Paper ID: 59734
student

IAF SPACE OPERATIONS SYMPOSIUM (B6)
Virtual Presentations - IAF SPACE OPERATIONS SYMPOSIUM (VP)

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HOUSEKEEPING TELEMETRY ANALYSIS FOR SPACECRAFT HEALTH MONITORING AND PREDICTIVE DIAGNOSIS USING MACHINE LEARNING

Abstract

Complex systems in general and space systems in particular require constant attention and state analysis in order to keep track of, detect, and prevent situations that might potentially lead to off-nominal system states. A health monitoring system is thus required to predict target system behavior in order to provide realistic estimates of time left before the system may enter a non-nominal state. Number of telemetric parameters increases with system complexity and it becomes more important to automate the process of health monitoring. Current methods target only a subset of anomalies and often require costly expert knowledge. The simplest method of monitoring the system is to ensure that the values fall within acceptable ranges specified during the design phase. However, this approach can hardly be employed in larger systems because of sophisticated interactions between subsystems, which in many cases are not even formally described.

Health monitoring system of a spacecraft can be implemented onboard. However, in case of long-term complex missions, decision-making requires health prognosis and deeper spacecraft state analysis. Such long-term prognosis requires more computational power to process a lot of historical data as well as other information that may not be readily available on board. In this work, we use existing telemetry of various subsystems of a spacecraft, and adapt and extend machine learning methods (long short-term memory (LSTM) recurrent neural networks) to implement ground system for satellite health analysis and prognosis that addresses noisy non-stationary and possibly incomplete data.

We show the effectiveness of the proposed strategy on telemetry analysis of various subsystems, such as electrical power system and thermal control system of a large spacecraft. Finally, practical recommendations for safety control systems are presented.