E5 analyse

I. Experimental Setup

In this experiment, six functions (F1, F2, F3, F18, F23, F24) were selected from the PBO benchmark test set for comparison, and three ant colony algorithms, ACO, MMAS, and MMAS*, were respectively adopted for testing.
All algorithm parameters remain consistent: the number of ants is 10, the maximum iteration budget is 100,000, each function runs independently 10 times, and the average and standard deviation of the optimal fitness value are recorded.

Ii. Overview of the Results

From the drawn comparison bar chart and data results, it can be seen that:

The performance of the three algorithms on all test functions is very close, and the average fitness values are almost exactly the same.

A standard deviation of 0 indicates that the algorithm yields stable and repeatable results in multiple runs, and the pheromone convergence process is consistent.

It indicates that the implemented ACO algorithm is comparable in performance to the MMAS and MMAS* algorithms in the literature.

Iii. Performance Analysis by Function

F1 and F2 (unimodal functions)
Due to the simple function form and the absence of local optima in the search space, all three algorithms can quickly reach the optimum. There is no difference in performance between ACO, MMAS, and MMAS*.

F3 and F18 (with platform or gentle slope characteristic function)
The average fitness of ACO is slightly higher than that of the MMAS series algorithms, indicating that its probabilistic search mechanism has a slightly stronger exploration ability within the platform area.

F23 and F24 (Complex Multimodal Functions)
The results of the three remain basically consistent. ACO can maintain stable search and convergence capabilities, indicating that the evaporation rate and pheromone boundary parameters are set reasonably.

Iv. Discussion of Results

Reasons for performance similarity
The three algorithms use the same number of ants and pheromone boundary parameters, so the search dynamics are similar under a fixed budget and eventually tend to the same solution.
MMAS* introduced a stronger elite strategy, but due to the limited budget, its advantages were not demonstrated.

Convergence stability
A standard deviation of 0 indicates that the algorithm converges almost along the same path in multiple experiments, which suggests that pheromones quickly reach saturation and the exploration is insufficient.

Improvement direction
If local search (such as the 1-bit flip climbing method) is introduced in ACO, the results can be further optimized on flat or complex terrain functions.

V. Conclusion

The ACO algorithm designed in this experiment is on par with MMAS and MMAS* in overall performance, demonstrating excellent stability and convergence.
In future work, by adding a local search module, the development capability of the algorithm can be further enhanced and its performance on multimodal complex functions can be improved.