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ARTIFICIAL INTELLIGENCE IN PLANETARY EXPLORATION: ENABLING AUTONOMOUS DECISION-MAKING FOR SPACECRAFT

Abstract

Artificial Intelligence and Machine Learning (AI/ML) technologies have the potential to revolutionize the field of planetary exploration by enabling spacecraft to make autonomous decisions in real-time. In this paper, we explore the role of AI/ML in planetary exploration and focus on some of the challenges of this approach.

Many in the field have realized that AI/ML approach may lead to non-deterministic results, which limits potential applications. Another challenge is that missions, especially beyond the Low Earth Orbits, have to rely on radiation hardened hardware to operate in outer space environments.

One of the most promising applications of AI in planetary exploration is in the field of autonomy for landing and navigation. Our work will concentrate on creating an autonomous system for planetary navigation. The most advanced planetary rover, Mars Perseverance, is using the classical approach to path planning and still relies significantly on the information received from mission control. The Mars helicopter Ingenuity on the other hand, features a very efficient and capable architecture for autonomous flying. As the next step, NASA Researchers proposed machine-learning capabilities for future NASA's Mars Sample Fetch Rover via the NASA HPSC program, which delivers 100x compute power. We are preparing a demonstration rover platform for planetary navigation. Experimental architectures will be based around a specialized RISC-V processor with additional computational modules to enable fast AI processing. The platform will be equipped with a simple stereo camera setup with an IMU and a sun-sensor. The goal of the research is to identify the most effective combination of sensor, algorithms, and computing platform to enable autonomous traverse. The objectives will be to minimize the power consumption, enable operations during minimal light conditions and achieve faster traverse speeds, compared to today's rovers.

AI has the potential to revolutionize the field of planetary exploration by enabling spacecraft to operate autonomously in challenging and unpredictable environments. In this work, we identified experimental architectures to enable autonomous traverses. The next step will be to understand robustness of the algorithms through modeling and testing in the desert. Another effort will be concentrated on a layered structure to handle fault tolerance due to radiation and autonomous requirements.