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ARCHITECTURE OF MODERN DATAOPS PIPELINE FOR SPACECRAFT HEALTH MONITORING

Abstract

Data-driven methods are becoming more popular in spacecraft health monitoring for three main applications: anomaly detection, fault identification and residual life estimation. Eventually, the results of telemetry analysis affect operational decisions to cut technical risks and provide uninterrupted services. Although the number of housekeeping telemetry parameters that can be collected on board varies, the amount of generated housekeeping telemetry usually far exceeds available downlink bandwidth. Thus it can be beneficial to apply telemetry analysis onboard to provide better insight into satellite state.

Considering onboard health monitoring, classical thresholding methods are usually applied. However, there is a huge interest in academic and industrial communities towards applying data-driven methods due to their advanced abilities to provide insight or detect more complex faults, and low computational cost in comparison with physics-based simulations. Advanced data compression for transfer can be also achieved with autoencoders. The benefits of using ML and data-driven models come at cost of technical and operational difficulties of advanced data and model versioning, their management across satellite fleet; difficulties of deploying data-driven models, especially in case of onboard processing.

Emerging fields of DataOps and MLOps solve problems of collecting, storing and presenting the data, designing, training and deploying machine learning models in a structured way using a set of software applications and best practices. These fields include technical as well as organizational solutions to streamline data-related processes. In this work the authors present requirements for each stage of data processing for the case of space-bourne applications and follow with an example of emerging architecture for modern data analysis for spacecraft health monitoring. The authors discuss functions, requirements and implementation of each building block in data processing pipeline. Additionally, we consider on-board as well as ground-based data processing which is important in case of strong restrictions of downlink bitrate.

The authors demonstrate an implementation of MLOps pipeline for space applications on telemetry analysis of univercity-built cubesat project. Additionally, the authors provide considerations for scaling up the solution to be used for larger projects, such as large telecommunication constellations.