A Novel Control System for Autonomous Quadcopter Navigation

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Quadcopters have many uses like delivering packages and search-and-rescue, due to easy maneuverability. However autonomous quadcopters are difficult to control since 4 motor inputs control 6 positional states of the quadcopter (3 translational, 3 rotational). This project investigates autonomous navigation for quadcopters with a novel dual-loop control system, so they can "self-drive". A novel dual-loop was developed with 2 independent control loops to navigate the quadcopter. In between each navigation update to reposition the quadcopter, the quadcopter angles are forced closer to their hover states so that navigation can be robust and smooth. Four feedback control algorithms (PD, PID, BSC, SMC) were modified to fit the dual-loop control system. Original MATBLAB programs simulated the quadcopter navigation. Parametric analysis was used to optimize each control algorithm based on settling time, noise and maximum range. A single axis quadcopter model (theta) and quad axis quadcopter model (theta,phi,psi,z) were built to determine real-world workings of quadcopters and validate MATLAB simulation data. Each prototype contained motors, propellors, ESCs, MPU6050 (accelerometer-gyroscope), and Raspberry Pi or Pico microprocessor. The prototypes' Angle and Angular Velocity results validated the simulation data. A cost function based on settling time, noise output, and maximum range revealed SMC control algorithm performed the best (9.4 SMC, 25 BSC, 12 PD, 16 PID) due to fast settling times and reasonable levels of angular velocity to move the quadcopter in the x-y positional states. The novel dual loop system was 2X faster and more robust than existing single loop control systems in current literature.

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