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ENHANCING AUTONOMOUS ROVER OPERATIONS: A TEST FACILITY FOR NAVIGATION AND SLIP ESTIMATION ON LUNAR-LIKE TERRAIN

Abstract

Autonomous planetary rovers navigate highly complex terrains characterized by uneven surfaces, craters, and loose regolith, which significantly impact mobility and navigation accuracy. Wheel slippage, a major challenge in such environments, necessitates frequent manual intervention from Earth-based operators, reducing operational efficiency and limiting the time available for scientific exploration. Addressing these challenges requires advanced navigation and slip estimation algorithms, rigorously tested in controlled environments before deployment on planetary missions.

Despite India's growing presence in space exploration, there has been a lack of dedicated planetary rover research facilities within the country. The successful landing of Chandrayaan-3 and the deployment of the Pragyan rover have marked the beginning of a new era for space robotics in India. To further strengthen this emerging field, it is crucial to develop advanced testing environments that support future planetary rover missions from both public and private sectors.

This paper presents a planetary rover test facility at IIT Kanpur, designed to simulate lunar-like conditions for evaluating and improving autonomous navigation capabilities. The facility features a large sand pit embedded with boulders and craters to replicate lunar terrain characteristics, complemented by specialized lighting systems to simulate lunar illumination conditions. A six-wheeled miniature rover, equipped with a diverse suite of sensors, including cameras, LiDAR, IMUs, and encoders, has been developed to support real-world testing and validation of autonomous algorithms.

As one of the first facilities of its kind in Indian academia, this testbed represents a significant step toward advancing autonomous planetary rover technologies. It provides a critical infrastructure for future Indian planetary missions by enabling rigorous algorithm testing and development, reducing reliance on manual intervention, and enhancing operational efficiency in extraterrestrial environments.