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SUBSURFACE EXPLORATION ON MARS AND MOON WITH A ROBOTIC SWARM

Abstract

The subsurface exploration has been identified as a key component for understanding planetary evolution and geology, as well as searching of possible life beyond Earth. Both on Mars and Moon subsurface structure remains largely unexplored. Future exploration missions therefore aim for a detailed exploration of the planet's subsurface to prepare landing/base sites, or in case of Mars shed light on the question of life existence. For instance, such missions as ExoMars or Mars2020 plan to equip robots with ground penetrating radar for the exploration of the Martian subsurface to search for ice or water. Moreover, NASA's Dragonfly mission launching in 2026 plans the use of a single drone equipped with a seismometer to measure seismic activity on Titan.

In contrast to single robot systems, in future exploration missions we envision the use of multiple mobile robots for subsurface exploration that operate as an intelligent, cooperative swarm. Such a multi-robot system shall perform seismic surveys in a cooperative and autonomous fashion. Each robot is equipped with an active signal source for the seismic experiment, a seismometer and communication and navigation units. Robots are then able to communicate with each other in order to decide for the next sampling position and to cooperatively reconstruct the subsurface. Such a swarm of mobile robots enables a larger sensing aperture and therefore a larger acquisition of samples and a faster subsurface reconstruction. Besides, the swarm is resilient against failures of robots since its functionality does not depend on a single entity as in single robot systems. We will investigate the suitability of various seismic survey methods such as reflection and refraction, electromagnetic and ground penetrating radar methods for an operation within a swarm of mobile robots. The development of seismic reconstruction algorithms and exploration strategies that function in a distributed fashion within the multi-robot system will play a central role of our research activities. In this paper, we present the basic idea of our exploration concept and show first algorithmic results for subsurface exploration by a multi-robot system.