IAF SPACE SYSTEMS SYMPOSIUM (D1)
Technologies to Enable Space Systems (3)

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PREDICT - PATTERN-BASED REAL-TIME MONITORING FOR FAULT DETECTION IN SPACE

Abstract

Due to their high complexity and the unforgiving environment they are operating in, spacecraft are vulnerable to mission-critical faults and failures. For prevention, spacecraft employ fault detection, isolation and recovery (FDIR) techniques to sense, identify the source of and recover from faults. Typically, spacecraft use rule-based paradigms for FDIR where telemetry values are monitored against specific logic statements such as static upper and lower limits. The development process of those rules includes identification of all possible faults that might occur and definition of their mitigating actions by systems engineers during all spacecraft design phases.

Our goal is to increase efficiency with better performance for spacecraft FDIR by using a spin-in: advanced machine learning methods from industry 4.0 predictive maintenance applications. The PREDiCT technology is used successfully in automotive manufacturing lines and packaging machines.

Compared to spacecraft, these applications have similar requirements like high availability of production lines which are highly complex systems with large number of parameters from sensors and actuators to be monitored. Transferring these software techniques cross-industry into the space domain thereby developing new space technology offers advantages in the future automation of spacecraft operations by using the knowledge gained about the system during the development process to support the operator on ground.

The key feature of PREDiCT is the real-time condition monitoring of all spacecraft parameters. Engineering of limit values for all the parameters will be obsolete because the algorithms do not learn from developers, but from the machine itself. The observed patterns in the data are compared to the ones of the nominal operating state, which are created on ground within a hardware-in-the-loop simulation and used as a reference. If there are deviations of parameters, the Out-of-confidence-algorithm computes their statistical relevance and inform the operator about the identified deviation, significant statistics and correlated patterns for further analysis. A deviation manifests earlier than the fault itself. Thus, appropriate actions can be taken by ground operators not only to recover from faults, but also to prevent faults from occurring or to reduce their impact.

PREDiCT is beneficial in any highly complex system with a high degree of automation and big data to be analysed for identifiying anomalies before they lead to catastrophic damages, significant power interruptions or loss of business functions. Examples are power plants, production lines, packaging machines, autonomous driving as well as smart city applications. The interdisciplinary cooperation enables these spin-offs into terrestrial applications.