Dari TRENDAFILOV

Bio-inspired control for collective motion in swarms of drones

Summary

Research and development in collective Unmanned Aerial Vehicle (UAV) systems has grown significantly in recent years, driven by the need for scalable, autonomous, and robust solutions. While traditional centralized control architectures lack resilience and flexibility, distributed approaches allow local decision-making based on limited information, and increased fault tolerance. Maintaining stable formations, efficient path planning and trajectory generation, require coordinated responses under real-world constraints, such as, sensing inaccuracies, communication delays, environmental disturbances, and obstacle-rich environments. Despite recent progress, challenges persist in achieving reliable collective behavior, robust communication, low-latency synchronization, and resilience to failures. Bio-inspired strategies, based on collective behaviors observed in nature, such as fish schools or bird flocks, have gained attention as effective frameworks for UAV swarm coordination. These approaches demonstrate that complex, adaptive, and resilient group behaviors can emerge from simple local interaction rules, offering a low-cost and computationally efficient alternative to centralized frameworks. Recent work demonstrate the feasibility of self-organized UAV flocking with collision and obstacle avoidance and reinforce the value of bio-inspired decentralized algorithms for UAV swarms, as they combine adaptability, robustness, and efficiency. Leveraging local sensing and decentralized decision-making enables collective motion, collision avoidance, and environmental responsiveness without the need for leaders or centralized oversight. Bio-inspired models, refining self-organizing principles into practical algorithms, such as those derived from the rummy-nose tetra fish, have been applied to UAV swarm coordination, demonstrating promising results for enabling autonomous, scalable, and safe multi-robot systems capable of operating across diverse and dynamic contexts.