ATHMoS: AUTOMATED TELEMETRY HEALTH MONITORING SYSTEM

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Introduction

Goal

Operational AI to monitor the satellite telemetry of all satellites operated by the German Space Operations Center (GSOC)

Main Challenges

- unlabeled data → unsupervised method
- *ugly* data → extensive preprocessing
- explainability → classical AI using statistical features
- $\mathcal{O}(10^4)$ parameters per satellite → optimized performance
- security → all computations on premise

Current Status

- extensive validation and verification with TET | BIROS | Eu:Cropis | EnMap
- operationally used for TerraSar-X | TanDem-X | Grace Follow-On 1&2
- a success story: all relevant anomalies detected*

*there was one ☺

ATHMoS Workflow

Training

Historic model: last 365 days
Recent model: last 30 days

Determine Parameter Type

Compute Features

Clustering

Model Computation
Recompute using nominal data

Inference (daily)

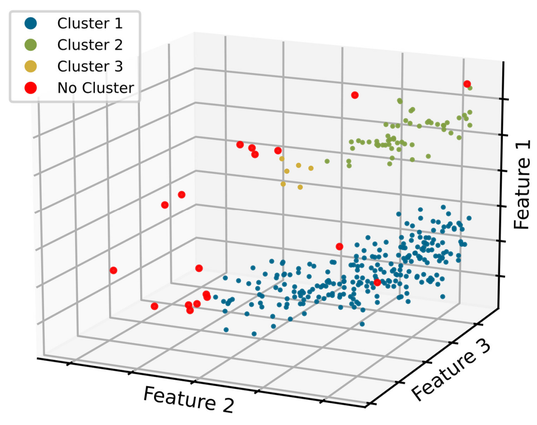
Compute Features

Model Inference

Classify Novelties

Clustering

Problem: unlabeled training data might contain anomalous samples
Solution: prune data via clustering



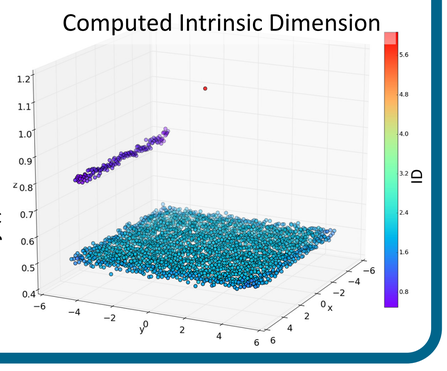
Model Computation

Outlier Probability via Intrinsic Dimension (OPVID)

- based on *LoOP* using Intrinsic Dimension instead of Euclidean distance
- robust against high dimensional and heterogeneously distributed feature vectors

Compute a *k*NN model with a sufficiently large *k* based on *Features*
for each f_i in *Features*:
1. Calculate the Intrinsic Dimension of id_i
2. Calculate the Probabilistic Intrinsic Dimension Outlier Score $pidos_i$

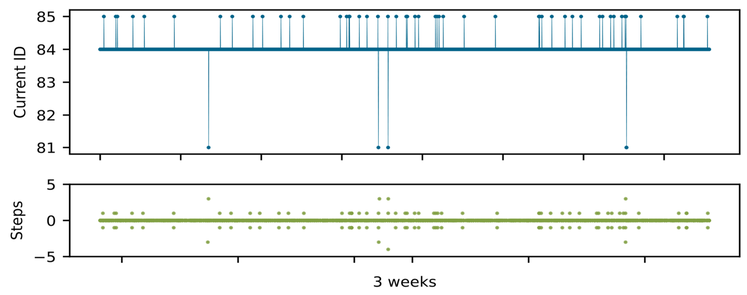
Model *M* = (*kNN*, *ID*, *PIDOS*)



Features

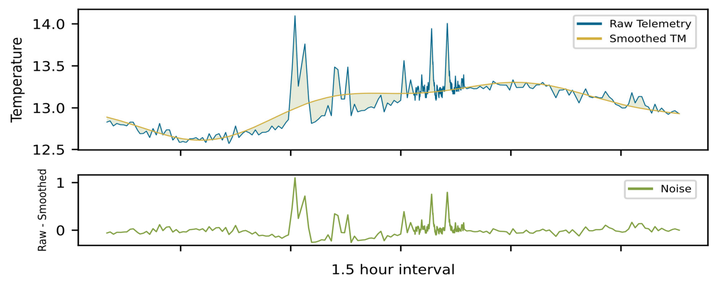
- each feature vector describes statistical characteristics of a sliding window in the telemetry
- features depend on automatically determined parameter type

Discrete Parameters



min | max | #steps | rate positive steps | rate negative steps | max positive step | min negative step

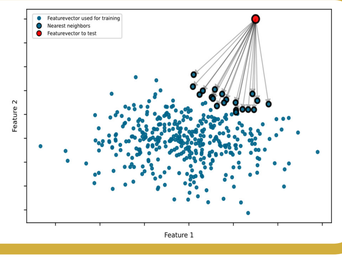
Continuous Parameters



25% | 50% | 75% | std | mean | amp | $\frac{max+min}{2}$ | max | min | std | 75%

Model Inference

compare new test data to trained models



Classify Novelties

use overlapping windows to classify detections and reduce false positive rate

Adoption and Outlook

Technology Adoption

- agile development: regular reviews with our GSOC users in-house
- results displayed in existing long-term monitoring software ViDA
- feedback wiki page (low barrier)
- direct user interaction in the UI: reclassification of timeframes, novelty labelling

Roadmap

- 2nd operational (shadow) workflow to test changes in an operational environment
- new parameter types: status parameters and counters
- extend use to all GSOC missions

Going on-board

- real-time monitoring using the onboard computer of a satellite
- live notifications
- demo planned on CAPTn-1 in 2026/2027