Virtual Simulation System with Path-Following Control for Lunar Rovers Moving on Rough Terrain

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Abstract: Virtual simulation technology is of great importance for the teleoperation of lunar rovers during the exploration phase, as well as the design of locomotion systems, performance evaluation, and control strategy verification during the R&D phase. The currently used simulation methods for lunar rovers have several disadvantages such as poor fidelity for wheel-soil interaction mechanics, difficulty in simulating rough terrains, and high complexity making it difficult to realize mobility control in simulation systems. This paper presents an approach for the construction of a virtual simulation system that integrates the features of 3D modeling, wheel-soil interaction mechanics, dynamics analysis, mobility control, and visualization for lunar rovers. Wheel-soil interaction experiments are carried out to test the forces and moments acted on a lunar rover's wheel by the soil with a vertical load of 80N and slip ratios of 0, 0.03, 0.05, 0.1, 0.2, 0.3, 0.4 and 0.6. The experimental results are referenced in order to set the parameters' values for the PAC2002 tire model of the ADAMS/Tire module. In addition, the rough lunar terrain is simulated with 3DS Max software after analyzing its characteristics, and a data-transfer program is developed with Matlab to simulate the 3D reappearance of a lunar environment in ADAMS. The 3D model of a lunar rover is developed by using Pro/E software and is then imported into ADAMS. Finally, a virtual simulation system for lunar rovers is developed. A path-following control strategy based on slip compensation for a six-wheeled lunar rover prototype is researched. The controller is implemented by using Matlab/Simulink to carry out joint simulations with ADAMS. The designed virtual lunar rover could follow the planned path on a rough terrain. This paper can also provide a reference scheme for virtual simulation and performance analysis of rovers moving on rough lunar terrains.

Key words: lunar rover, comprehensive simulation system, rough terrain, wheel-soil interaction mechanics, path-following control

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