Kalman Filtering IMU and LiDAR Data to Accurately Estimate Drone Position

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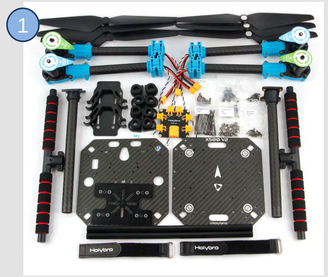
Purpose

To accurately estimate the location and heading of drones through Inertial Measurement Units (IMUs) and Light Detection and Ranging (LiDAR) data, with noise reduction by a Kalman Filter, to be used in situations with unreliable GPS and noncooperative targets

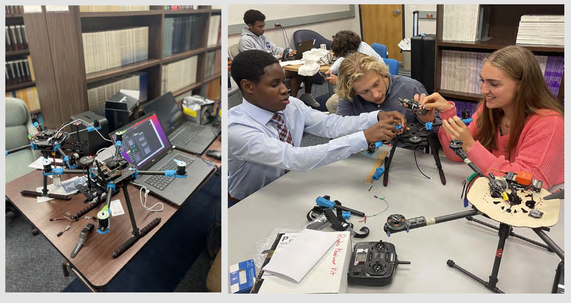
Materials & Software

1. Holybro X500 V2 Development Kit (with GPS, SiK Telemetry, ESC power distribution board)
2. LiDAR A1M8
3. Herelink
4. Radiolink
5. Radio Master
6. QGroundControl



Drone Assembly and Obstacles

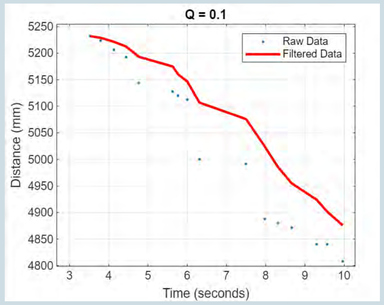
- All three of the kits required drilling bolt holes because the baseplates had manufacturing defects
- Major issues arose with getting power to the hardware, as each team required different voltage inputs
- Two teams used the Sik telemetry unit, while one team used the Herelink system
- The drone's center of mass also needed to be adjusted for stable flight

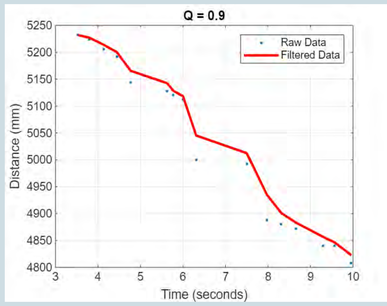


Kalman Filter

The Kalman Filter is a method of location prediction and estimation through a type of moving (recursive) average with a weighted, low-pass filter

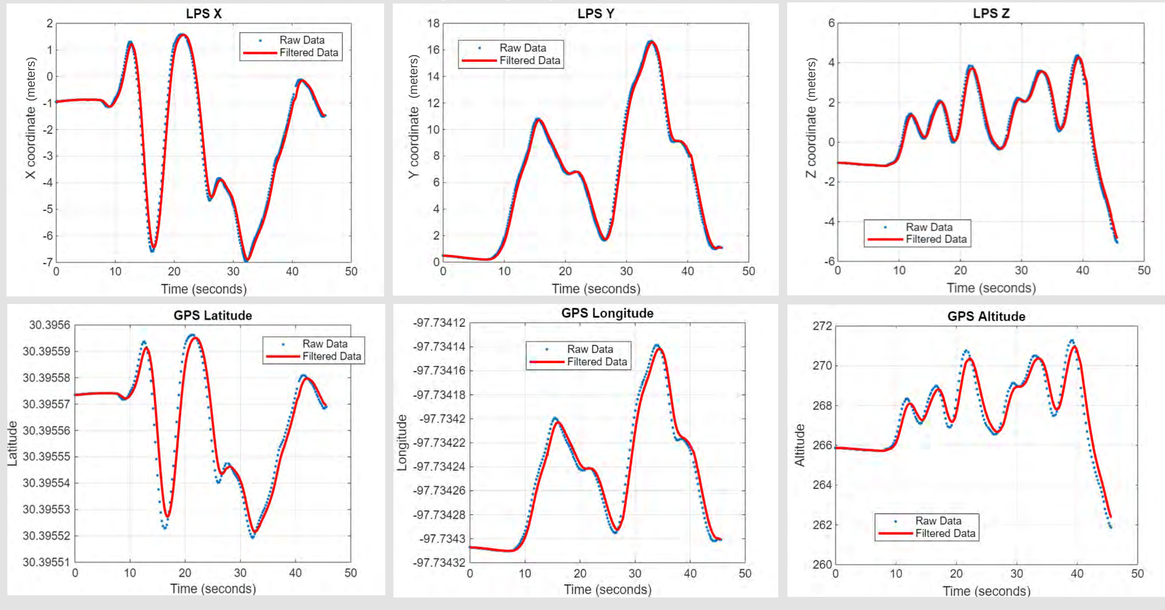
- Used to graph and estimate LiDAR data and the position of a drone's flight path in 3 planes (x-y-z with Local Positioning and latitude-longitude-altitude with Global Positioning)
- Reduced noise and gaps in the data by using previous data to make an accurate estimation





Graphs of LiDAR data filtered through the Kalman Filter with different Q values (Q represents the noise covariance variable)

Kalman Filtered Comparison of Local Positioning (LPS) vs Global Positioning System (GPS) in 3 Dimensions



Previous & Future Studies

We would like to thank UT Austin's Drone Estimation Lab for their research, help, and foundation in beginning this project

In the future, we want to improve the position estimate by fusing multiple data sources and evaluating using an Extended Kalman Filter

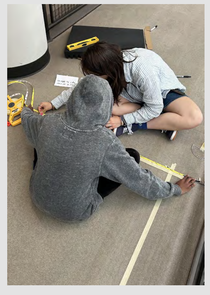
Testing

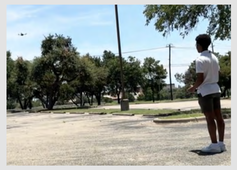
LiDAR

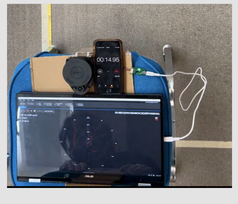
- Set up a track with known measurements and an object at the end
- Mounted the LiDAR on a chair for easy movement to and from the object
- Recorded both the direct LiDAR data and the actual position

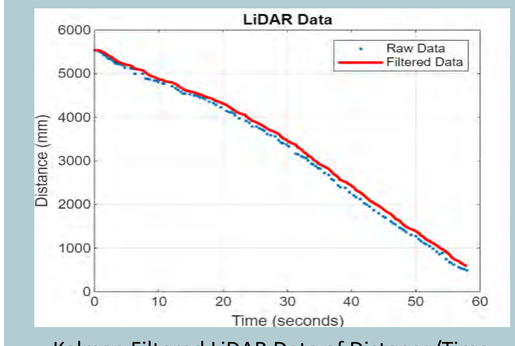
IMU & GPS

- Recorded onboard IMU and GPS data
- Drone flew outside with few obstacles and clear GPS signal









Kalman Filtered LiDAR Data of Distance/Time

Results

- Assembled 3 drones and achieved stable flight with 1 using the Radio Master Controller

Using a Kalman Filter we:

- Successfully increased the accuracy of our position estimation
- 3D modeled an accurate flight path of the drone
- Reduced the noise in IMU/GPS data by 24%
- Smoothed the overall LiDAR data and decreased the overall estimation error by ~50%