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IAF SPACE EXPLORATION SYMPOSIUM (A3)
Moon Exploration – Part 1 (2A)

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FROM SINGLE AUTONOMOUS ROBOTS TO COOPERATIVE ROBOTIC TEAMS FOR FUTURE PLANETARY EXPLORATION MISSIONS

Abstract

Abstract: This paper describes the experience gained from the ROBEX (Robotic Exploration of Extreme Environments) analogue mission, performed on Mt. Etna, Italy in 2017. The goal of this mission was to demonstrate the deployment and operation of a seismic network in a relevant environment, and to perform a profile measurement in order for identifying the subsurface constitution. In this demonstration, Mt. Etna served as an analogue site for the lunar environment.

The findings will be applied to the newly acquired project ARCHES (Autonomous Robotic Networks to Help Modern Societies). Major focus of ARCHES is the cooperative aspects of heterogeneous robotic teams. They shall work together to explore, deploy, and maintain infrastructure and scientific instrumentations on planetary surfaces. These methods and technologies will be relevant for the robotic support and operation of permanent installations and bases (e.g. the lunar village concept, or large scientific observatories, such as interferometers). Furthermore, this paper discusses the different conceptual modes of operating robots in such scenarios, starting from highly autonomous behaviors, over shared-autonomy concepts, up to teleoperation.

The aim of ARCHES is to develop approaches that allow robots to acquire, analyze, and interpret measurement data autonomously. Consequently, the scope of ARCHES also includes the intelligent automation and cooperation of robotic systems. Both of these aspects are essential for the deployment of standalone robots and robot teams. Concepts for autonomous navigation in unknown areas, interaction and manipulation inside the environment, energy management systems and self-organizing communication systems, which enables the communication between different robots and mission control will also be investigated.

ROBEX and ARCHES share the following key technological requirements:

- Mobile robots that can explore demanding rough terrain with a high degree of autonomy
- Dedicated sensor and communication systems
- Tools for manipulation and acquisition of samples
- Methodologies for cooperation among robots as well as between robots and human operators
- Different robotic systems, which provide complementary capabilities, for example flying explorers, transport rovers, and small cave crawlers
- Reconfigurable robotic systems to deploy scientific and infrastructure elements

All of these mission and operational concepts are in line with the Global Exploration Strategy, that aims toward human robot cooperation, partly autonomous robotic systems, and the installation of permanent bases, e.g. the lunar village, and the cis-lunar habitat or the Deep Space Gateway. Finally, a robotic strategy of the near future developments will be presented as outlook of this paper.