UAS Flight Encounters at the DFW/Alaska Airport, It’s Message Report Frequencies and Outlier Detection

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Abstract

One of the most recent problems in Unmanned Aircraft Systems (UAS) today, is message dropout. This occurs when a receiver fails to collect messages over a certain period. These messages typically contain important positional information such as altitude, longitude, and the attitude of the aircraft. In this study, we develop a statistical framework for identifying an upper bound for acceptable time delays between consecutive GPS messages. If we receive time delays greater than this upper bound, we consider that to be an instance of message dropout.

Methodology

Any time delay greater than the mean time delay (Δt) plus the root-mean-square-error (ΔRMSE) of the time delay multiplied by a constant k=2 would be defined as a statistical outlier.

\[ \text{Outlier}_k = \Delta t + k \times \Delta \text{RMSE} \]

\[ \Delta \text{RMSE} = \sqrt{\frac{1}{k} \sum (\Delta t_i - \bar{\Delta t})^2} \]

For both the DFW and Alaska data sets we have received, we primarily looked at the Mavic Air 2 drone. The messages within each of these data sets allowed us to perform statistical analysis with information regarding the time delay between consecutive messages with these flights. Using built in libraries in python, we gathered mean, median, and mode statistics that give us general areas within the flights where dropouts could be occurring.

Results and Discussion

Figure 1 shows that all flight durations did not exceed 30 minutes, with an average flight time nearing around 16 min. The average maximum altitude was near 375 ft, and a typical time delay after outlier removal was approximately 3.5 seconds. The average upper bound for determining dropout instances was near 6.25 seconds for the flights analyzed. The mode and median time intervals were relatively consistent at 4 seconds. This data was gathered from P4 Series, Mavic Mini 2, Mavic Air 2, M300 RTK, Mavic 2, Mavic Mini, and FPV Drones.

Results and Discussions Cont.

Figures 3 and 4 show the mean time delay gathered, as well as the average number of messages reported within each rolling mean time interval tested. The data we received for the Alaska Mavic Air 2 flights, had time delays as little as 100 milliseconds, while DFW Mavic Air 2 flights had delays between 2 seconds to 15 seconds per message. Therefore, the mean calculations are much more precise in the Alaska set comparatively to the DFW set. We can see for both sets, however; as the minute interval increases, the mean time delay typically decreases slightly.

Conclusions/Future Work

With the data and calculations gathered, we now have a better way to locate where dropouts would most likely be occurring. Being able to break down each flight by the minute, gives us a more in-depth analysis of each flight, so we can see where these dropouts could be occurring. In order to take this research further, we would need to require more data sets with these similar drones, to compare and see which drones are most susceptible to message dropout. If we can receive data with smaller differences between each time delay, this would allow us to obtain more accurate and precise results on where dropout would be occurring.

References


Acknowledgements

Words cannot express my gratitude to my professor for taking me on this team and guiding me through such groundbreaking research. I must also thank my team from the DECS Lab for all the collaborative support and willingness to answer any questions I had along the way. I am truly grateful to have had the opportunity to gain hands on experience with much different projects within the lab, and to work alongside such great people.

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