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A RAG-ENABLED LARGE LANGUAGE MODEL WITH KNOWLEDGE GRAPH INTEGRATION FOR LIVE TELEMETRY-DRIVEN AI ASSISTANCE OF LUNAR PAYLOAD OPERATIONS

Abstract

This paper presents an AI Assistant developed for the MAPP rover's two MIT payloads on the Intuitive Machines-2 (IM-2) Mission to the Moon, launched in February 2025 under MIT's "To the Moon to Stay" initiative. The two payloads, a Kinect-based 3D depth-mapping camera for high-resolution imaging of the lunar south pole and the AstroAnt micro-rover for autonomous exploration, were transported aboard the Intuitive Machines Nova-C lander and launched on a SpaceX Falcon 9 rocket.

To engage the public with mission activities, we developed an interactive Unreal Engine dashboard that visualizes operational data for both the AstroAnt and the lunar camera payload. This dashboard displays recent commands sent to each system and provides real-time status updates. A key component of this interface is an integrated AI chat assistant, enabling users to request mission data and payload status in natural language.

The AI chat assistant uses a Large Language Model (LLM) combined with Retrieval-Augmented Generation (RAG), underpinned by a continuously updated Knowledge Graph (KG) that stores live telemetry from the rover and the camera system. Through this architecture, users can access both current rover metrics, such as PCB temperature, battery voltage, and orientation, and historical analytics, for instance, summarized sensor trends over custom timeframes. The graph-based retrieval ensures accurate, contextually relevant responses while maintaining the flexibility to adapt to evolving mission requirements. The integration of RAG moreover ensures that text-based information about the mission, based on published papers and the mission website, can be used to answer questions reliably.

This paper describes the system's technical implementation, including the data integration pipeline, Knowledge Graph structure, RAG query processing workflow, and methods for generating real-time responses. The proposed AI-driven interface offers a novel approach to enhancing telemetry monitoring

and operational decision-making for lunar surface missions, illustrating how language models can deliver reliable, interactive insights for both mission control and public outreach.