Kalman Filter for SunSat

Why and How?

Rory Haggart

December 2020

1 Introduction

The SunSat avionics includes a dedicated subsystem for parachute deployment and attitude determination activities. Each of these two distinct tasks require some sort of state estimation based on the inputs from sensors during flight. This iteration of the Nova platform is using a passive parachute deployment system, but future iterations may use an active system. Active deployment should be triggered at the point of apogee in the flight, and for this to happen, sensor data needs to be processed appropriately such that the point of apogee can be detected in real-time.

2 What is a Kalman Filter?

To estimate the states of a system, we would ideally use a huge suite of sensors to log every possible output over the period of interest. However, this is obviously a very complex, expensive, and sometimes impossible task. Instead, we want to be able to measure certain states of the vehicle by processing the data from existing, low-cost sensors. For example, we want to know the velocity of the satellite. We want to know velocity because we can then use the point of $u_z = 0$ to be the point of apogee (the vertical (z-axis) velocity is zero at the maximum height). However, we don't really have any practical means of directly measuring this.

- We can't use a rotary speed sensor - as used in cars - as we don't have any rotational motion that we can measure and translate into linear velocity
- We can't use a pitot tube - as used by aircraft - as we are enclosed in the rocket's payload section and so wind speed is not measurable.

We can, however, use an accelerometer. Acceleration is the first time derivative of velocity, and therefore, velocity is the integral of acceleration over

the interval $[0, t]$.

$$a = \frac{du}{dt} \tag{2.1}$$

$$u = \int_0^t a \mathrm{d}t \tag{2.2}$$

And so if we want to measure the velocity of our satellite, surely we can just integrate the output from out accelerometer in the z-direction?

3 Why should we use one?

4 Kalman Filter as a part of the parachute deployment activities