Context Aware 2D Layout Sensor Placement & Activity Simulation using PSO + GA

Objective Summary:
The goal of our project is to solve a multi-objective optimization problem using a hybrid combination of PSO and GA algorithms. There will be two phases:

1. **Phase 1:** This phase will try to closely follow a well-established implementation from a reputable paper. The goal is to minimize sensor deployment cost and sensor coverage overlap while maximizing coverage over 2D floor plans sourced from publicly available, highly reputable, and unbiased datasets (Eg. https://github.com/TeaganLi/HouseExpo?tab=readme-ov-file).

2. **Phase 2:** This phase will be the "novel" part of our project. The goal is to retain the optimized layout from phase 1, but minimize the sensor count based on time-dependant occupancy datasets that are publicly available, highly reputable, and unbiased (Eg. https://github.com/CCWI/Coddora/blob/main/README.md?utm_source=chatgpt.com). The objective is to identify and prioritize the most active sensors across different time windows to determine key sensors that will be most active during certain hours of the day.

The goal is to apply the algorithms to a randomly selected layout and oppancy data from the datasets above. In the future, these can be dynamically applied to further improve the overall solution.

Implementation Details:

1. ***Phase 1: Sensor Placement Optimization (Static Layout)***
    - ***Step 1:*** Load floor plans from dataset
        - Import 2d floor plan (Eg. HouseExpo)
        - Randomly select and process an imported 2D layout for implementation
    - ***Step 2:*** Define the optimization problem and constraints
        - Specify sensor range and placement rules
        - Define multi-objective fitness function that maximizes coverage + minimizes overlap and cost
    - ***Step 3:*** Define PSO & GA Hybrid Optimization
        - Define algorithm functionality and parameters for PSO
        - Define algorithm functionality and parameters for SA to run after PSO
        - Use PSO for global search and GA for refinement
    - ***Step 4:*** Data logging and Visualization
        - Display a log of final sensor layout and fitness trends
        - Display relevant plots for visualization

2. ***Phase 2: Time-Dependant, Occupancy-Based, Sensor Layout Optimization***
    - ***Step 1:*** Load activity profiles from dataset
        - Load time-based occupancy data from dataset (Eg. Coddora)

    - Define fixed time windows (eg. Morning: 6–10 AM, Midday: 10 AM–2 PM, Evening: 6–10 PM, Night: 10 PM–6 AM)
    - Randomly assign room-level activity profiles from the occupancy dataset randomly to rooms in the Phase 1 layout
- ***Step 2:*** Define the optimization problem and constraints
    - Calculate occupancy weights to rooms based on imported occupancy profiles categorized by time segment
    - Use these weights to re-calculate the fitness of the layout from Phase 1 for each time segment
    - Therefore, fitness function will now account for time-segmented weighted activity level based on coverage vs. number of sensors active
        - Weighted room coverage during active hours
        - Number of sensors active per time window
        - Penalty for low-priority sensor usage during inactive hours
- ***Step 3:*** Define PSO & GA Hybrid Optimization for this second run
    - Use the same hybrid optimization structure as phase 1
    - Apply optimization to the updated time-aware fitness function
- ***Step 4:*** Data logging and Visualization
    - Log optimal sensor layouts based on time-specific coverage
    - Log fitness trends
    - Display relevant plots for visualization