

Satellite telemetry anomaly detection

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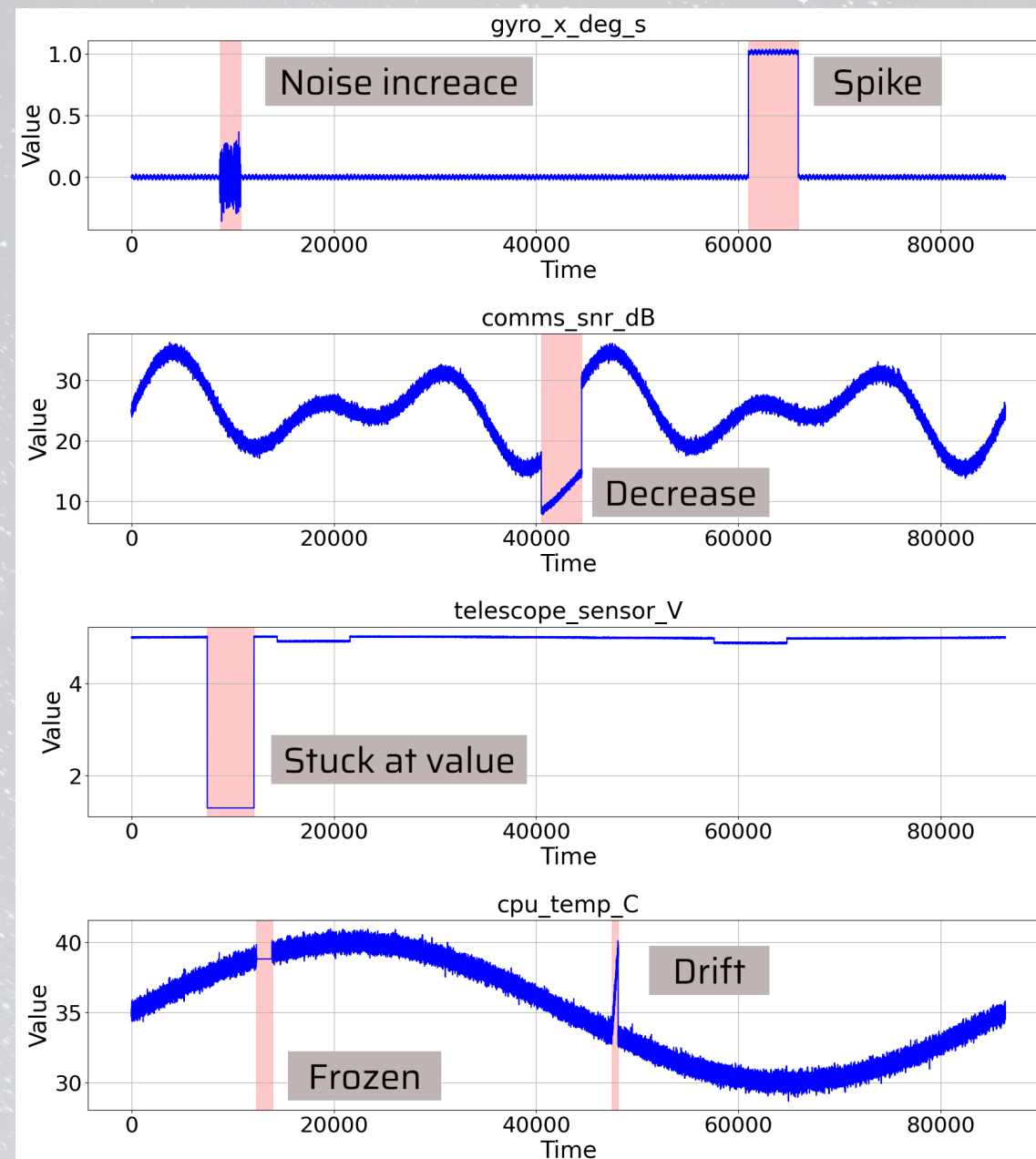
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Telemetry

- The satellite telemetry is multi-variate timeseries (each serie is called **channel**)
- channel is associated with sensor
- monitors the satellite's health and operational status.

Existing open datasets:

- NASA SMAP & MSL
- ESA Anomaly Detection Benchmark
- OPS-SAT

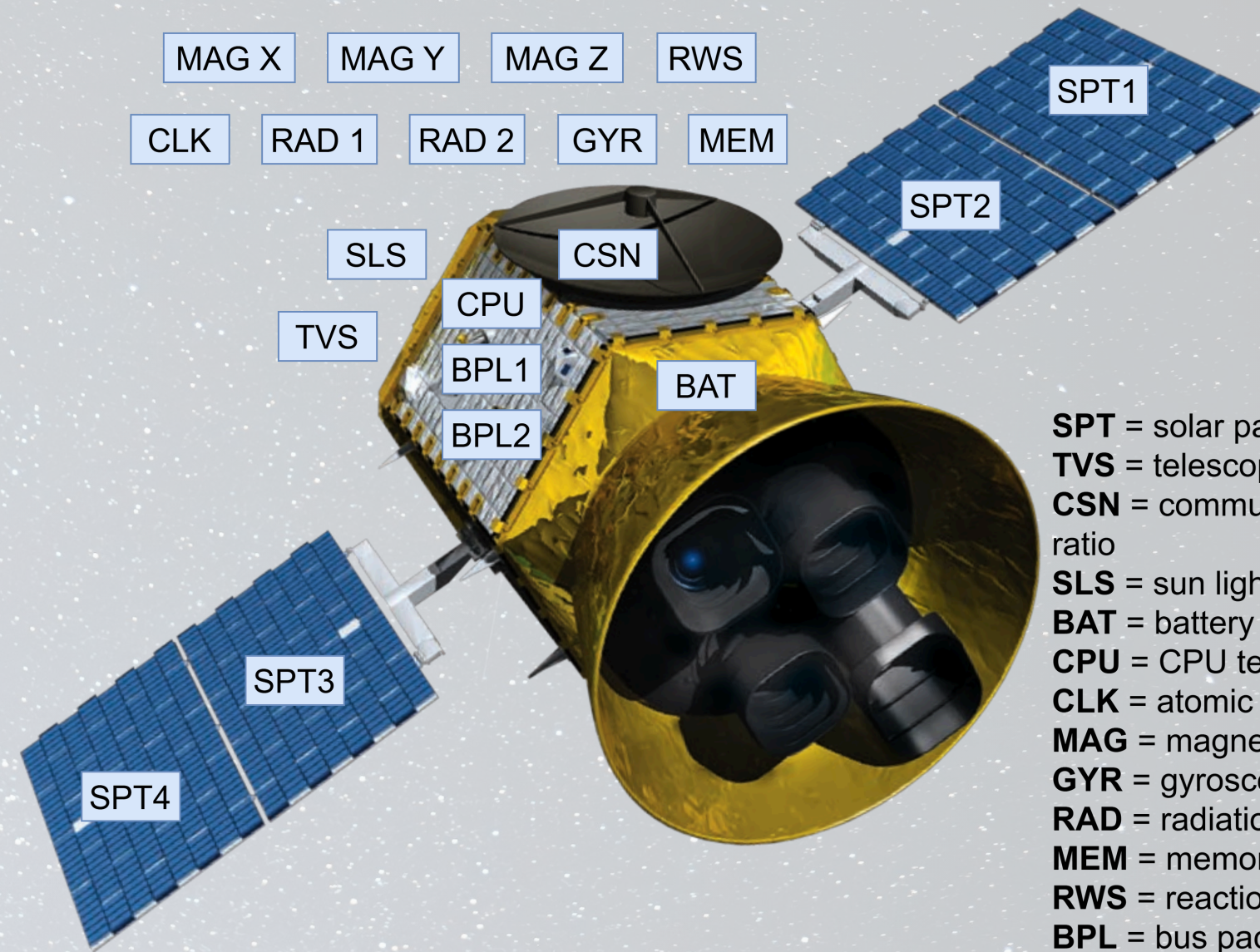


Anomaly types:
sensoric, environmental

Synthetic satellite telemetry generator

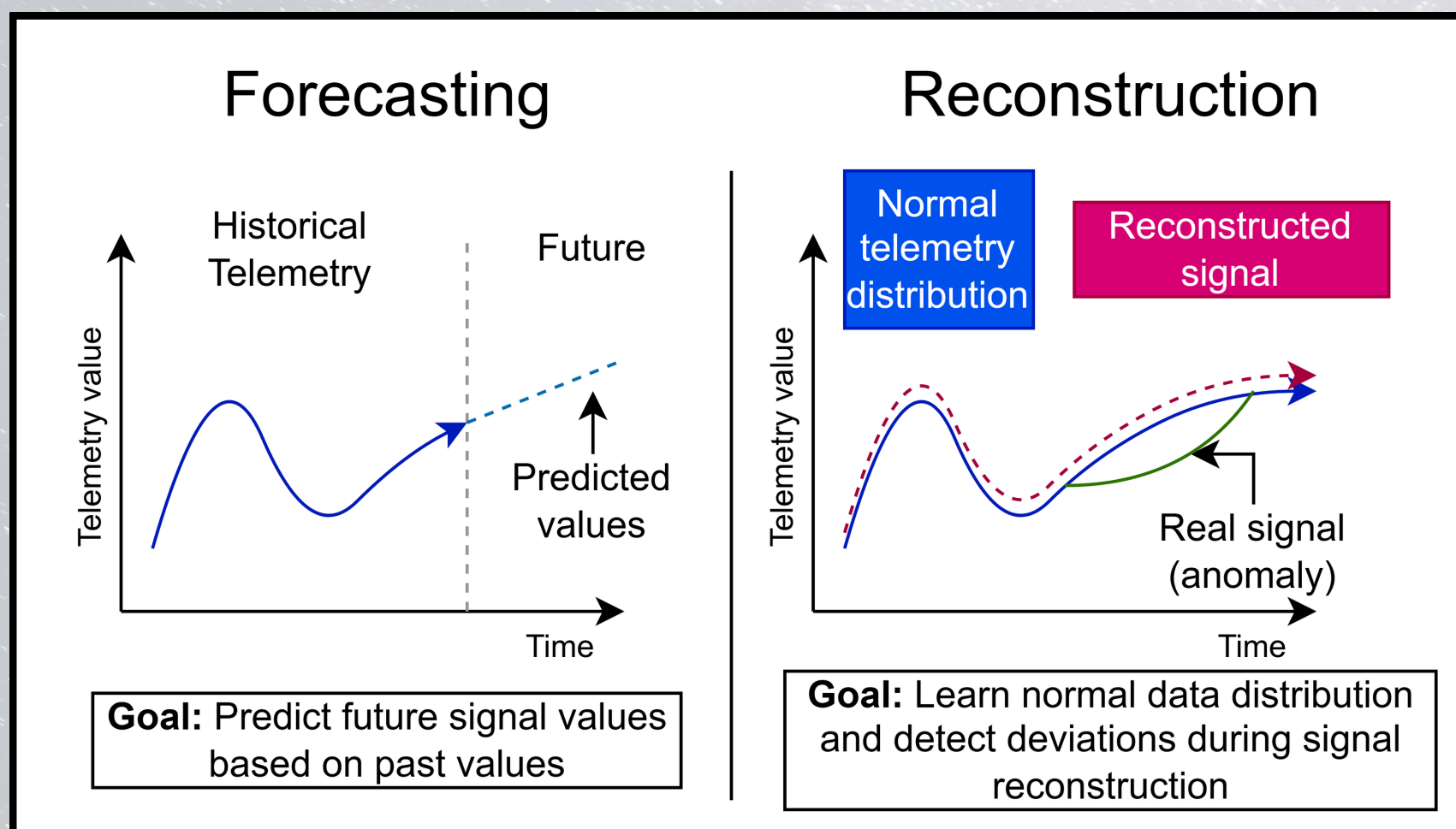


Available at GitHub



SPT = solar panel temperature (°C)
TVS = telescope voltage sensor (V)
CSN = communication signal-to-noise ratio
SLS = sun light sensor (0 is dark)
BAT = battery voltage (V)
CPU = CPU temperature (°C)
CLK = atomic clock drift (μs)
MAG = magnetometer x,y,z (μ Teslas)
GYR = gyroscope degrees
RAD = radiation sensor counts (per 1 s)
MEM = memory usage (percentage)
RWS = reaction wheel speed (rpm)
BPL = bus packet loss (percentage)

Anomaly detection



Input shape:
(seq_len, num_channels)
Output shape:
(seq_len, num_channels)

Input shape:
(seq_len, num_channels)
Output shape:
(next_steps, num_channels)

Anomaly detectors

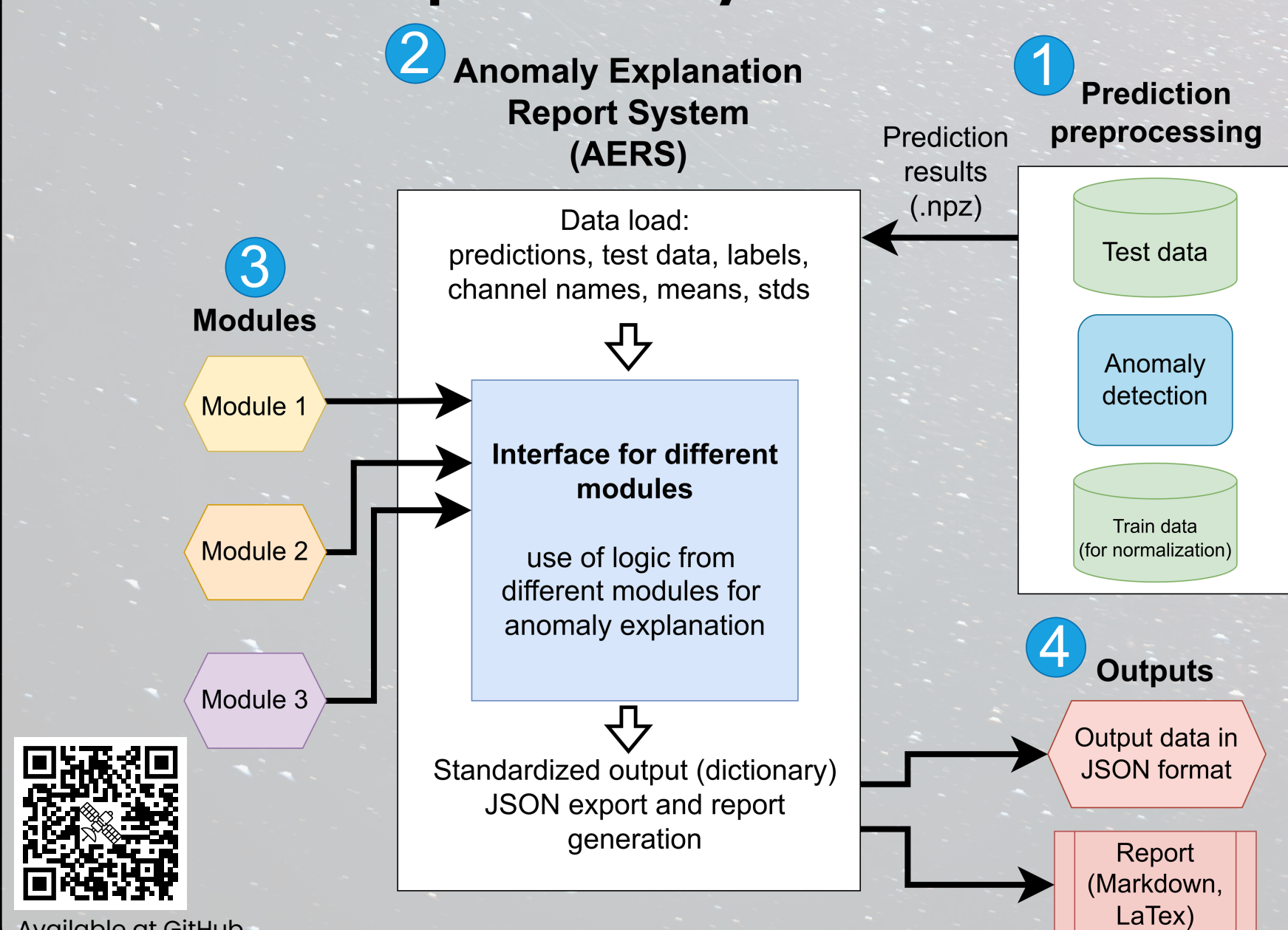
- Models implemented in TensorFlow
- Converted to TensorFlow Lite and ONNX for edge devices
- Dataset shape: (86400, 20)

Metrics:

- Precision
- Recall
- Area under Precision-recall curve
- Inference time
- Power consumption

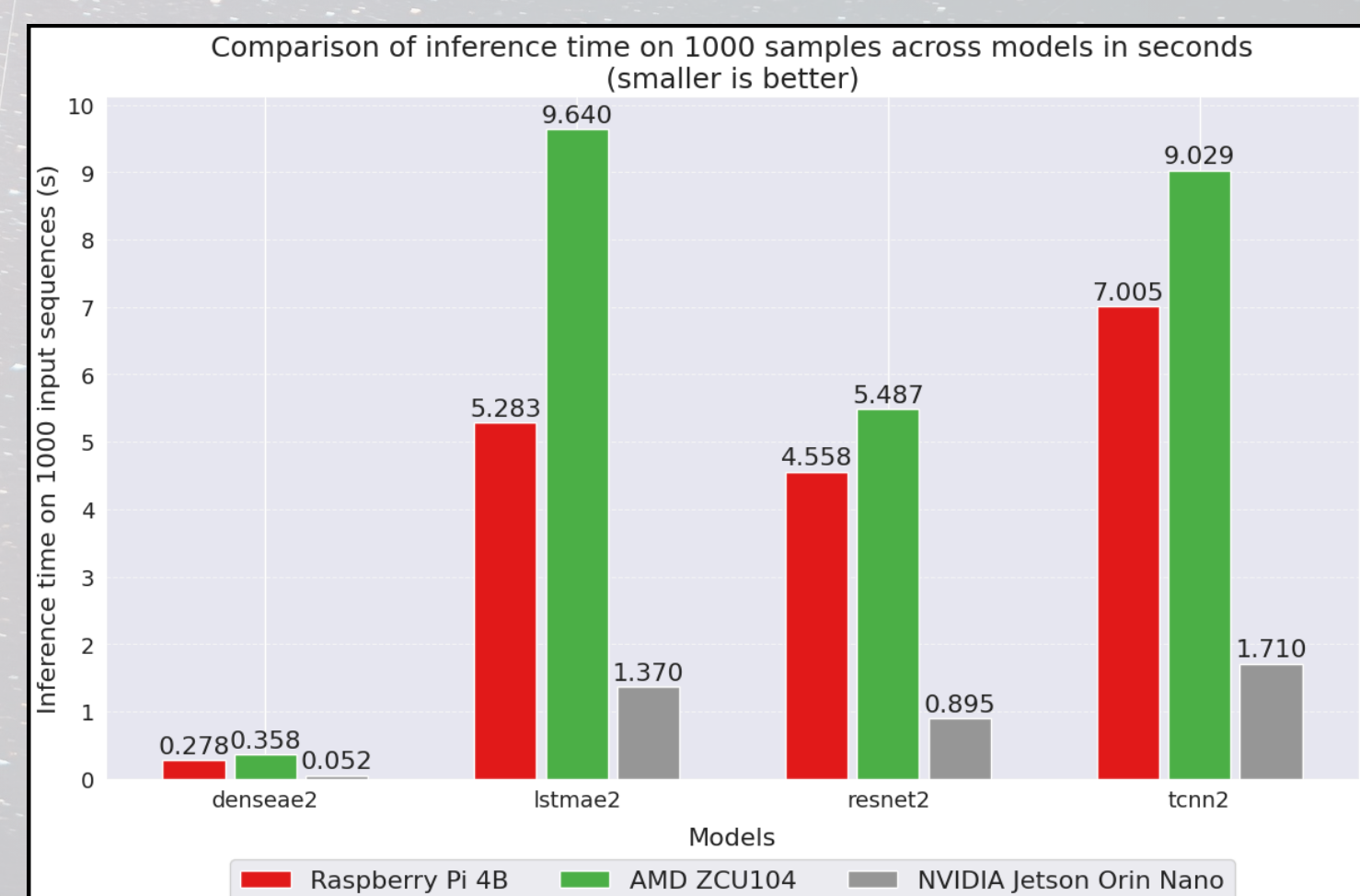
Model (best variant)	Size	PR AUC
Telemanom	330 KB	0.768
Dense Autoencoder	18.64 MB	0.870
LSTM Autoencoder	3.21 MB	0.946
GRU Autoencoder	9.24 MB	0.874
ResNet	97.93 MB	0.841
TCNN	5.51 MB	0.788

Anomaly Explanation and Report System (AERS)

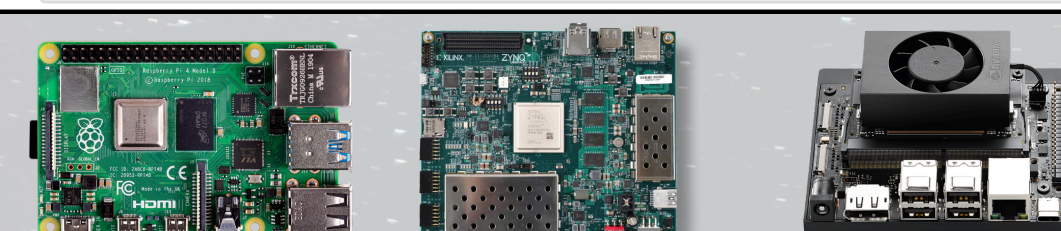


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Spaceboard devices



measured for LSTM AE
Peak power consumption



5 W 13.04 W 8.02 W

Energy per 1 inference 0.0264 J 0.1257 J 0.0110 J