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REAL-TIME ADAPTIVE APOGEE PREDICTION FOR A SUBORBITAL STUDENT ROCKET

Abstract

Real-time prediction of apogee for small suborbital launch vehicles is an enabling technology for student rocketry teams entering competitions including EuRoC, Spaceport America Cup, and Mach-X. Most existing methods for apogee prediction rely heavily on accurate modelling and trajectory simulation software. These methods are unable to be performed in real-time and apogee control is instead achieved by following a predefined flight path consisting of way-points. These methods struggle to compensate for large variations in rocket flight characteristics. This paper presents a novel method for the real-time prediction of apogee, independent of predefined rocket characteristics using an adaptive estimation algorithm. A Kalman filter is used to generate estimates of the rocket's kinematics which are then used to dynamically characterise the rocket's flight parameters. The flight parameters are then used to predict the time and altitude at which the rocket will reach apogee. An estimate for the uncertainty is also derived using sample particles which are propagated through the prediction algorithm, providing estimates for the undershoot and overshoot of the apogee prediction based on the posterior distribution of the estimator states. The presented approach is demonstrated on previous flight data from GU Rocketry's ASTRA flight computer and simulations of upcoming launches, providing accurate apogee predictions throughout the coasting phase of flight. An implementation of the algorithm is provided and results from GU Rocketry's latest launch provides validation for the approach.