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FAULT DETECTION AND ISOLATION FOR SATELLITE USING THE IMM-UKF ALGORITHM

Abstract

Satellite attitude control system including sensors and actuators is a critical subsystem. The satellite system becomes complicated with system configuration and complex missions. The failure of the satellite system can result in serious problems during the satellite operation. For example, the scientific mission cannot succeed and it highly costs to recover the system failure. To deal with this, the robust fault detection and isolation algorithm is required. This paper studies the application of the interacting multiple model (IMM) and unscented Kalman filter (UKF) algorithms to state estimation in the presence of failure in the satellite system. Many researches have developed the FDI algorithms for several dynamic systems according to the demands for fault tolerance, reliability, and high safety. One of the most effective approaches for FDI is multiple-model (MM) estimation. In MM estimation, a bank of filters runs in parallel that operate independently. The output of each filter is used to detect the system fault. The MM estimation has drawbacks; it does not perform for the large structural or parametric changes including failure or damage. An IMM method was developed to overcome the problem of the MM estimation. The IMM estimation introduces the interaction among single-model-based filters, and therefore it leads to significantly improved performance. Thus, the IMM estimation has been widely applied for the detection and diagnosis of sensor and actuator failures, the design of active fault-tolerant control, and target tracking. The IMM estimation is efficient method of sensor and actuator FDI for the linear system. However, when applied to the nonlinear system, the IMM estimation can yield undesired state estimation and fault detection performance because of the prediction errors between the nonlinear and linearized equations. Therefore, the nonlinear approach such as the UKF is required. The UKF has the capability of capturing the posterior mean and covariance to the third order, and thus it is known that UKF can provide good results for the highly nonlinear system. In order to improve the performance of the IMM estimation, the IMM-UKF algorithm for the satellite system is proposed in this study. To verify the performance of the proposed algorithm, numerical simulations are performed. The performance of the IMM estimation is compared with the proposed IMM-UKF algorithm. Numerical results can show that the performance of IMM-UKF is more efficient than the IMM estimation. This result demonstrates that the IMM-UKF can provide the good performance for fault tolerant satellite attitude control system.