Multiple UAV Coordination

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Introduction

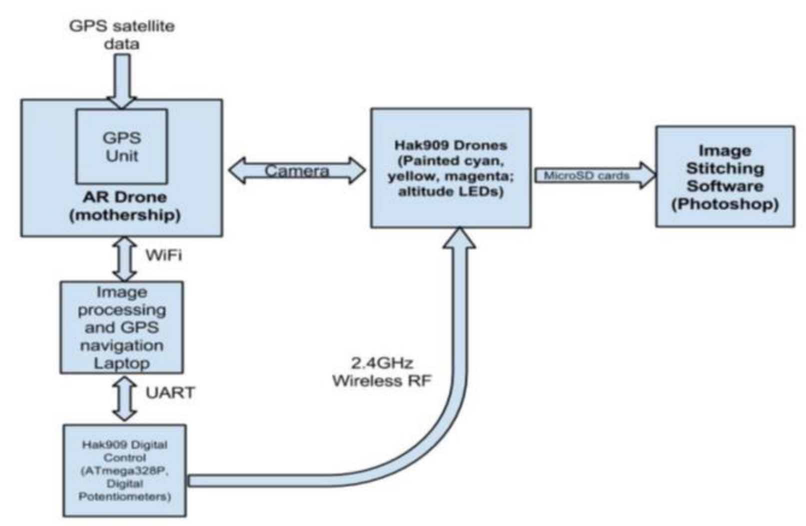
The goal of this project is to create an overhead image map of the Bradley University Alumni Quad using multiple autonomous unmanned aerial vehicles (UAVs). As evidenced by patents, research, and prior work in this field, it is clear that global attention has been placed on the use of such UAVs or drones for accomplishing military, commercial, and research tasks. This emerging technology offers gains in efficiency to these sectors that were previously unavailable. The following proposal identifies constraints and design considerations, considers economic feasibility, societal impacts, provides a timeline for project completion, and makes a case in support of the financial support of this project.

AR Drone 2.0: Mothership

By using a combination of a single higher- cost drone –equipped with GPS guidance for navigation and image processing techniques for obstacle avoidance – with lower-cost drones set to follow the leader and maintain a flocking formation amongst each other, this project can cheaply accomplish such aerial tasks as surveying a specified region of land, among other potential areas of development. Furthermore, current research indicates that the coordination of multiple slave drones with the implementation of a flocking algorithm is possible. Impacts of this project include increased data on the health of crops, increased safety for first responders, military, and police, and quicker problem solving for fire fighters and first responders.

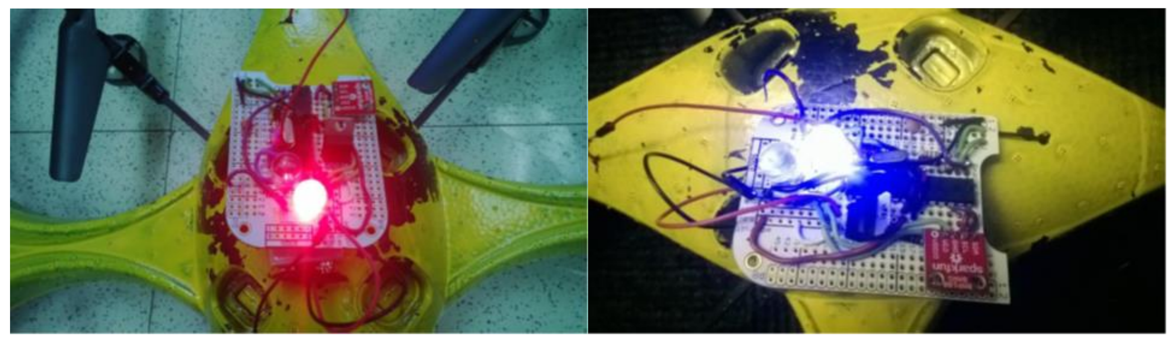
Hak 909: Color Coded Slave Drones

Methods

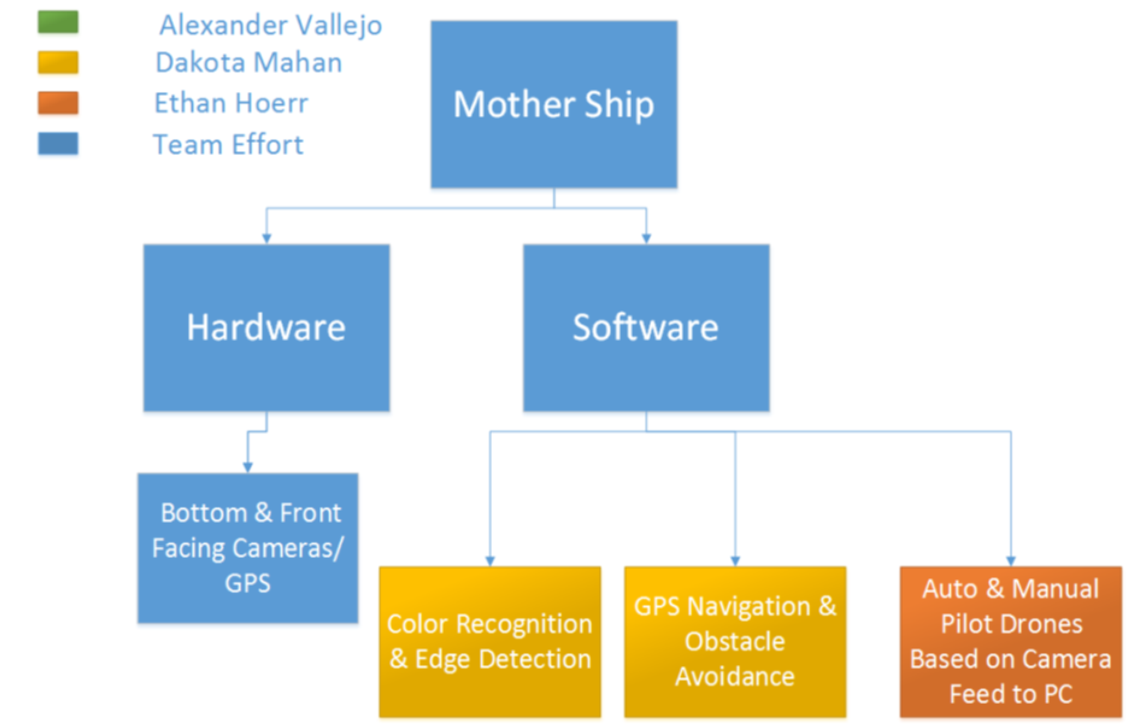


FlowChart: Design Overview

In order to achieve multiple UAV coordination, we designated one quadcopter as the primary leader drone, and assigned several quadcopters to serve as the secondary follower drones. For the primary leader drone, we used a Parrot AR Drone 2.0, shown in Fig. X, which is equipped with: GPS navigation capabilities for autonomously navigating a specified area; front-facing camera for obstacle avoidance; downward-facing camera for slave drone detection; WiFi communication for transmitting data to the remote brain computer. We used three Haktoys Hak909 quadcopters, shown in Fig. Y, as secondary slave drones, using bright spray paint to clearly differentiate between each drone. These drones feature a maximum payload capacity sufficient for carrying the camera and barometer detection circuits, as well as a remote control which can be reverse-engineered to received digital control signals from the remote brain computer. The leader drone will navigate the specified region autonomously based off of predefined coordinates sent to the GPS unit. During flight, the downward-facing camera continuously streams images of the slave drones to the remote brain computer. Using color and blob detection, the computer detects whether the slave drones are within formation, and sends command signals to each slave in order to maintain parallel formation. Each follower drone is also equipped with an altitude-sensing circuit which changes the color of a status LED if the drone is too high or too low. The slave drones are equipped with downward-facing 808 cameras set to a fixed-interval timer to capture images of the region below. Once the flight is complete, these images are transferred from the MicroSD cards and merged into one composite image in Photoshop.



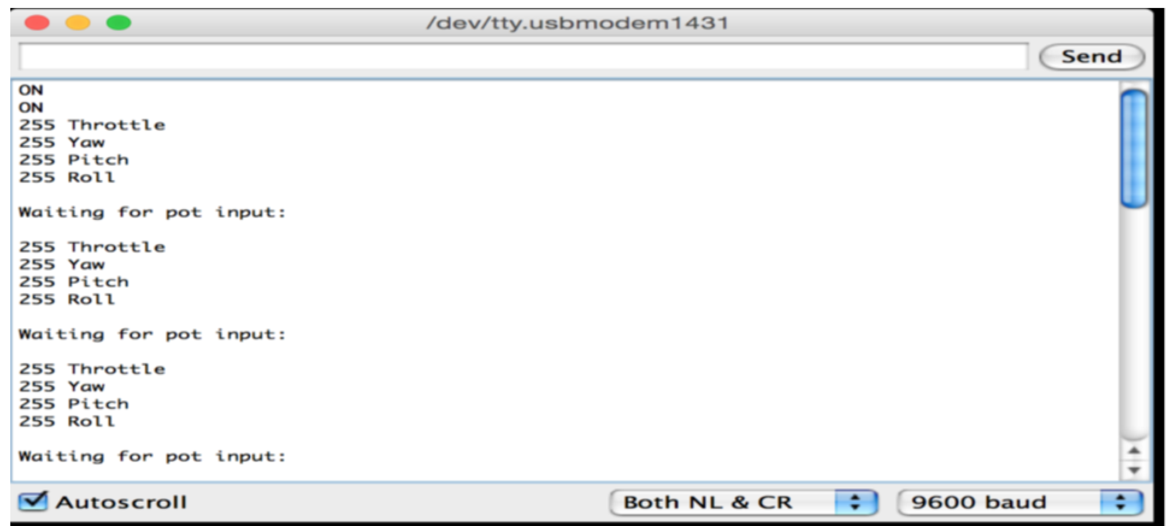
Altitude Sensing: Below 15 Feet(red) and Above 25 Feet(Blue)



System Block Diagram: Mothership

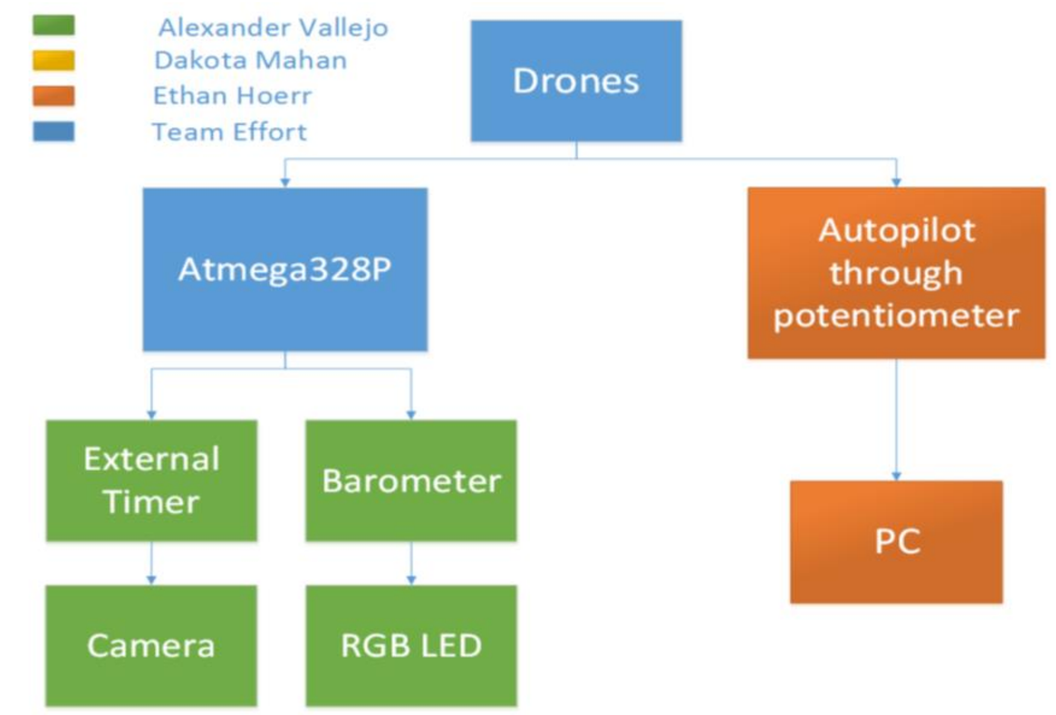
Results

Our testing of the additional hardware for the follower drones, as well as our image-stitching software, was successful. The altitude-sensing system installed on each Hak909 worked as planned. The system initializes on power up at ground level. The red and blue LED successfully indicated height in testing. We also verified the functionality of the timed-shutter camera system attached to each Hak909 by automatically taking a snapshot every 5 seconds. Using Photoshop, we were able to merge multiple snapshots taken by the camera system into a single composite image. From above, the downward-facing camera on the mothership drone was able to detect the cyan, magenta, and yellow follower drones separately from a distance of at least two meters. The front-facing camera was able to detect edges between 1-10 meters. We were able to test that the mothership drone could receive a GPS signal with a range of accuracy of approximately six meters.



Controls: Serial Data from Potentiometers

The mothership drone was also capable of receiving accurate heading or compass data within 5% error. The digital controller subsystem showed promising results. We were able to send throttle and yaw control signals to the Hak909 quadcopter with this microcontroller system, proving that this control method was valid. Furthermore, because the Hak909 quadcopters needed control signals from the remote brain computer, we verified that the digital controller could receive command signals via serial communication by using a software serial monitor on the test computer. Finally, we tested the kill switch requirement by power cycling the modified controller, which cancelled any flight commands the Hak909 was following.



System Block Diagram: Follower Drones

Conclusions and Future Work

To successfully create a parallel image map, numerous subsystems inside the Multiple Unmanned Autonomous Vehicle system needed to interface. These subsystems included altitude sensing, an autonomous camera circuit, a process for image stitching, a drone control scheme, GPS navigation, and obstacle avoidance.

Photos from 808 Camera: Stitched Images

Communication between the AR Drone 2.0 mothership and the Hak909 follower UAVs was achieved using image processing and color detection. The mothership drone gathered position data from the follower drones using color detection of and the altitude-detection status LEDs. The mothership program communicates control signals via a serial communication protocol to each of the follower drones. The digital control subsystem makes use of digital potentiometers to alter throttle, yaw, pitch, and roll parameters of the radio controllers for each of the follower drones. The camera circuit subsystem automatically took pictures of the terrain below at a fixed interval. Images retrieved from these cameras' MicroSD cards were merged using image-stitching software, creating a composite "map" image. We have laid the groundwork for further development of this project, including writing the software to take the data from the leader drone image processing and decide the direction of the follower UAVs. Once the mothership and follower drones are in the air, the project then would have the capability to create a parallel map using multiple UAVs.