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FAULT DETECTION AND ISOLATION FOR A MULTI-ENGINE CLUSTER OF A REUSABLE LAUNCHER

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Résumé

Fault Detection and Isolation (FDI) systems gained more importance with the development of reusable launchers in the mid-2010s. These launchers are equipped with a multi-engine cluster to meet a wide range of thrust requirements. The redundancy provided by a propulsion cluster composed of multiple engines allows for more complex recovery strategies. These strategies require a complex and precise FDI system.

This thesis considers the development of a model-based FDI system for a multi-engine propulsion cluster capable of detecting and isolating sensor and actuator faults. A model of a propulsion cluster composed of three identical Liquid-Propellant Rocket Engines (LPRE) is developed. The main components of the cluster are the propellant tank, the feeding lines, and the LPREs. To detect and localize leakages in the feeding lines, the performance of three observer schemes—based on the Luenberger Observer, Unknown Input Observer (UIO), and High-gain Observer (HGO)—is compared using Monte Carlo simulations.

To detect and isolate sensor and actuator faults across all components of the cluster (tank, feeding lines, and LPREs), structural analysis is used. First, the structural model is obtained using the analytical model of the cluster. The structural model is then used to determine the possibility of FDI under different measurement scenarios and to compute residual generator candidates. An intractably large number of candidates are obtained, and a residual selection algorithm is proposed to construct subsets of residual generators capable of detecting and isolating all faults with minimal cardinality. Hundreds of subsets with the same minimal cardinality are obtained, and a method to numerically analyze the residual signal of each candidate is presented. Based on the numerical sensitivity of the residuals that form a subset, a Subset Sensitivity Index (SSI) is obtained. The subsets with the highest

SSI should thus be more sensitive to faults and provide the best FDI performance. Monte Carlo simulations are performed to analyze the correlation between the SSI and the fault detection and isolation rates.

Mots clés

Model-based fault detection and isolation; Multi-engine cluster; Structural analysis; Residual Selection