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# NEURAL NETWORK BASED FAULT DETECTION IN CUBESAT TELEMETRY - A LUNAR EXPLORATION CASE STUDY

**Abstract**

Nanosatellite platforms such as CubeSats are increasingly being used for deep space exploration purposes, however CubeSat reliability has historically been low, which contradicts the high availability and reliability requirements of deep space missions. Improved CubeSat Fault Detection, Isolation and Recovery (FDIR) is required to address this, but FDIR systems are difficult to create from scratch and often require expert knowledge which is not always available to the developers of these platforms. This paper aims to demonstrate a novel, unsupervised machine learning based fault detection approach by applying it to the AOCS system of a 12U deep space CubeSat: the Lunar Meteoroid Impacts Observer (LUMIO) mission. LUMIO is currently undergoing its Phase B study with Politecnico di Milano (Italy) as Prime contractor, under funding from the European Space Agency (ESA). The result is an Autoencoder based neural network for detecting anomalies in telemetry, trained on the simulated telemetry of LUMIO AOCS maneuvers such as detumbling, slewing and lunar tracking.

The resulting algorithm shows high fault detection rates (FDR) of 80.9% on average, with low false alarm rates (FAR) for the same scenario averaging 10.5%. Additionally, training the system requires no expert knowledge of spacecraft dynamics or the AOCS algorithm. The Autoencoder shows little FDR and FAR performance drop when the number of neurons is reduced: 60% reduction in the number of neurons in the network results in an FDR drop of only 4.3 percentage points to 77.6% and a quasi-stable FAR, which increases by 0.5 percentage points to 11.0%. This shows the system can be scaled to be more suitable for deployment on CubeSat processors with little computational resources available. Further improvements planned include using signature matrices to correlate time series such as reaction wheel momentum and angular rates, and the validation of the network on real spacecraft telemetry, such as the available data from ESA's OPS-SAT spacecraft.