Path Planning for Power Inspection Robots Using Classical & Improved MBO and PSO

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Abstract:

Autonomous power inspection robots (ground or rail/line-walking platforms) require safe, short, smooth, and energy-efficient paths while avoiding obstacles and respecting kinematic limits. This paper presents a unified metaheuristic path-planning framework that compares classical Particle Swarm Optimization (PSO), improved PSO (iPSO), classical Migrating Birds Optimization (MBO), and improved MBO (iMBO) for waypoint-based 2D path generation in cluttered inspection environments. Classical PSO is implemented in its canonical form, while iPSO integrates adaptive inertia, constriction-based stabilization, and diversity injection to reduce premature convergence. Classical MBO follows the V-formation neighbor-sharing principle introduced in the original MBO concept, while iMBO adds adaptive neighborhood sizing, leader-rotation scheduling, and obstacle-aware waypoint repair + smoothing to improve feasibility and path quality. A simulation testbed is provided with reproducible seeds, colored visualization of obstacles and paths, and convergence plots. The resulting framework is suitable for power inspection navigation modules and can be extended to 3D corridors or dynamic window controllers.

Keywords:

Power inspection robot, Path planning, Particle Swarm Optimization, Migrating Birds Optimization, Metaheuristics, Obstacle avoidance, Waypoint optimization, Convergence analysis, Swarm intelligence.