Abstract

This thesis report details the methods to achieve three objectives: (1) setting up an indoor flight arena in the Dynamics and Controls Lab at The Cooper Union, (2) modeling, simulation, and physical implementation of hover and trajectory tracking control algorithms, and (3) the development of synchronous, swarming demonstrations of physical analogies, using nano quadrotors as visualization nodes.

To achieve the objectives of the project, required subsystems were researched, implemented, and tested. The quadrotor chosen was the Crazyflie 2.1 system. Drone localization was achieved through the installation of a Vicon motion capture system. A custom software architecture was developed using a hard fork of the Crazyflie ROS distribution by the University of Southern California [9].

Mathematical modeling, simulation, and physical implementation of hover and trajectory tracking control algorithms were completed. The quadrotor's dynamics were explored and formed into a computationally efficient linear state-space model. A simulation with an animated component was created that mimicked the behavior of the physical system. Controllers were formulated in the simulated environment that dictated stable hover and trajectory tracking flight maneuvers. A methodology and data-structure was established for computing trajectories. Physical flight tests were conducted that validated the simulation results.

Lastly, demonstrations for swarming, synchronous motion were developed, tested, and filmed. The demonstrations employ the drones as visualization nodes for physical phenomena such as standing waves, planetary motion, and bird migratory flight patterns. The presented work will serve as a robust foundation for future student research at The Cooper Union.