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IMPROVED DESIGN AND CONTROL FOR SLIDING LOCOMOTION FOR LEGGED ROVERS ON STEEP TERRAIN DURING SPACE EXPLORATION

Abstract

Robots are key to planetary exploration. One of the major challenges of today's rovers used for exploration of Moon and Mars is their limited mobility over challenging terrain, like steep craters or rocky surfaces. All deployed robots so far used wheels for their locomotion. An exception is Ingenuity, the Mars helicopter of NASA that has accomplished 72 flights from April 2021 till January 2024. Even though helicopters can fly over challenging terrain, their payload and battery capacity are limited. Wheeled rovers, on the other hand, have high payload capacity, but cannot access scientifically-interesting areas such as steep craters and underground cavities. Legged rovers have gained attention for future exploration missions due to their rough terrain mobility combined with payload capacity. Permanently-shaded areas such as Moon's Shackleton crater are interesting for planetary exploration since they are a potential source of water-ice and most were formed over two billion years ago. The crater walls of Shackleton for example have an average slope of 31° with peaks of 35°.

All major space agencies have been financing legged rover development projects over the past decades. The recently completed ESA-project ANT, with DFKI, IIT and Airbus as partners, developed and tested software for quadruped and hexapod rovers on steep crater analogues with a maximum inclination of 30° [1]. Other notable projects included DFKI's Scorpion, Mantis, Space-Climber, as well as FZI's Lauron, ETH's SpaceBok, DLR's Bert and NASA JPL's Lemur, ATHLETE and RobotSimian.

In our recent publication at ESA-ASTRA 2023 [2] we presented for the first time a novel type of locomotion for efficiently descending steep terrain such as crater walls. We demonstrated how a 4-legged robot with custom-designed torso can lift its legs and slide down on a 33° inclined 10m tall pile of pebbles. The robot can control its motion with the legs to steer, brake and thrust.

In this abstract and oral presentation, we will show the results of the most recent developments in terms of improvements of the torso and leg design, as well as motion control.

[1] A. Dettmann, S. Planthaber, V. Bargsten, R. Dominguez, G. Cerilli, M. Marchitto, G. Fink, M. Focchi, V. Barasuol, C. Semini, M. Robert, Towards a Generic Navigation and Locomotion Control System for Legged Space Exploration, ASTRA, 2022.

[2] V. Barasuol, M. Villa, M. Marchitto, G. Cerilli, C. Semini, Controlled Sliding Locomotion for Legged Rovers on Steep Terrain During Space Exploration, ASTRA, 2023.