A Fully Autonomous Heterogeneous Drone Swarm for Collaborative Target Pursuit

Wang, Michelle (School: Carbondale Community High School)

This project developed a leader-wingman drone swarm that can autonomously detect and track objects of interest (OOI). The leader drone is a custom-built X500 quadcopter equipped with a Jetson Xavier NX GPU and a visual/depth camera. The wingman drones are low-cost off-the-shelf TELLO mini drones. Python programs were developed to carry out the essential tasks required in the swarm operation, including image capture and preprocessing, object detection, object distance estimation, PID-based navigation control, and communication and video streaming between the leader and wingman drones. All the developed programs are executed on the leader drone’s onboard GPU. The leader and wingman drones communicate via Wi-Fi. Docker containers and port forwarding are utilized to avoid IP conflicts among wingman drones. This project also trained a YOLOv4-tiny convolutional neural network for detecting wingman drones and stop signs (OOI in this project). A novel method was developed to synthesize diverse wingman drone datasets for YOLOv4-tiny training, which improved the network accuracy by up to 4%. In addition, a novel adaptive confidence thresholding method was developed that further increased the network accuracy by 3%, reaching an overall detection accuracy of 88%. The project also investigated how the system performance is affected by the number of wingman drones. With one wingman connected, the developed swarm achieves 25.4 frames per second image processing throughput and 0.1427-second control latency. Finally, the swarm's autonomous operation was successfully demonstrated in outdoor flights.

Awards Won:
Fourth Award of $500
Air Force Research Laboratory on behalf of the United States Air Force: Glass trophy and USAF medal for each recipient
Air Force Research Laboratory on behalf of the United States Air Force: First Award of $750 in each Regeneron ISEF Category, FOR 2023 ONLY: EBED WILL HAVE TWO