Robotic Mobility in Extreme Environments

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The previous generation of NASA missions to the outer solar system discovered salt-water oceans on Europa and Enceladus, each with more liquid water than Earth. These oceans, in contact with a silicate core on Europa and actively venting through large geysers on Enceladus, are compelling targets to look for extraterrestrial life. Closer to home, JAXA and NASA have imaged sky-light entrances to lava tube caves on the Moon more than 100 meters in diameter and ESA has characterized the incredibly varied and complex terrain of Comet 67P. While JPL has successfully landed and operated four rovers on the surface of Mars using a 6-wheeled rocker-bogie architecture, future missions will require new mobility architectures for these extreme environments. Unfortunately, the highest value science targets often lie in the terrain that is hardest to access.

This talk will explore technologies that allow robots to reach science targets in extreme terrain. To prepare for use in space where repair or replacement is not possible, we field-test these robots in analog extreme terrain on Earth. We have deployed rock-climbing robots to lava tubes in New Mexico and California, ice-climbing robots in glacial caves at the top of Mt. Rainier and Mt. St. Helens, fissure mapping robots into volcanic vents on Hawaii's big island, and robotic grippers deep in our own ocean. A new Discovery Mission Proposal, Moon Diver, seeks to fly the first extreme terrain rover, a rappelling robot, into the Tranquillitatis Pit on the Moon.

Our lab develops systems using iterative design principles and frequent field tests to Earth's extreme environments. Many of these systems are enabled by advances in autonomy. The talk will present an overview of our work and detailed case studies of 1) a biologically inspired rock gripper, and 2) software that autonomously selects footsteps for a legged climbing robot using a machine learning approach on LiDAR point clouds of the terrain.