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COMPARISON OF LEGGED SINGLE-ROBOT AND MULTI-ROBOT ANALOG EXPLORATION SYSTEMS

Abstract

The current development of ongoing and future planetary exploration missions calls for novel, effective robotic exploration technologies. Whether in the search for traces of life on Mars, sample return missions, or resource prospection to prepare for human arrival on the Moon, interesting targets often lie in hard-to-reach areas such as craters, caves, and volcanic rilles. Accordingly, several institutions are investigating and developing novel technologies such as flying and walking robots to access these hard-to-reach targets. Combined into heterogeneous robotic teams with individual skill sets, these systems can enable effective exploration missions with novel operational concepts. A first impressive deployment of a planetary multi-robot mission is the operation of Perseverance and Ingenuity on Mars. Inspired by this initial success, we investigate the design and deployment of heterogeneous robotic teams and the accompanying operation concepts.

In this paper, we describe both a single-robot and a multi-robot system we developed for analog exploration missions using legged robots. We focus on the operational concepts the two systems enable and how we used them in the analog deployments at the ESA/ESRIC Space Resources Challenge. We show a performance comparison of our approaches, including scientific data output, scheduling considerations, redundancy, and payload utilization. Furthermore, we present our lessons learned concerning the implementation and maintenance complexity of both approaches. Our work shows that a heterogeneous robotic team allows higher mission effectiveness and a safer redundancy concept compared to single-robot approaches. Furthermore, compared to homogeneous robotic teams, a heterogeneous team enables a more efficient deployment of instruments for detailed investigation, which leads to a high payload utilization.