Indoor Swarm Drone Management System

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Abstract:
Indoor drone operations are plagued by the absence of GPS, and localization and swarm coordination are a huge challenge in confined environments. This research work presents an inexpensive, vision-based Indoor Swarm Drone Management System for real-time tracking and autonomous control of multiple drones by leveraging infrared markers along with multicamera vision and an ESP32-based communication and control interface. Each drone is mounted with an IR emitter and an ESP32 module, whereas four cameras situated at the corners of the room capture IR signatures for estimating drone coordinates through image processing. It is followed by multicamera fusion at the central processing unit to determine the accurate position of every drone, which radio-transmits these controls wirelessly into the ESP32 over a PWM-to-analog conversion system implemented via low-pass RC filtering and subsequent opamp buffering. This analog output currently sits inside the remote controller in place of the traditional joystick potentiometers, thus enabling direct coordinate-to-control translation for achieving truly autonomous flight. The system aims to provide a low-cost alternative to expensive indoor positioning systems, such as UWB or motion capture setups, while providing acceptable accuracy and responsiveness for swarm coordination. The experimental results presented after this demonstrate the feasibility of IR-based detection, stable analog control injection, and multi-axis autonomous motion, hence proving the suitability of the proposed approach for academic, research, and warehouse-scale indoor applications of drones.

Keywords:
Indoor drone localization, swarm robotics, infrared tracking, multi-camera vision, ESP32, autonomous UAV navigation, low-cost positioning.