Synthesizing High-Fidelity, Multivariate Spacecraft Telemetry Data: A Comparative Study of Two Advanced Generative Models

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Abstract

In the defense and space context, original spacecraft telemetry data are frequently placed under strict regulations and safeguards, restricting the sharing of these datasets with internal and external partners. Additionally, these datasets are not representative of the entirety of anomalies that spacecraft could emit. In order to assist in the development of unsupervised anomaly detection models, as they pertain to monitoring spacecraft testing campaigns and early in-orbit behavior, the generation of synthetic telemetry anomalies has been identified as an area of interest and potential financial gain. In preparation for generating representative anomalies, the ability to generate synthetic, multivariate spacecraft telemetry data must be experimentally verified. Motivated by recent studies into time series generation (TSG) with Generative Adversarial Networks (GANs) and Variational Autoencoders (VAEs), this paper aims to synthesize high-fidelity, multivariate spacecraft telemetry data and provide a comparative study of DGAN, a PyTorch implementation of DoppelGANger (DG), and TimeVQVAE. Research indicates that this paper's comparative implementation of DGAN and TimeVQVAE to generate multivariate spacecraft telemetry is the first of its kind. Additionally, this paper evaluates the quality of the synthetic datasets using a comprehensive and holistic evaluation suite that comprises multiple metrics and visual assessments. The exploration lays the groundwork for the development of a pipeline for TSG in the context of the spacecraft industry.