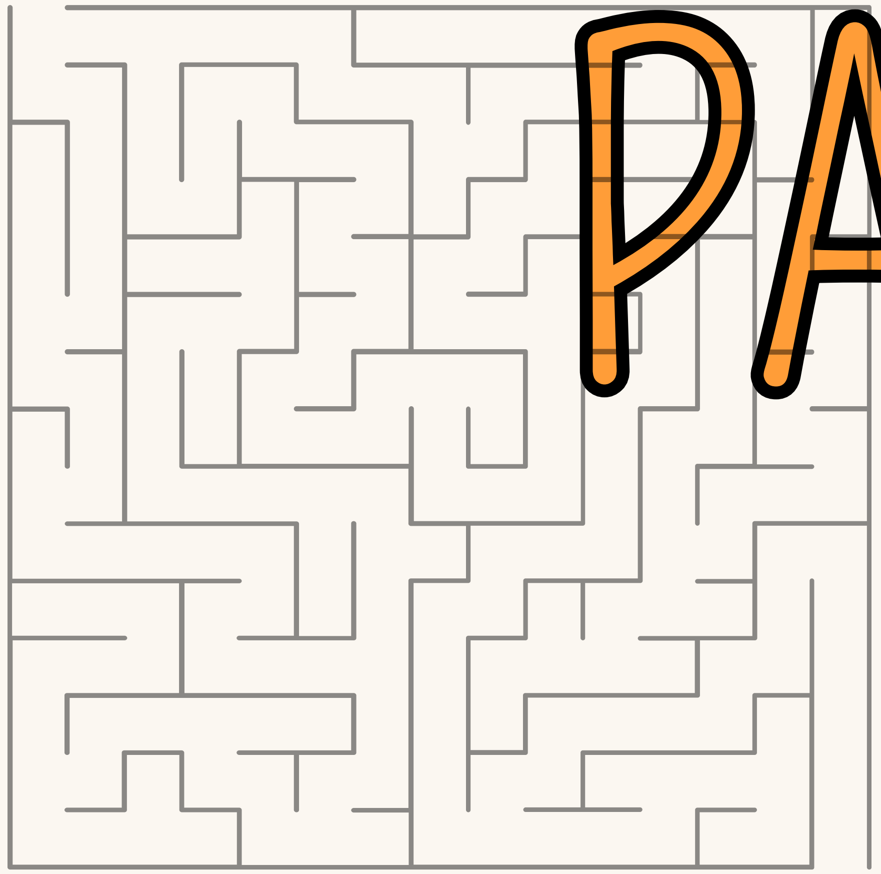
SMARTGRID-PATHFINDER



The team

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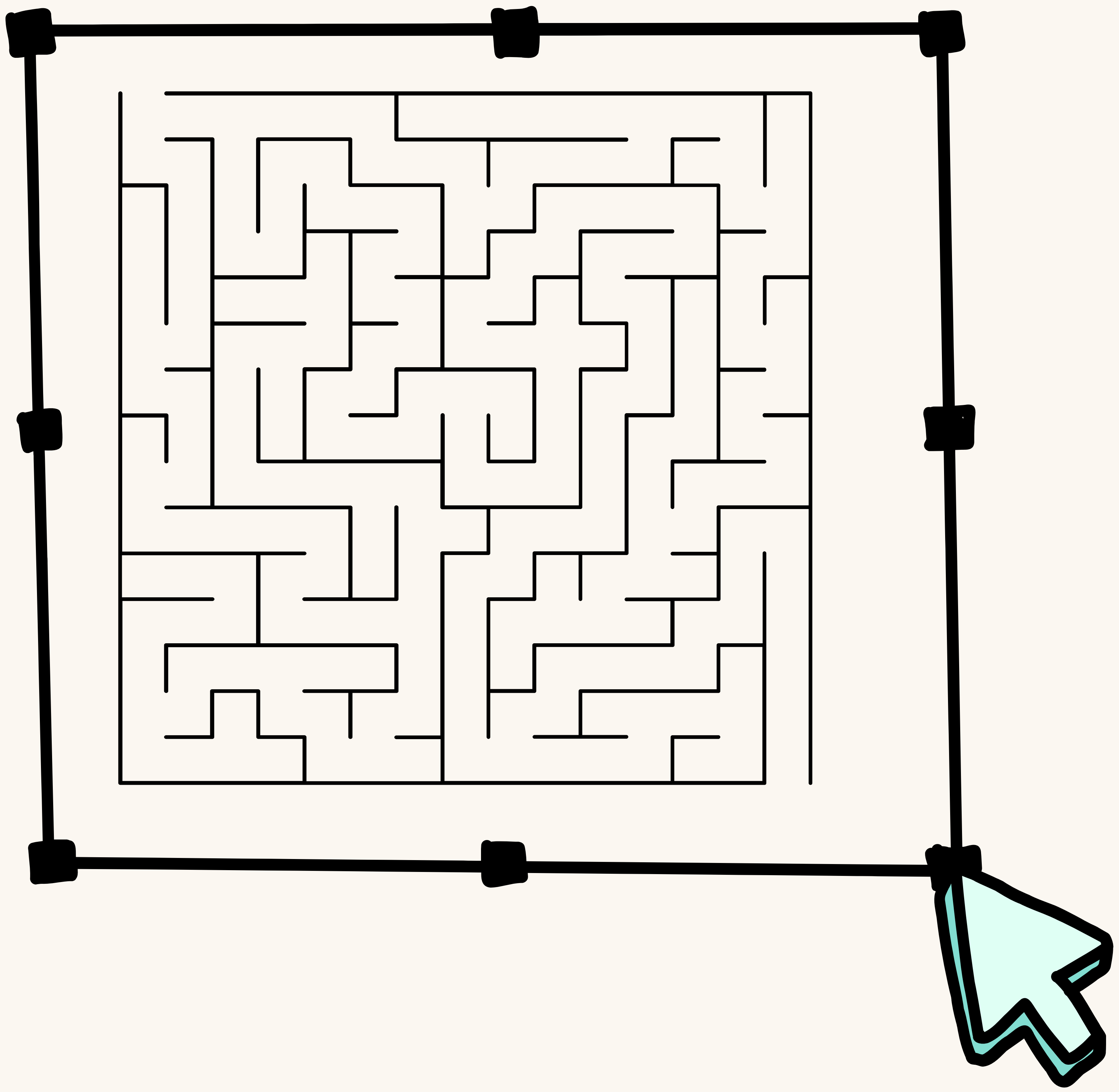
Introduction



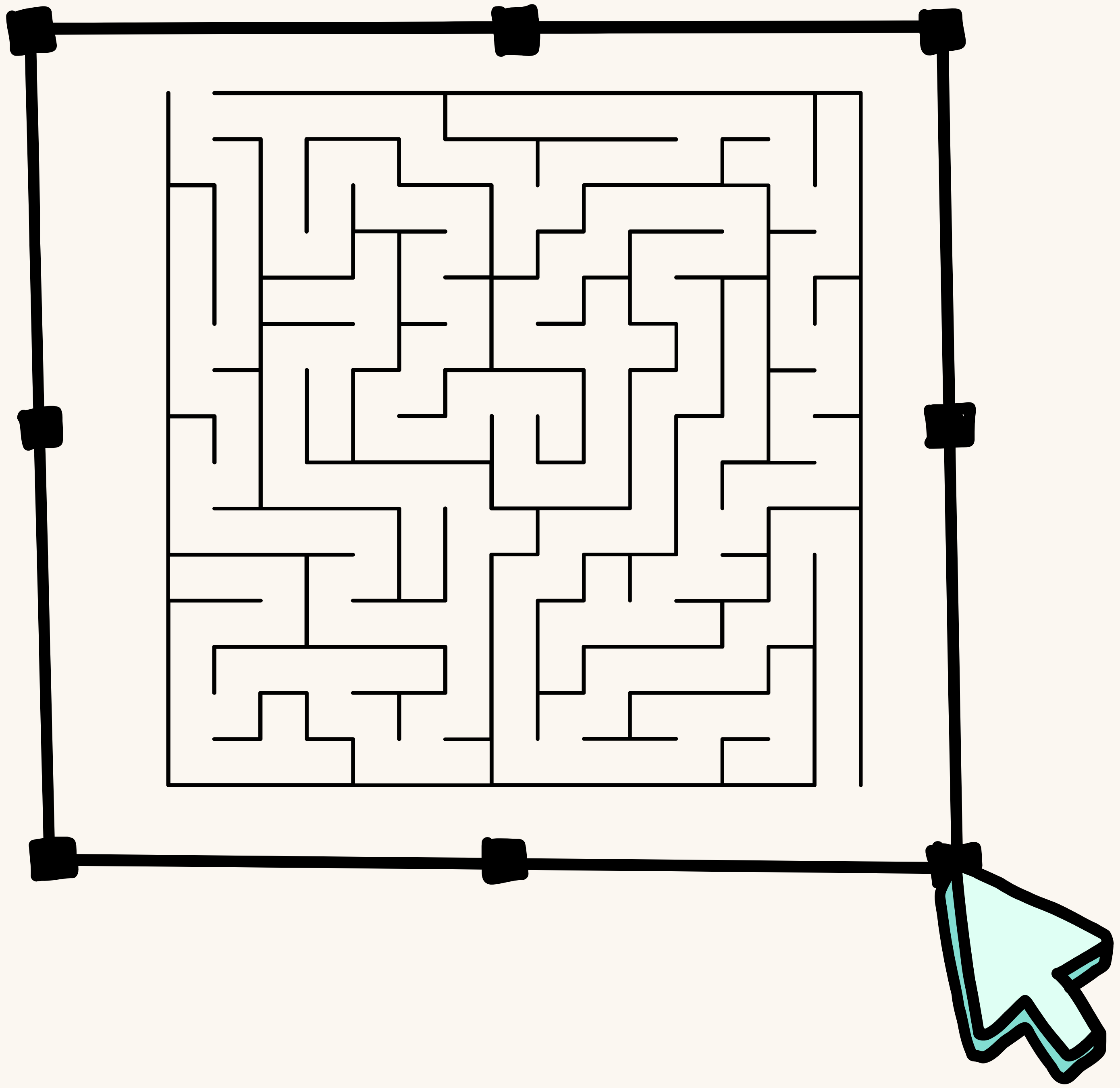
1. Project Idea

In this project, we are working on a path planning problem for a robot on a grid.

🎯 Objective: Move from a defined **start point to a goal point, while:

- ✅ Collecting predefined items
- 🚫 Avoiding obstacles

Introduction



To achieve this, we implemented and compared the performance of three bio-inspired optimization algorithms:

- 🐜 Ant Colony Optimization (ACO)
- 🐝 Artificial Bee Colony (ABC)
- 🐦 Particle Swarm Optimization (PSO)

The goal is to find the most efficient and intelligent path for the robot.

BFS WITH RANDOM EXPLORATION

This function finds a path from the start to the goal using Breadth-First Search, exploring neighbors in a random order.

🔧 How It Works:

- Starts from the initial position.
- Explores all valid neighboring cells using a queue.
- Randomizes neighbor order to introduce variety.
- Stops when the goal is reached.

📦 Returns:

- A list of positions from start to goal.
- None if no path is found.

🚀 Useful for generating diverse paths in ABC and PSO algorithms

ARTIFICIAL BEE COLONY (ABC)

"LET THE BEES GUIDE THE WAY"

🔷 Key Roles:

- Employed Bees: Search around known food sources (paths).
- Onlooker Bees: Observe and choose promising sources.
- Scout Bees: Explore randomly for new food sources.

🔷 Steps:

1. Generate initial random paths (food sources).
2. Evaluate them based on path quality (fitness).
3. Explore around best paths to improve.
4. Replace bad solutions with new random ones (scouting).

🔷 In Our Project:

- Each path is a bee's "foraging route".
- Bees try to collect as many items as possible on the way to the goal.
- Fitness is based on:
  - Path length
  - Number of items collected
  - Reaching the goal

✅ Good for exploring a diverse set of solutions.

PARTICLE SWARM OPTIMIZATION (PSO)

"FLOCKING TO THE BEST PATH"

🔷 Concept:

- Each particle represents a path solution.
- Particles adjust their path by:
  - Their own best solution (pBest)
  - The global best solution (gBest)

🔷 Steps:

1. Initialize particles (random paths).
2. Evaluate fitness of each.
3. Update particles to move toward the best-known solutions.
4. Iterate until convergence.

🔷 In Our Project:

- A path is a particle's position.
- The particle learns from:
  - Its own past best (shorter, item-rich path)
  - Best path found by others
- Particles "move" by altering path decisions slightly.

✅ PSO helps quickly converge to optimal or near-optimal paths

ANT COLONY OPTIMIZATION (ACO)
"FOLLOW THE PHEROMONES"

◆ Core Ideas:

- Each ant lays a pheromone on its path.
- Future ants are more likely to follow stronger pheromone trails.
- Over time, good paths get reinforced.

◆ Steps:

1. Generate many random paths (ants explore).
2. Evaluate each path.
3. Add pheromone based on path quality.
4. Evaporate pheromone over time (to avoid overfitting).

◆ In Our Project:

- Each ant creates a path from start to goal while collecting items.
- Better paths leave more pheromone.
- Ants are more likely to follow better paths in the future.

✅ Excellent for balancing exploration and exploitation.

🧠 2. How We Applied ACO, ABC & PSO in Our Grid

Each algorithm was tested on the same environment to ensure fairness:
Same grid configuration
Same start & goal
Same number of items and obstacles

🐝 Artificial Bee Colony (ABC)

Bees explore and exploit food sources (paths). Employed bees search locally, while scout bees explore randomly.

🐜 Ant Colony Optimization (ACO)

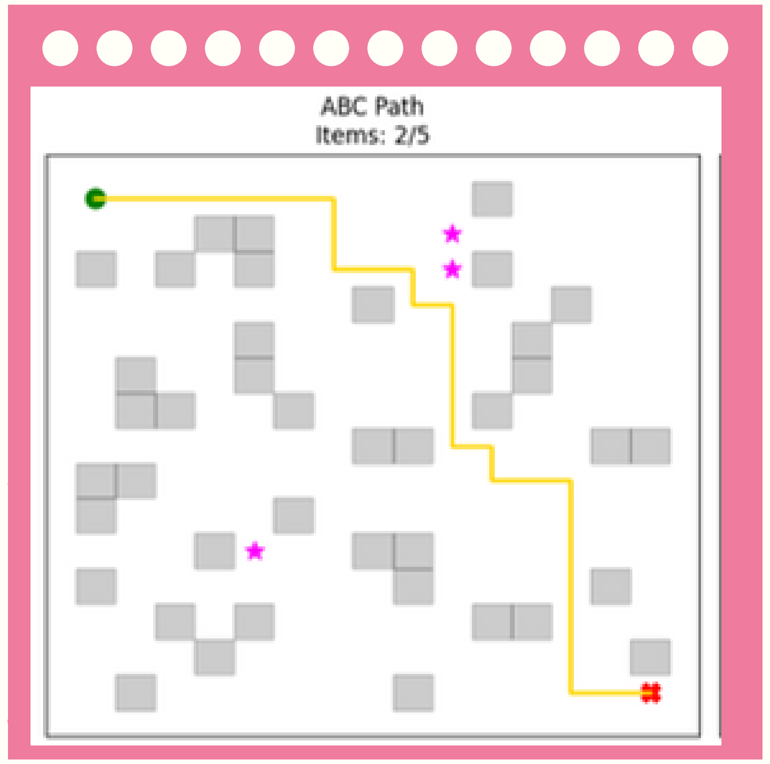
Simulates ants leaving pheromone trails. Better paths leave stronger pheromones, guiding others toward optimal paths.

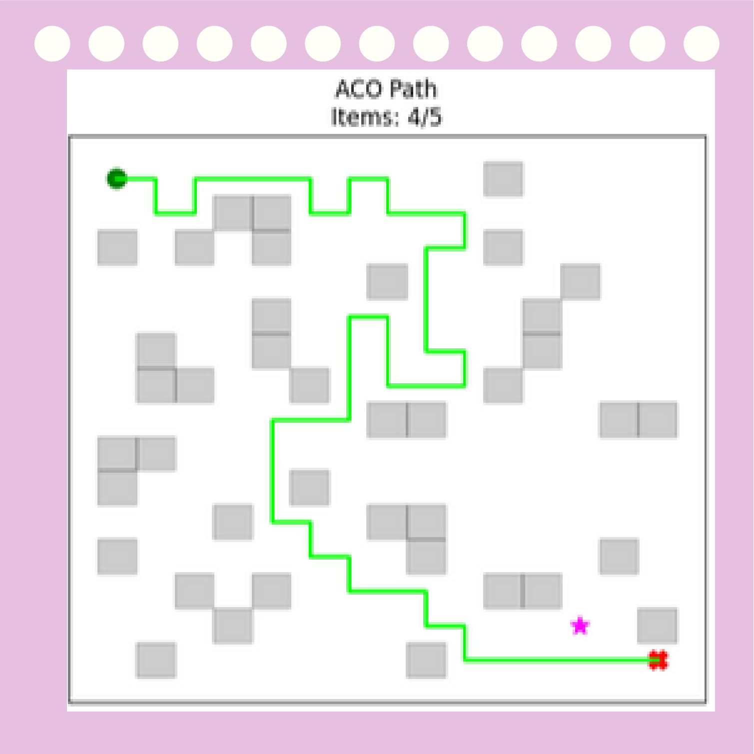
🐦 Particle Swarm Optimization (PSO)

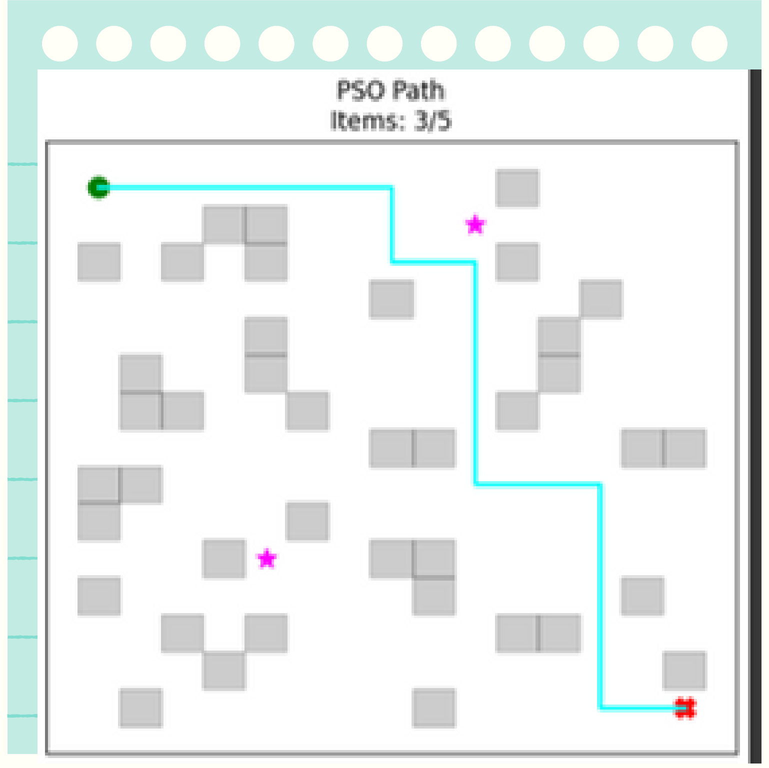
Particles move in the grid and adjust their directions based on their best path and the global best, mimicking bird flocking behavior.

📝 Best Performer

PARTICLE SWARM OPTIMIZATION (PSO) IT PROVIDED THE BEST BALANCE BETWEEN EFFICIENCY AND EFFECTIVENESS IN OUR GRID SCENARIO.







Algorithm	Path Length	Items Collected	Valid Path
ABC	29	2/5	✅
ACO	49	4/5	✅
PSO	29	3/5	✅

THANK YOU!

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