

# README – Multi-Robot Pollution Source Seeking

Project: ASC 2025 – CentraleSupélec

## Overview

This project implements and compares two decentralized multi-robot control strategies for pollution source seeking:

- **AAPF (Adaptive Artificial Potential Field)**
- **Leader-Follower with Gradient Ascent**

Each robot is modeled as a single integrator and uses only local information (pollution measurements and neighboring positions) to navigate toward regions of higher pollution. The final objective is to reach the global maximum of a scalar pollution field and reconstruct it from the robots' trajectories and measurements.

## File Descriptions

- `control_algo_potential.py` – Defines the two control laws (AAPF and Leader-Follower).
- `etude_de_cas.py` – Runs the full simulation, visualizes results, computes evaluation metrics, and reconstructs the pollution field.
- `lib/` – Contains utility modules for robot dynamics, potential fields, and simulation.

## How to Run

### 1. Run the Control Script First

This script initializes the global potential field and defines both control laws:

```
python control_algo_potential.py
```

### 2. Then Run the Simulation Script

```
etude_de_cas.py
```

This will execute the simulation loop, generate trajectory plots, plot robot speeds, animate the evolution, and reconstruct the pollution field using interpolation.

### 3. Choosing the Control Mode

At the top of `main_simulation.py`, change:

```
MODE = "AAPF" # or "LEADER_FOLLOWER"
```

**AAPF** (default) is more robust and efficient under high difficulty (e.g., `difficulty=3`).

## Evaluation Metrics

After the simulation, two key metrics are printed:

- **Relative Potential Found Error** – Measures how close the robots got to the global maximum.
- **Total Distance Traveled** – Sum of all distances traveled by each robot.

## Pollution Field Reconstruction

Using all collected measurements and robot positions over time, the pollution map is reconstructed using 2D spatial interpolation via `scipy.interpolate.griddata`. This map allows us to visually validate that the swarm has successfully explored and reconstructed the pollution field.

## Key Parameters

- `difficulty` in the Potential Field: set to 3 for complex multi-peak scenarios.
- `k_att` (AAPF): adaptive based on distance to best robot.
- `k_rep` (AAPF): adaptive based on pollution value.
- `step_size` (Leader-Follower): based on distance to pollution maximum.
- `consensus_strength` (LF): varies with distance to best robot.

## Authors and Acknowledgements

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