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MODEL-BASED SYSTEMS ENGINEERING SIMULATION TOOL FOR THE DESIGN AND PERFORMANCE ANALYSIS OF MODULAR LUNAR ROVERS

Abstract

The rise in interest in lunar surface exploration presents an opportunity for the novel uses of lunar rovers. Modularity in lunar rovers would make robotic activity on the lunar surface accessible to researchers and prospectors. However, there are a limited number of simulation tools available to enable systems-level analysis of modular lunar rovers.

This work presents a simulation tool that will allow a systems-level analysis of the behavior of lunar rovers. The simulation tool uses Model-Based Systems Engineering (MBSE) for design and simulation. MBSE enables modification of subsystem blocks in accordance with requirements while maintaining clear traceability between subsystem blocks. This provides a comprehensive understanding of the impact of different subsystem parameters on the rover's overall performance, providing valuable insights for informed decision-making regarding the design, deployment, and operation of lunar rovers. Key performance metrics can be extracted from the simulation. These metrics can then be optimized according to the requirements of the mission, including rover behavior, terramechanics simulation data, power cycle simulation data, and mechanical performance data, across a user-defined terrain map.

Additionally, this tool facilitates the optimization of the rover's design and operation. By simulating different scenarios, users can test the rover's behavior and identify any areas for improvement, or even integrate optimization tools to optimize different aspects of the rover configuration.

The tool, built using MATLAB's Simscape environment, allows users to input parameters of the rover, the mission profile, and the terrain that impact the rover's behavior. These parameters are then utilized to model the rover's behavior in a user-defined simulated environment, providing a representation of the rover's performance under a variety of conditions, verified through comparing with the literature and experimental data. Unlike other similar tools, the utilization of MBSE, the focus on the systems-level analysis of the tool, and the familiarity and flexibility of the MATLAB environment, allows this simulation tool to be utilized for a variety of rover applications, both terrestrial and planetary, and generate viable simulation results.

This tool can prove to be an essential part of the toolkit for system engineers in the field of lunar rover design and deployment. Its comprehensive systems-level analysis capabilities and flexible design make it an ideal tool for users who require simulation data to inform their decision-making. It is anticipated that this tool will ease the systems-level analysis effort of the rover design process and will be used in future efforts in developing accessible rover technology.