

Innovations

1. By incorporating a repulsive function and a driving force, we realize collision avoidance and convergence to a predefined formation pattern within the framework of the classic CS model.
2. Unlike many existing works where the swarm stabilizes to a static configuration, our system maintains continuous collective motion even after the desired formation is achieved, meeting the practical needs of mobile swarms. Meanwhile, this paper mainly realizes that the formation direction and the movement direction can be at any angle, which has important application significance for the UAV cluster to cross complex terrain.
3. Moreover, We propose a novel control protocol $G(x_{\{i\}}, v_{\{i\}})$ that couples velocity orientation and group position distribution. By leveraging each agent's deviation from the group centroid, this protocol achieves integrated direction alignment and positional constraint, ensuring both velocity alignment and formation maintenance.