Autonomous Follower Drone

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Project Goal

In our project, we focus on having an autonomous follower drone to follow a primary leader drone. The project would help improve military technology by exploring ways for a single drone to communicate or control multiple autonomous drones.

Background

Drones are currently used in military surveillance. Although drones are a useful piece of technology, there is a need for better drone coordination; drone coordination still has room for improvement, which will greatly improve surveillance operations.

Implementation

Computations to obtain desired heading:

$$\theta = \mathrm{atan2}(\sin \Delta\lambda \cdot \cos \varphi_2 ,\ \cos \varphi_1 \cdot \sin \varphi_2 - \sin \varphi_1 \cdot \cos \varphi_2 \cdot \cos \Delta\lambda)$$

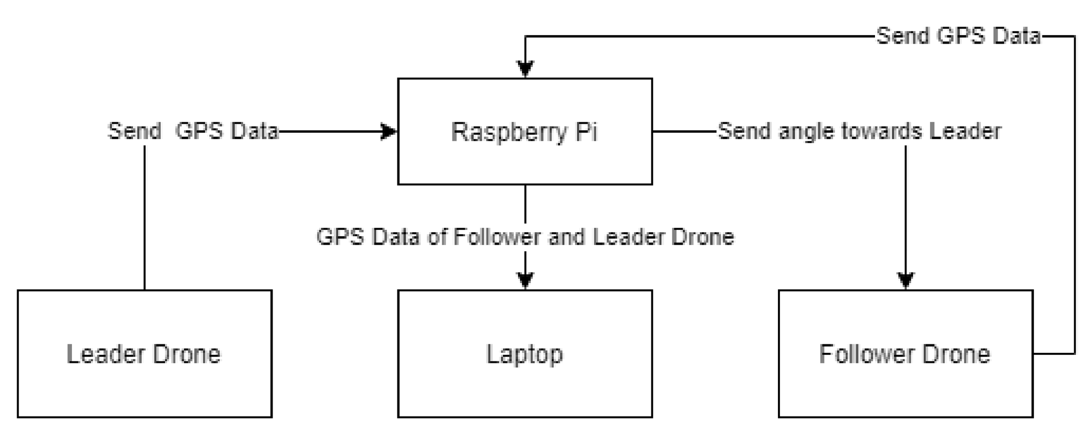
- φ_1,λ_1 is the starting point
- φ_2,λ_2 is the end point
- $\Delta\lambda$ is the difference in longitude

We enabled and calibrated the drone's magnetometer then obtained the drone's magnetic heading as well as current coordinates. Next, we calculate the desired heading which is the direction of the leader drone relative to the follower drone. The drone then rotates until it achieves the desired heading and then flies forward. The drone also increases its elevation until it is within a certain threshold of the leader drone.

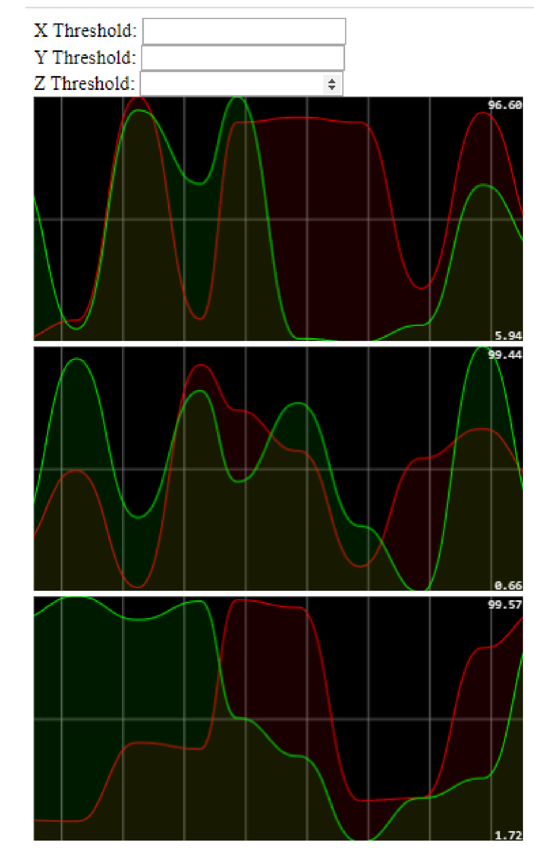
Drone connection and other computations will be established through the Raspberry Pi. The Leader drone will have the Raspberry Pi attached, which connects the autonomous follower drone, and base station. The Raspberry Pi will collect GPS coordinates of the Leader drone and perform the computation needed to alter the flight path of the follower drone.

Results

The Follower drone calculates the direction of the Leader drone; after calculating the angle at which it needs to turn, the Follower drone will calibrate its GPS location, and begin spinning. The Follower drone spins until it faces the Leader drone, at which it begins moving forward until it reaches a threshold distance from the Leader drone. There is a slight inaccuracy of the calculated angle, as the Follower drone's GPS module has some conflicting data when compared to the Leader drone's GPS data. With this inaccuracy, however, the drone is still capable of flying towards the Leader drone and maintain a set distance. .

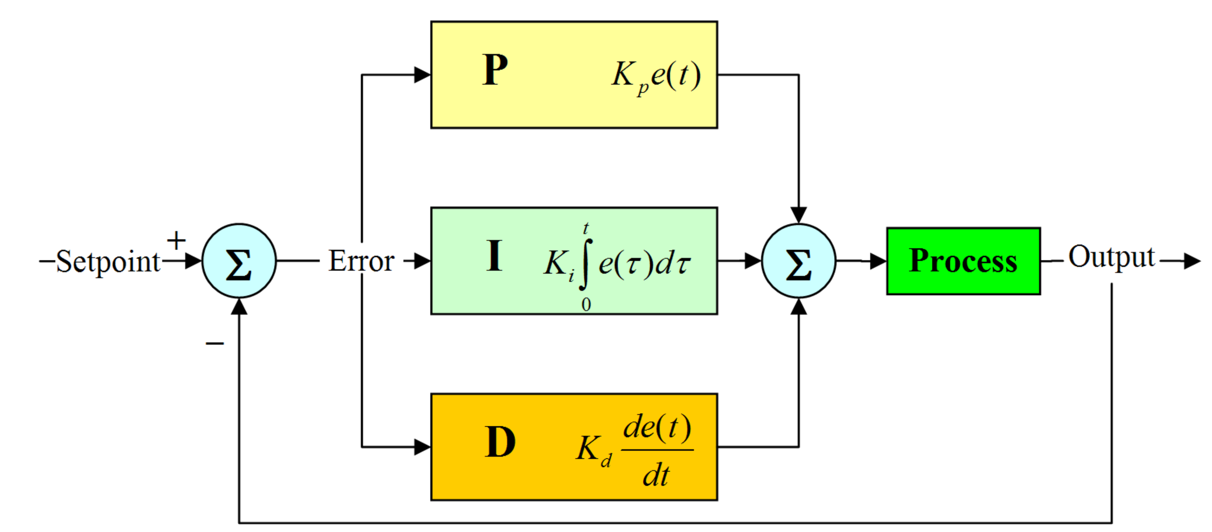


Implementation (cont.)



The GUI has been implemented with Express, HTML, Javascript, and Smoothie.js. The user can change the threshold difference between the follower drone and the leader drone. Real-time graphs are created so that both of the GPS locations of the leader drone and the follower drone are displayed; each graph represents the latitude, longitude, and elevation of each drone.

We have implemented PID controllers for drone movement. PID stands for proportional, integral and derivative. The controllers will continuously calculate the error by subtracting the set value with the actual value and its job is to reduce the error to be close to zero. This allows the drone to fly autonomously and to match the distance thresholds as close as possible.



Improvements

Object Detection

Object detection would be a good improvement, as it will allow the drone to move out of the way of obstacles. Currently, the drone cannot detect these obstacles and could cause a collision.

Fine Tuning of PID Controller

The drone could have a smoother form of movement. Currently, the drone must first spin and then fly straight. It would be an improvement if the drone could turn and move at the same time.

References

1 P. Bouman, et al. Dynamic Programming Approaches for the Traveling Salesman Problem with Drone. Networks, vol. 72, no. 4, 2018, pp. 528–542.
2 L. Mottola et al. Team-Level Programming of Drone Sensor Networks. Proceedings of the 12th ACM Conference on Embedded Network Sensor Systems - SenSys '14, 2014.

Future Research

Object detection through a camera attached to the drone will allow the drone to avoid obstacles while flying towards the GPS coordinates of the leader.
The drone's ability to autonomously return back to the base station will also be implemented. The drone will either backtrack using previous GPS coordinates, or calculate the shortest distance and fly straight to the base station.

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