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WIND-DRIVEN TUMBLEWEED ROVERS FOR MARS EXPLORATION

Abstract

A tumbleweed rover is a lightweight, spherical rover designed to explore locations of scientific interest on Mars. The rover is an autonomous vehicle that relies on the Martian winds for propulsion rather than depending on internal power sources, as do traditional wheeled rovers used in past missions. Conceived by N ASA investigators at the Jet Propulsion Laboratory and the NASA Langley Research Center, the tumbleweed rover is believed to be capable of traveling to remote distances over difficult terrain with the ability to navigate rough landscapes in places of geological interest. Since the mass of individual tumbleweed rovers should be significantly less than traditional rovers, a team of tumbleweeds could be deployed across the Martian surface to provide global coverage. This paper will present a detailed overview of current tumbleweed rover prototypes which have been designed, built, and tested at North Carolina State University, and will also present parametric computer-based studies of how a Mars tumbleweed rover would perform on the Martian surface. Rocks are believed to exist in most terrains on Mars, and they are abundant over considerable portions of the Martian surface. Consequently, a tumbleweed rover's ability to maneuver through rock fields will dictate its effectiveness in reaching places of interest, which frequently lie in regions outside of suitable landing sites. We have developed a procedure for creating randomized Martian rock fields based on current statistical models, and the procedure generates small patches of terrain as the rover travels over the Martian surface, minimizing the computational cost associated with exploring large regions. The procedure can accommodate any combination of consecutive bounces off rocks and surfaces, and it allows for transitions between bouncing and rolling (or sliding). We will present simulation results that show that bouncing is the rover's dominant mode of travel through the rock fields, and we will present Monte Carlo simulations demonstrating how the rover's speed over the terrain depends on the rover design and atmospheric conditions. Finally, we will present simulations which verify the tumbleweed rover's capacity for long-distance travel over Martian rock fields.