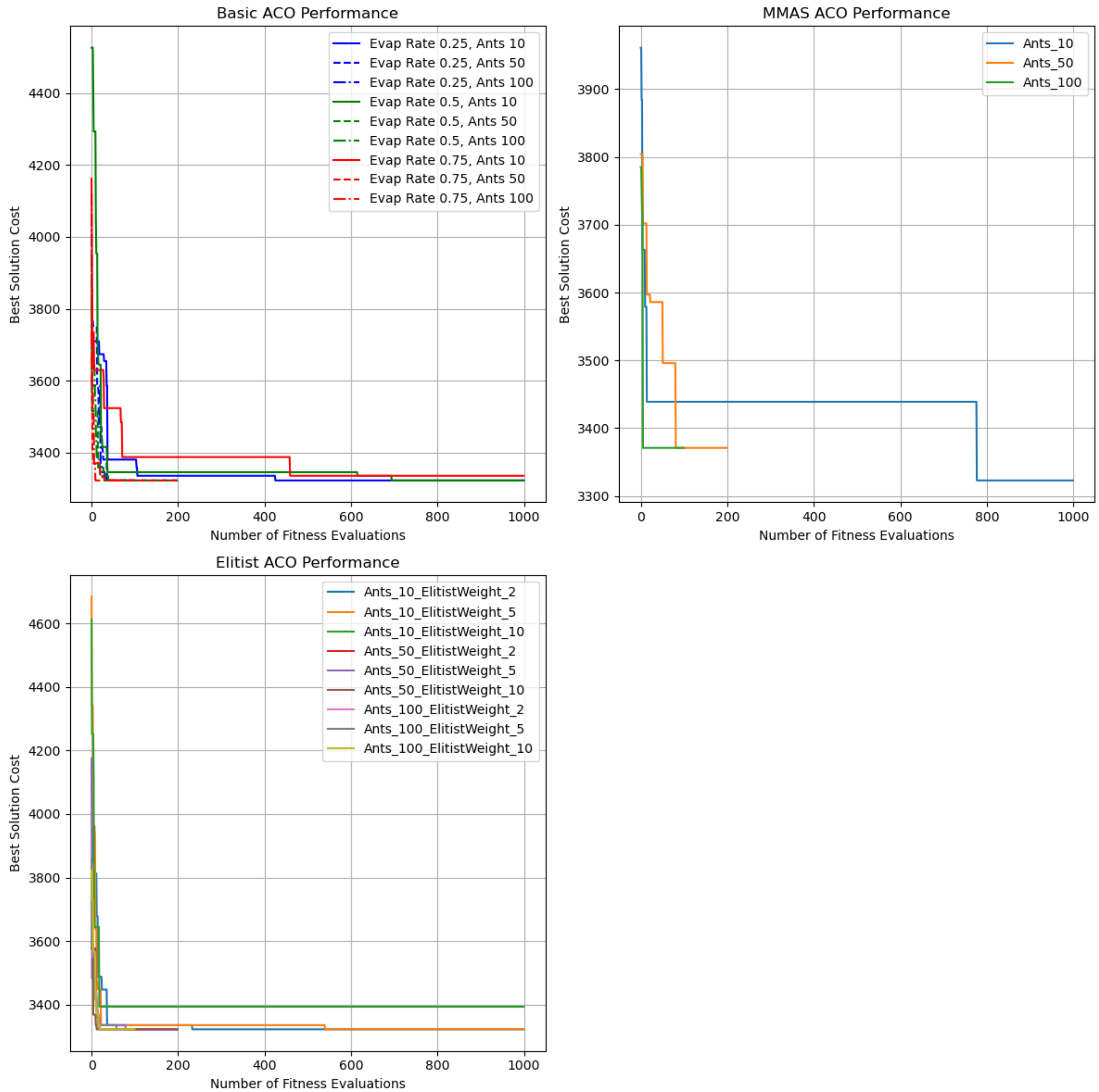

Figure 1: Performance comparison of different ACO variants across varying parameters for Burma.

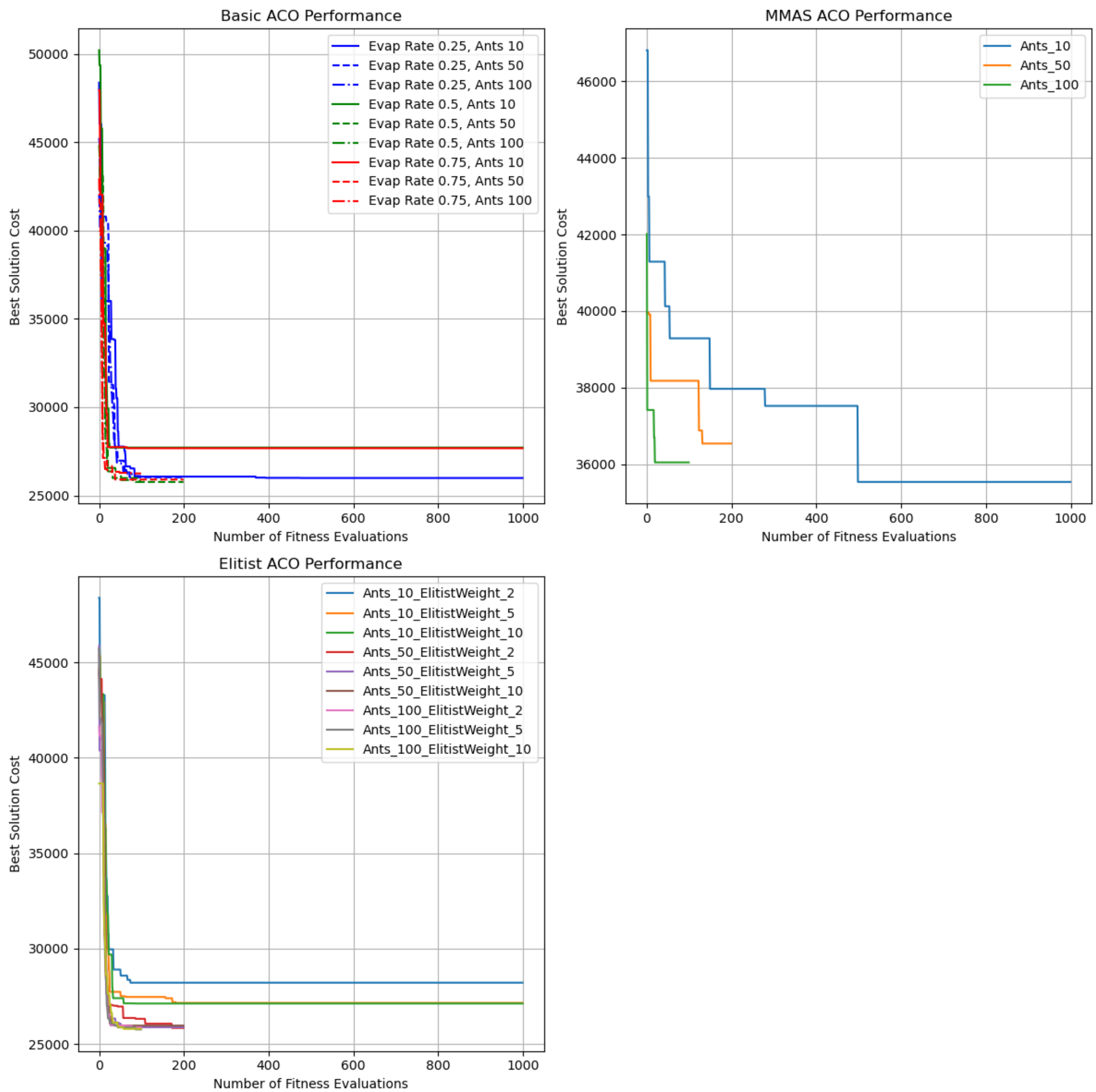

Figure 2: Performance comparison of different ACO variants across varying parameters for Brazil.

1.1 Final Best Costs Analysis

The analysis yields the final best costs for each variant of the ACO algorithms, demonstrating the impact of different parameters such as evaporation rates and elitist weights on the optimisation process. The summarised results are presented in the following tables:

Basic ACO Variants (Burma)

Configuration	Best Cost
EvapRate 0.25, Ants 10	3323.0
EvapRate 0.25, Ants 50	3323.0
EvapRate 0.25, Ants 100	3323.0
EvapRate 0.5, Ants 10	3323.0
EvapRate 0.5, Ants 50	3323.0
EvapRate 0.5, Ants 100	3323.0
EvapRate 0.75, Ants 10	3323.0
EvapRate 0.75, Ants 50	3323.0
EvapRate 0.75, Ants 100	3323.0

Basic ACO Variants (Brazil)

Configuration	Best Cost
EvapRate 0.25, Ants 10	25992.0
EvapRate 0.25, Ants 50	26037.0
EvapRate 0.25, Ants 100	26100.0
EvapRate 0.5, Ants 10	27713.0
EvapRate 0.5, Ants 50	25769.0
EvapRate 0.5, Ants 100	25769.0
EvapRate 0.75, Ants 10	27676.0
EvapRate 0.75, Ants 50	25906.0
EvapRate 0.75, Ants 100	26248.0

MMAS ACO Variants (Burma)

Configuration	Best Cost
Ants 10	3323.0
Ants 50	3371.0
Ants 100	3371.0

MMAS ACO Variants (Brazil)

Configuration	Best Cost
Ants 10	35533.0
Ants 50	36537.0
Ants 100	36044.0

Elitist ACO Variants (Burma)

Configuration	Best Cost
Ants 10, Elitist Weight 2	3323.0
Ants 10, Elitist Weight 5	3323.0
Ants 10, Elitist Weight 10	3394.0
Ants 50, Elitist Weight 2	3323.0
Ants 50, Elitist Weight 5	3323.0
Ants 50, Elitist Weight 10	3323.0
Ants 100, Elitist Weight 2	3323.0
Ants 100, Elitist Weight 5	3323.0
Ants 100, Elitist Weight 10	3323.0

Elitist ACO Variants (Brazil)

Configuration	Best Cost
Ants 10, Elitist Weight 2	28218.0
Ants 10, Elitist Weight 5	27161.0
Ants 10, Elitist Weight 10	27128.0
Ants 50, Elitist Weight 2	25848.0
Ants 50, Elitist Weight 5	25884.0
Ants 50, Elitist Weight 10	25970.0
Ants 100, Elitist Weight 2	25876.0
Ants 100, Elitist Weight 5	25769.0
Ants 100, Elitist Weight 10	25799.0

Question 1: Which combination of parameters produces the best results?

To determine the best combination of parameters, we need to look at the lowest 'Final Best Costs' from the provided data for each dataset.

Brazil Dataset: Among all, the Elitist_ACO_variant with 50 ants and an elitist weight of 5 yields the best result.

Burma Dataset: For the Burma dataset, the Basic and Elitist_ACO_Variants (with various settings) equally produce the best results.

Question 2: What do you think is the reason for your findings in Question 1?

Brazil Dataset: The combination of 50 ants and an elitist weight of 5 in the Elitist ACO variant likely provides a balanced approach between exploration and exploitation. The higher number of ants allows for more thorough exploration of the solution space, and the elitist weight emphasises the influence of the best-performing ants, guiding the colony more effectively.

Burma Dataset: The consistent results across different settings suggest that the solution space might be less complex or the algorithm is quickly finding near-optimal solutions, making further improvements marginal.

Question 3: How does each of the parameter settings influence the performance of the algorithm?

The data indicates that a lower evaporation rate and moderate number of ants in the Basic and Elitist ACO variants lead to a more stable and faster convergence. The MMAS seems to be more sensitive to the number of ants, potentially due to its stricter pheromone update rules

Question 4: Can you think of a local heuristic function to add?

Node Degree Heuristic Prefers paths leading to nodes (cities) with fewer connecting edges, which can be useful in reducing the probability of revisiting the same node. This could help reduce early convergence which seems to be a common trend within these algorithms.

Question 5: Can You Think of Any Variation for This Algorithm to Improve Your Results? Explain Your Answer.

Hybrid ACO: Combining ACO with other optimisation techniques, like Genetic Algorithms or Tabu Search, could improve results. This hybrid approach can balance the exploration and exploitation capabilities of ACO with the strengths of other algorithms.

Dynamic Parameter Adjustment: Adjusting parameters like evaporation rate or elitist weight during runtime based on the performance could lead to better optimisation, adapting the algorithm to different stages of the search process.

Question 6: Do You Think of Any Other Nature-Inspired Algorithms That Might Have Provided Better Results? Explain Your Answer.

Genetic Algorithms: GAs are good at exploring a wide solution space and can be effective in complex optimisation problems. They might provide better results, especially in scenarios where ACO is prone to premature convergence. The paper titled "An efficient genetic algorithm for the traveling salesman problem with precedence constraints" concluded that their proposed GA approach was superior to other traditional algorithms [1].

The paper "Particle Swarm optimisation for Traveling Salesman Problem" explores the application of Particle Swarm optimisation to the Traveling Salesman Problem. PSO's success in the study indicates its potential in effectively exploring the solution space and converging to optimal solutions, possibly providing better results than ACO in certain scenarios. The adaptability of PSO to different problem types, including its application to discrete problems, highlights its versatility as a nature-inspired algorithm. The study's positive outcomes suggest that exploring PSO or similar algorithms might yield improved results in optimisation challenges where ACO faces limitations, such as premature convergence or inefficiency in exploring complex solution spaces [2].

1.2 Conclusion

In conclusion, this report has analysed various Ant Colony Optimisation variants, focusing on their performance under different parameter configurations. Through comprehensive comparisons, it has identified the most effective ACO variant and parameter combination for specific optimisation problems, emphasising the balance between exploration and exploitation in optimisation processes. Additionally, the report has proposed innovative approaches like hybrid ACO and dynamic parameter adjustment to further enhance optimisation results. It also recognises the potential of other nature-inspired algorithms, such as Genetic Algorithms and Particle Swarm optimisation, in overcoming some limitations of ACO, particularly in complex optimisation scenarios.

References

[1] Chiung Moon, Jongsoo Kim, Gyunghyun Choi, and Yoonho Seo. An efficient genetic algorithm for the traveling salesman problem with precedence constraints. pages 10–11, 2001.

[2] KANGPING WANG, LAN HUANG, CHUN-GUANG ZHOU, and WE1 PhG. Particle swarm optimization for traveling salesman problem. pages 2–3, 2003.