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LOW REACTION TRAJECTORY GENERATION FOR A HEXAPOD ROVER ON NON-HORIZONTAL TERRAIN IN MICROGRAVITY

Abstract

The exploration of small celestial bodies has evolved from initial flyby observations and rendezvous studies to more sophisticated stages involving soft landings on the surface, as well as sample collection and return missions. Against this backdrop, the deployment of robotic platforms for mobile exploration on the surfaces of these celestial bodies can effectively enhance the depth and breadth of exploration missions. However, constrained by the microgravity environment and unstructured terrain of small celestial bodies, robotic locomotion control faces significant challenges. Based on the self-developed robot platform, Hexapod Rover, we propose a locomotion method for hexapod robots that is specifically tailored for non-horizontal terrains in microgravity. The locomotion system of the Hexapod Rover is primarily composed of six legs, each equipped with three degrees of freedom, and is capable of achieving locomotion through statically stable movement. The proposed method consists of two main modules. The first module is terrain prediction based on probabilistic fusion. Utilizing gait planning and foot height information obtained from the robot's onboard sensors (IMU, motor encoders, etc.), a foot-ground contact probability model is established. By integrating probabilistic models through Kalman filtering, the contact state between the foot and the ground is predicted, thereby enabling the estimation of the current terrain slope. The prediction outcomes are subsequently transmitted to the second module: low reaction trajectory generation. Under the constraints of foot-ground friction in microgravity, the desired foothold is planned according to the terrain slope. Sequentially, the foot trajectory of the Hexapod Rover is optimized in real-time using a seventh-order Bezier curve. By minimizing the dynamic reaction forces, the impact effects during motion are suppressed, thereby reducing the risk of the Hexapod Rover detaching from the celestial surface. The proposed method not only ensures stable attachment of the robot to the surface in microgravity, but also enables traversal of non-horizontal terrains, which transcends the limitations of conventional locomotion approaches.