Edge AI Telemetry Triage for On-Orbit Anomaly Detection
A Simulation-Validated Proof of Concept

Abstract

As satellite constellations scale, operational monitoring remains largely ground-centric, relying on continuous telemetry downlink followed by post-hoc analysis. This introduces response latency, inefficient bandwidth usage, and increasing cognitive load on ground teams. This paper presents a simulation-validated proof of concept (PoC) for onboard telemetry triage using lightweight edge intelligence. Experimental results demonstrate reductions in time-to-action and approximately 98% reduction in downlinked telemetry volume while preserving contextual data for high-confidence anomalies.

1. Introduction

Satellite operations face increasing challenges in responsiveness, cost, and scalability. While onboard data generation continues to grow, anomaly detection remains largely ground-based, motivating interest in incremental onboard intelligence.

2. Problem Definition

Ground-centric monitoring introduces delays due to downlink constraints and transmits large volumes of nominal telemetry, creating inefficiencies as constellations scale.

3. System Architecture

The PoC implements a conservative onboard-style pipeline including telemetry simulation, dual-path anomaly detection (rolling statistics and instantaneous spike override), event aggregation, severity classification, and structured decision outputs.

4. Experimental Setup

Telemetry was simulated at 1 Hz across three channels with injected anomalies. A severity-based downlink policy determined whether data was transmitted immediately, stored, or suppressed.

5. Results

The system reduced time-to-action by approximately 10–20 minutes compared to a ground-only baseline. Bandwidth usage was reduced by approximately 98% while preserving contextual data for high-confidence events.

6. Discussion

Conservative detection reduces false positives and builds trust in onboard decisions. Autonomy is treated as a spectrum, with triage representing a low-risk entry point.

7. Conclusion

The PoC demonstrates that lightweight onboard intelligence can deliver significant operational value without complex ML models or flight hardware qualification.