Evaluation of Control Strategies for Drone Path Tracking and Cooperative Multi-Agent Exploration of Indoor Environments

Ediz Guzey, Josh Chang, Shreyas Sundaram

Unmanned aerial vehicles (UAVs) are increasingly utilized in agriculture, military operations, transportation, infrastructure inspection, and environmental conservation. Although UAV technology has advanced over the past decade, control systems for individual drones and coordination systems for teams of drones remain key areas of research. Building on previous work involving curvature-based velocity control of drones in a simulated racing environment, this study experimentally evaluates control strategies for simulated quadrotors in a high-fidelity simulation platform at two scales: a single drone tracking a planned path and a four-drone team exploring an unknown maze. For single-drone tracking, an A* algorithm was used to generate the shortest possible grid path through a maze. A family of eight controllers (pure pursuit on the raw path, pure pursuit on the Catmull-Rom cubic and quintic spline smoothings, direct cubic and quintic spline following, and three corner-aware, adaptive speed scheduling methods) was tested under both MaxDOF and ForwardOnly flight modes. A 220-configuration sweep (660 runs) measured lap time, cross-track error, wall clearance, and altitude stability. Adaptive velocity controllers, which fly straight sections at fast speeds and slow down for turns, had some of the fastest reliable lap times. The same principles were then applied at a multi-agent scale using decentralized exploration, shared frontier allocation with dynamic task reassignment, and local collision avoidance. The swarm achieved full coverage of mazes by distributing exploration workload and more efficiently navigating loopier, braided mazes, in which drones exhibited reduced backtracking behavior. The findings of this ongoing research will contribute to a larger study on multi-agent navigation and exploration.