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# NEUROMORPHIC AI FOR AUTONOMOUS SPACECRAFT: A LOW-POWER ALTERNATIVE FOR REAL-TIME DECISION-MAKING IN DEEP SPACE MISSIONS

**Abstract**

As space exploration advances toward increasingly autonomous missions, artificial intelligence (AI) is becoming essential for real-time decision-making, spacecraft navigation, and system diagnostics. However, traditional deep learning models, while effective, are computationally intensive and energy-demanding, making them less suitable for resource-constrained environments such as deep space missions. This research explores the potential of neuromorphic computing and spiking neural networks (SNNs) as an alternative AI paradigm for autonomous spacecraft operations. Unlike conventional artificial neural networks (ANNs), neuromorphic systems process information in an event-driven manner, closely mimicking biological neural mechanisms, which significantly reduces power consumption and improves real-time adaptability in space environments.

The study investigates three critical aerospace applications where neuromorphic AI could provide advantages over traditional deep learning models: (1) autonomous navigation for spacecraft and planetary rovers, (2) real-time anomaly detection in spacecraft systems, and (3) adaptive decision-making for mission-critical tasks. A series of benchmarks are conducted to compare SNN-based models against traditional deep learning approaches, evaluating key metrics such as energy efficiency, computational latency, adaptability in novel scenarios, and reliability in harsh space conditions.

Preliminary findings indicate that neuromorphic AI could enhance the autonomy of spacecraft by reducing computational overhead, enabling faster in-situ decision-making, and improving robustness in dynamic and unpredictable space environments. The research also explores potential trade-offs, including the complexity of training SNNs and their suitability for different types of mission profiles. By presenting a novel approach to AI-driven space autonomy, this study aims to pave the way for next-generation spacecraft that can operate with greater independence and resilience in deep space exploration.