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INDIVIDUAL FAULT DETECTION AND ISOLATION SYSTEM FOR CUBESATS USING NEURAL NETWORKS AND MULTIMODEL ALGORITHMS

Abstract

Maturing space technologies and the desire to create more difficult and ambitious missions lead to a significant increase of complexity in designing space vehicles, even for micro/nanosatellites. Among them, the *Fault Detection and Isolation System* (FDI) plays an important role in monitoring the integrity of all components of the satellite. Due to the limited processing capabilities of the on board processor of small size satellites, the choice of an effective procedure able to distinguish between a real failure and the inherent disturbances is very important. The paper aims to develop a robust FDI algorithm that detects any error occurring in each of the primary systems of a 1U CUBESAT and moreover identifies the exact location of the error (Example: ADCS system x-axis reaction wheel) and assign it to a possible fault scenario.

This research paper is organised as follows: the first section presents an introduction in which the common solutions for FDI CUBESATS subsystems are briefly presented. The second section describes the selected approaches throughout a succinct comparison between the two methods considered: a deterministic *MULTIMODEL METHOD* and a method based on *NEURAL NETWORKS*. The performances of the two FDI algorithms are analysed and compared considering actuators and sensors failures and malfunctions in the presence of disturbances acting on the satellite motion. The conclusion of this comparative analysis is that a FDI based on NEURAL NETWORKS can be successfully used as a redundant method. The third section presents the main contribution of the paper: *the development of a complex FDI system for an entire nanosatellite, using the MULTIMODEL METHOD* which revealed a better precision and a much more rapid response than the NEURAL NETWORKS approach. The method consists of creating a series of fault scenarios that can occur during the mission. Based on these scenarios, corresponding models for the MULTIMODEL architecture are determined. The fault is detected and isolated by comparing the measurement with the model outputs.

The last part of the paper presents experimental results concerning the faulty behaviour of the CUBESAT in various situations. These results are analysed both from the point of view of the success rate of fault detection and from the computational effort of the satellite processor. The conclusions regarding this case study emphasize that the proposed MULTIMODEL method can be an effective solution for CUBESAT subsystems mainly due to its robustness and simplicity.