Paper ID: 93961
student

AI Impact & Autonomy on Space Exploration (14)
AI Impact & Autonomy on Space Exploration - Session 4 (4)

Author: Mr. Raúl Gianmarco Chávez Chávez
Universidad Nacional de Ingeniería (Lima, Perù), Peru

Mr. Fidel Castro Suazo
Universidad Nacional de Ingeniería (Lima, Perù), Peru
Mr. Juan Salvador Palacios Bett
Universidad Nacional de Ingeniería (Lima, Perù), Peru

ADAPTIVE CONTROL SYSTEM FOR ROVER STABILITY IN LOW-GRAVITY AND UNEVEN TERRAIN EXPLORATION

Abstract

In the exploration of celestial bodies with reduced gravity, such as the Moon and Mars, the mobility and stability of rovers face significant challenges. Irregular terrain and low-gravity conditions affect traction and maneuverability, increasing the risk of rollover and mission failure. This project presents the development of an adaptive control system through advanced simulation that dynamically adjusts a rover's movement parameters to optimize stability and response to variations in terrain and gravity. The system employs real-time adjustments based on control algorithms that simulate accelerometer, inclination, and contact sensor data, allowing the rover to autonomously respond to the terrain conditions it encounters.

The methodology includes three main phases: Design and implementation of adaptive control algorithms using tools such as MATLAB, Simulink, and ROS, which manage stability and traction under reduced gravity; simulation of a virtual environment replicating lunar and Martian terrains with varied surface types and gravitational settings to test the algorithms' performance; and performance analysis based on simulation data, including rover stability, efficiency, and traction across various terrain scenarios. The simulation environment allows testing of the system's responses to rocks, slopes, and other obstacles, adjusting parameters in real-time for optimized stability and control.

Unlike conventional control systems, which require manual configuration to adapt to diverse terrains, this system autonomously adjusts its movement parameters, providing a flexible response to unpredictable environmental changes. This approach minimizes the need for hardware dependency during the project's initial phases, enabling thorough system optimization within virtual environments and reducing associated costs and risks. Furthermore, the adaptive control system improves the potential safety and operational efficiency of rovers in the exploration of challenging, low-gravity environments.

The project's findings support the feasibility of deploying autonomous, adaptive control systems for future space missions, where rovers can benefit from real-time adjustments to terrain variations without direct human intervention. Such advancements are expected to enhance the effectiveness of robotic exploration on the Moon, Mars, and beyond, contributing to the success of long-term space exploration missions.