Paper ID: 18013
student

ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (2) (2)

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A RESIDUAL-BASED ADAPTIVE UNSCENTED KALMAN FILTER FOR MICROSATELLITES

Abstract

The role of microsatellites in space missions rapidly grows in this new space age because of low development time and cost. Due to the limited size, microsatellites usually have high level of integration which may generate unexpected noise or disturbance from working environments or other components. Therefore, maybe the statistical properties of system process noise and/or measurement noise are time-varying and unknown a priori. In some cases, the conventional Unscented Kalman Filter (UKF) produces large estimation errors and even diverges if incorrect process noise and measurement noise covariance matrices were used. This paper presents a method of Adaptive Unscented Kalman Filter (AUKF) in which the process noise and measurement noise covariance matrices are real-time updated in case that a monitoring system gives out a warning signal. The monitoring system consists of several statistical estimators which can be used to determine the mean and covariance of each attitude sensor output and a residual vector. The residual vector, a difference between model-predicted value and sensor measurement value, is calculated inside the UKF. In case the UKF normally works, the residual vector should be a form of Gaussian white noise with zero mean and fixed variance. In order to save power consumption and reduce the calculation cost, only when the statistical estimator of residual vector detects something unusual by comparing the mean and covariance values with dynamics thresholds. Then the warning signal is given out and other statistical estimators for each sensor output will be turned on. After that, the convention UKF also will be changed to AUKF form with real-time process noise and measurement noise covariance matrices updated from statistical estimators of each sensor. Numerical comparisons of the AUKF with the convention UKF are conducted and analyzed to show the advantage of the proposed method when satelliteswork with time varying and unknown a priori of process noise and measurement noise environments.