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AI-ENHANCED LASER-INDUCED BREAKDOWN SPECTROSCOPY FOR PLANETARY EXPLORATION

Abstract

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AI-Enhanced Laser-Induced Breakdown Spectroscopy for Planetary Exploration

Abstract

Laser-Induced Breakdown Spectroscopy (LIBS) has been implemented for *in-situ* analysis of Martian surface materials due to its ability to rapidly and accurately identify elements without causing destruction. This paper presents advancements in AI-enhanced LIBS through machine learning algorithms for spectral noise reduction and adaptive target selection in the volatile Martian environment.

Bayesian network models, utilized in Perseverance and other missions, process received LIBS signals through stochastic approaches to mitigate weather-induced signal distortion. Deep learning-based spectral classification is particularly trained to detect biosignatures and hydrated minerals in Martian analogs and laboratory datasets, with the aim of improving detection on Earth. Additionally, autonomous AI-based targeting optimizes laser shooting parameters for high-priority geological objects, enhancing mission efficiency.

Simulations demonstrate a 30% improvement in detection accuracy and a 25% reduction in transmitted data, addressing deep-space communication bandwidth limitations. This work highlights AI-augmented LIBS as a key tool for next-generation planetary reconnaissance missions.