Attitude Estimation of Quadrotor UAV

Extended Kalman Filter Implemented with Multiplicative Quaternion Method

Andrew Tortolano – 2048454t
MSc Aerospace Systems

Attitude estimation is of vital importance in many applications such as space missions, missile guidance and aircraft flight. Determining the attitude of a quadrotor UAV is particularly important due to the many applications it can be used in. Without accurate attitude information, mission objectives can be severely compromised.

The Extended Kalman Filter fused measurements from the gyroscopes and the magnetometers. The estimated output from the Filter was given by:

The Pololu MiniIMU-9 v2 was used as a sensor on the UAV to provide measurements on its orientation. This was an inertial measurement unit that consisted of an L3GD20 3-axis gyroscope and an LSM303DLHC 3-axis accelerometer. It also had a 3-axis magnetometer to provide attitude measurements. This data was read from the sensors into an Arduino Uno so that the data could be processed in MATLAB.

The attitude of the UAV was defined relative to an inertial reference frame. For the simulation, an attitude matrix mapped the reference frame to the UAV body frame:

The quaternion method was used to represent the attitude of the UAV. This method is very widely used due to the fact that it has no singularity and it is computationally less intense compared to the Euler angles.

The estimated quaternion very closely matched that of the true quaternion. The magnitude of the error is of $10^{-10}$.

The gyroscope bias estimate had an initial value of zero and for the first second, the error diverged before it converged back towards zero fairly rapidly. At the point when the error is at its highest, its magnitude is $30^{-5}$ deg/hour, which is very small so the Extended Kalman filter provides estimates of the bias extremely well.

Successful simulations were carried out that represented the performance of the Pololu MiniIMU-9 v2 to accurately estimate the attitude of the UAV. The simulation results proved that this method was a very effective way of estimating the attitude of a quadrotor UAV. It was done to a very high degree of accuracy, while at the same time did not have a high computational burden so could have the ability to be implemented in real time.

Conclusion