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PREDICTIVE MAINTENANCE AS ENHANCEMENT OF FAULT DETECTION, ISOLATION AND RECOVERY STRATEGIES OF SPACECRAFT

Abstract

Fault detection and diagnosis is a crucial part within the spacecraft system, its on-board software and operations. High-level fault detection, isolation and recovery (FDIR) strategies ensure reliability and availability of the spacecraft's services and safety as well as the overall mission success, while monitoring the status of all subsystems and equipment and ensuring a timely reaction towards faults and failures. Traditional FDIR systems trigger warnings or even safe modes when predefined thresholds or expected values are violated. The spacecraft itself depends heavily on intervention from ground to resolve those safe modes leading to service outages or loss of scientific data.

The novel approach of predictive maintenance (PM) by Industry 4.0 is investigated in this study, as a concept to advance the current FDIR strategies. The main advantage of this methodology is the capability to predict faults and system degradation before severe failures occur.
Predictive maintenance is a novel paradigm which has been explored in terrestrial applications, e.g. the maintenance of production lines or of different machine equipment and tools, for some time now. Traditional machine learning approaches like decision trees or support vector machines but also the currently arising deep learning methods like auto-encoders, convolutional neural networks or deep belief networks show promising results in fault diagnosis and predicting system statuses in uncertain environments based on sensor data.

The advantage of this approach is the capability to predict failures, malfunctions and component degradation well in advance before safe modes and service outages occur. Thus, to react early to possible failures with respect to the system status and its on-going activities, will benefit the spacecraft's operational lifetime, its service availabilities and the necessity of ground interventions.

This paper serves as a survey to implement the predictive maintenance approach of fault prognostics based on artificial intelligence and machine learning into the fault detection and diagnosis system of spacecraft. Moreover, a concept study of functions necessary for predictive fault detection and a process model thereof is presented.