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REVISITING THE FILTERING PROBLEM

Abstract

Consider a space object in orbit about the earth and suppose a sequence of angles only measurements is available at known times. The objective of the filtering problem is to successively update the predicted distribution of the state of the orbiting object. Each overall step of the filtering algorithm includes two parts: a propagation step and an update step. These tasks are simplest if the distribution of the propagated state vector and the measurement can be described in terms of Gaussian distributions, so that a variant of the classic Kalman filter can be used. It is well-known that ECI coordinates are unsuited for this purpose since the distribution of propagated position vector can have a pronounced banana shape (and hence is non-Gaussian) for large propagation times. A better coordinate system is given by equinoctial coordinates, which perform well in many (but not all) circumstances. Equinoctial coordinates depend on a “reference plane”, typically taken to be the equatorial plane.

In this paper, we explore the use of a recently developed new set of coordinates called “Adapted STtructural (AST)” coordinates. They are essentially a “local” or adapted version of equinoctical coordinates. The main difference from equinoctial coordinates is that the reference plane is now taken to be the orbital plane of the current best estimate of the state. There are also a few other differences between AST and equinoctial coordinates.

One of the benefits of AST coordinates is that a version of an extended Kalman filter (EKF) can be developed to simplify the update step, in contrast to the more typically used update based on the unscented Kalman filter (UKF). In this paper, we give a detailed investigation of the AST-EKF algorithm. In particular, we show that in certain circumstances under high ellipticity and using AST coordinates, the EKF update step can outperform the more conventional UKF update step.