# Enhancing Competitive Swarm Optimization through Time-Adaptive Selection between Adjacency-Guided and Random Strategies

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## Vision for Future Society

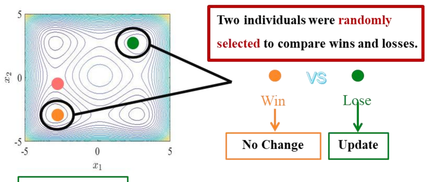
- **Time-adaptive optimization solves complex social challenges with high precision.**
- **Adaptive evolutionary computation supports a sustainable and resilient future society.**

Optimization for high-speed train design.

- As systems and products grow more complex, the need to solve optimization problems efficiently within limited time frames is increasing [1].
- Metaheuristic Algorithms (MAs), inspired by biological, physical, or population-based phenomena, include popular methods such as Genetic Algorithm (GA) and **Competitive Swarm Optimizer (CSO)**.

## The trouble with the original Competitive Swarm Optimizer (CSO)

- CSO is a Metaheuristic algorithm proposed in 2015. It is an **improved variant of Particle Swarm Optimization (PSO)** and incorporates a competitive mechanism to enhance optimization performance, like the pic.
- The original CSO algorithm randomly selects two individuals, which may result in the **obsoletion of multiple promising solutions and reduce the diversity of the search space**.




**Velocity Update:**

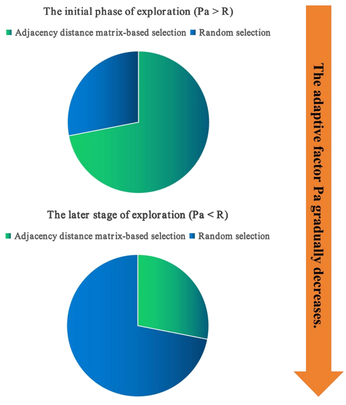
$$V_{lek}(t+1) = R_j(k,t)V_{lek}(t) + R_k(k,t)(X_{wek}(t) - X_{lek}(t)) + \varphi R_l(k,t)(\bar{X}_k(t) - X_{lek}(t)) \quad (1).$$

Winner Loser

**Position Update:**

$$X_{lek}(t+1) = X_{lek}(t) + V_{lek}(t+1) \quad (2).$$

## Our proposal




- The original CSO randomly selects individuals for win-lose comparisons, which may reduce diversity in early exploration. To improve this, we use an **adjacency distance matrix** to select from the **K nearest neighbors**, enhancing exploration. To avoid slow convergence later, we introduce an **adaptive factor that gradually shifts selection from neighbor-based to random**. This ensures strong exploration early and faster convergence in later stages.

## Future topics

- Future work includes automated parameter tuning, improving scalability for large problems, and applying the method to real-world domains such as energy, logistics, and machine learning.

## Related papers

1. Cao, Yang & Yu, Jun & Zhong, Rui & Munetomo, Masaharu. (2025). Forecasting Renewable energy and electricity consumption using evolutionary hyperheuristic algorithm. Scientific Reports. 15. 10.1038/s41598-025-87013-8.