A Novel Neighborhood Learning Based Virtual Center Butterfly Algorithm for UAV Path Planning

Abstract. The three-dimensional (3-D) path planning of unmanned aerial vehicles (UAV) is a multi-objective optimization problem. It aims to find a smooth, flyable, and optimal path from starting point to the target point in a complex environment. Traditional algorithms have difficulty ensuring the optimal path when faced with multiple objectives and complex cost functions. In this work, an improved butterfly optimization algorithm (IBOA) based on the virtual center butterfly (VCB) and Neighborhood dimension perturbation learning (NDPL) is proposed to solve the problem. Since BOA uses pairwise interactions between two random butterflies to perform the exploration. It makes the algorithm prone to miss the optimal solution, resulting in insufficient exploration capability. A novel VCB strategy was introduced into BOA to improve the exploration capability of the algorithm by creating attraction and repulsion effects on butterflies during the exploration phase. Meanwhile, the other individuals move toward the best individual in the exploitation phase, and if the best individual falls into the local extremes, it leads to premature convergence of the algorithm with low accuracy. A new NDPL is proposed, which constructs a neighborhood matrix after the BOA search is finished, then performs dimensional learning for each individual. The simulation experimental results in three scenarios show that the IBOA can acquire an effective and feasible route successfully, and its performance is superior to the other six algorithms.

Keywords: Unmanned aerial vehicles · Three-dimension path planning · Butterfly optimization algorithm · Virtual center butterfly · Neighborhood dimension perturbation learning

1 Introduction

Path planning is an indispensable part of UAV in mission execution aiming to find a smooth and flyable path from a given starting position to the target position, which has an optimal performance under constraints [18]. A series of algorithms have been proposed to solve this complex multi-constraint optimization problem, such as A^* algorithm [6], Artificial Potential Field (APF) [14], Rapidly-exploring Random Tree (RRT) [2] and Voronoi diagram [10]. However, as the number of nodes increases and the search space becomes larger, the computational effort of the A^* algorithm increases exponentially. APF algorithm will have a local minimum with equal attractive and repulsive forces, leading to the failure of the planning task. Therefore, the traditional optimization algorithm