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ENHANCING SMALL SATELLITE MISSIONS WITH MODEL BASED TRANSMISSION REDUCTION

Abstract

The amount of science data that can be returned by interplanetary missions is generally constrained by the link budget between the spacecraft and Earth. This limitation, while present for spacecraft of all sizes is particularly problematic for small spacecraft (e.g., SmallSat and CubeSat class spacecraft) where spacecraft size severely limits power availability and antenna size (and thus gain).

Model-based transmission reduction (MBTR) is an AI-driven approach to reducing the level of data that is required to be transmitted via employing onboard processing to ascertain whether the collected data tends to add support for or provide support to refute a pre-determined or dynamically updated model. At the most basic level, MBTR suppresses transmission of data that is not judged to be highly relevant. Further reduction is accomplished by ascertaining the impact of the data on the model, updating the model and transmitting only samples of each class of data (data that is deemed to support the model, refute the model or not impact the model) for validation. This data is reviewed by mission controllers and scientists to ensure that the spacecraft's onboard control system is functioning correctly. If the validation is successful, correct operation is inferred and the updated (based on the collected data) model and corresponding Dempster-Shafer-based model confidence value can be trusted.

The onboard autonomous control system will seek out data, based on an expert system rule set, to attempt to validate/refute each element of the model. Once a suitable level of data has been collected (based on configurable threshold values), a Dempster-Shafer belief function will be used to assess the level of confidence in the element. Based on this evaluation (and configurable threshold confidence values), the model-element will either be deemed validated, refuted or ambiguous. If a final (validated or refuted) state is reached, the status (and the associated confidence level value) will be queued for transmission. If the state is deemed to be ambiguous, the control system will incorporate additional data collection for the element into the mission plan.

This paper presents a detailed description of the MBTR concept. It reviews the types of planetary science data that is commonly transmitted and presents an assessment of each type's suitability for use with MBTR. The level of science return possible given a fixed link budget (or link budget reduction) is evaluated for a variety of possible mission types, levels of initial model accuracy and data types.