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Off-line parameter estimation for unmanned aerial vehicles after loss of control

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Abstract

Unmanned aerial vehicle (UAV) accidents are more prevalent than those in manned aircraft; however, not much work has been done in investigating these accidents. There is a need for the development of an inexpensive accident analysis tool that can be used to estimate UAV parameters before and after loss of control. A MATLAB/Simulink model of NASA's fixed-wing generic transport model (GTM) UAV was used to simulate loss of control and produce sensor data. The unscented and cubature Kalman filters were employed to estimate UAV kinematic and aerodynamic parameters before and after loss of control. Both these non-linear identification techniques adequately reconstructed the flight path of a UAV experiencing loss of control induced by control surface failure and experiencing sensor malfunction. Monte Carlo runs, root mean square errors and hypothesis testing at 5% level of significance revealed that the unscented Kalman filter (UKF) outperformed the cubature Kalman filter (CKF) in tracking the flight path of a UAV experiencing control surface hard-over, jam and float, as well as excessive sensor noise and sensor bias. The cubature Kalman filter however, had better performance under sensor blackout. Both the UKF and CKF successfully predicted all the aerodynamic force and moment coefficients and a majority of control surface deflections behind the loss of control or upset simulated in the MATLAB model. It was concluded that a combination of the flight path reconstruction results, predicted aerodynamic coefficients and estimated control surface inputs can be used to give insights into the reasons behind loss of control. It was determined that the UKF exhibits superior performance when compared to the CKF in systems experiencing excessive noise and highly non-linear environments. Unlike the CKF, the stability of the UKF decreased in situations where there were missing state data, which was the case in sensor blackout. The overall performance of the UKF and CKF was satisfactory, these parameter estimation techniques can be used in accident analysis.