EXERCISE 5: ANALYSIS OF CUSTOMACO VS MMAS VARIANTS

ALGORITHM DESIGN

CustomACO incorporates several distinctive features:

- 50 ants per generation (vs MMAS single-solution approach)
- Elite-based pheromone updates using top 20% of ants
- Local search applied with 10% probability (1-bit flip neighbourhood)
- Fixed evaporation rate of 0.2
- Problem specific heuristics slightly favoring 1-bits on OneMax, LeadingOnes, and Linear

PERFORMANCE BY PROBLEM TYPE

Easy Problems (F1 OneMax, F3 Linear): CustomACO performs comparably to all MMAS variants, reaching optimum quickly. The larger population provides no significant advantage on these smooth landscapes where focused exploitation is sufficient.

Sequential Constraint (F2 LeadingOnes): Competitive with MMAS variants. The sequential dependency limits benefits from parallel ant construction. Local search occasionally helps discover beneficial flips.

Deceptive/Difficult Problems (F18 LABS, F23 NQueens, F24 ConcatenatedTrap):

- On LABS, all algorithms struggle equally; CustomACO shows no advantage
- On NQueens, comparable performance with MMAS; population diversity provides modest benefit v
- On ConcatenatedTrap, CustomACO handles deception reasonably well elite selection helps prevent premature convergence

Highly Rugged (F25 NK-Landscapes): CustomACO remains competitive but shows no clear superiority. The 10% local search probability is insufficient to escape deep local optima on this extremely difficult landscape.

KEY INSIGHTS

Population Size Impact: The 50 ant population increases diversity and provides advantages on deceptive/rugged landscapes but offers limited benefit on smooth problems where MMAS's focused approach is more efficient.

Elite Selection: Using top 20% for pheromone updates balances exploitation and exploration better than single solution updates, providing robustness on deceptive problems without sacrificing performance on easy ones.

Local Search: The memetic component shows modest impact. The 10% probability may be too low for consistent effect, and single bit neighborhoods may be insufficient for complex problems.

Fixed Evaporation: The 0.2 evaporation rate provides reasonable balance but may be suboptimal for specific problems. MMAS testing multiple ρ values demonstrates the importance of this parameter.

COMPARATIVE PERFORMANCE

CustomACO does not consistently outperform MMAS variants but demonstrates robust, competitive performance across all benchmarks. It excels on ConcatenatedTrap's deceptive landscape and maintains consistent results on rugged problems, but shows no advantage on simple unimodal functions.

The results confirm that problem characteristics dominate algorithm design choices. On easy problems, all ACO variants succeed; on hard problems, all struggle. The optimal configuration is problem dependent rather than universal.

CONCLUSION

CustomACO represents a well designed population based ACO with competitive performance across diverse problem types. The larger population trades computational efficiency for robustness providing more consistent results but not faster convergence. Neither aggressive single solution MMAS updates nor population based diversity universally dominates, confirming that algorithm configuration should match problem structure. Future improvements could include adaptive evaporation rates, enhanced local search strategies, and stronger problem specific heuristics.