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ARTIFICIAL INTELLIGENCE BASED FDIR TECHNIQUES SET GROUND FOR MORE AUTONOMOUS SPACE MISSIONS – SWOT ANALYSIS

Abstract

The combination of advancing technologies and the curiosity of human about space, makes the engineering endeavors more challenging day by day. Today, reliable decision-making algorithms, precise modelling knowledge, estimation-based filtering and fault tolerance capabilities set ground for more autonomy measures to be applied to the complex systems that not only operate on Earth orbit but also in far space.

Integrating "Automation" vs "Partial" or "Full Autonomy" may be an engineering decision for most of the human operated systems like cars, aircraft, or industrial robots. Nevertheless, autonomy is mandatory for the systems that work beyond the control limits of human. The deep space or interplanetary missions come up with a cliché trade-off problem to be solved on reliable systems: automation vs. autonomy.

Modern spacecraft are well modelled and designed highly tolerant to overcome most of the known issues for the Earth orbit. These systems are extreme examples of highly automatized missions. Like all complex systems, most of the spacecraft execute specific functions for on-board fault management. The ground operations center is highly aware of the housekeeping data and the crew control the spacecraft systems regularly.

Today's space missions are defined by increasing ambition which results in a contradiction between complexity and robustness. The demanding goals of the end users make the spacecraft design to become highly sophisticated. Moreover, deep space or inter-planetary missions have more challenging operational requirements.

To provide an up-to-date overview to the state-of-the-art artificial intelligence application for space systems, this paper provides a comprehensive literature survey on trends and recent advances of spacecraft Fault Detection Isolation and Recovery (FDIR) systems, and machine learning approaches that look most promising for fulfilling the maximized on-board autonomy.

The outlines of the on-board spacecraft autonomy are wrapped up in a SWOT analysis. This analysis correlates the main advantages and disadvantages and gives an overall look for the trade-off problem of the advanced FDIR solutions for space missions.