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ON REALIZING MULTI-ROBOT COMMAND THROUGH EXTENDING THE KNOWLEDGE DRIVEN TELEOPERATION APPROACH

Abstract

Future crewed planetary missions will strongly depend on the support of crew-assistance robots for setup and inspection of critical assets, such as return vehicles, before and after crew arrival. To efficiently accomplish a high variety of tasks, we envision the use of a heterogeneous team of robots to be commanded on various levels of autonomy. This work presents an intuitive and versatile command concept for such robot teams using a multi-modal Robot Command Terminal (RCT) onboard a crewed vessel.

We employ an object-centered prior knowledge management that stores the information on how to deal with objects around the robot. This includes knowledge on detecting, reasoning on, and interacting with the objects. The latter is organized in the form of Action Templates (ATs), which allow for hybrid planning of a task, i.e. reasoning on the symbolic and the geometric level to verify the feasibility and find a suitable parameterization of the involved actions. Furthermore, by also treating the robots as objects, robot-specific skillsets can easily be integrated by embedding the skills in ATs.

A Multi-Robot World State Representation (MRWSR) is used to instantiate actual objects and their properties. The decentralized synchronization of the MRWSR of multiple robots supports task execution when communication between all participants cannot be guaranteed. To account for robot-specific perception properties, information is stored independently for each robot, and shared among all participants. This enables continuous robot- and command-specific decision on which information to use to accomplish a task. A Mission Control instance allows to tune the available command possibilities to account for specific users, robots, or scenarios.

The operator uses an RCT to command robots based on the object-based knowledge representation, whereas the MRWSR serves as a robot-agnostic interface to the planetary assets. The selection of a robot to be commanded serves as top-level filter for the available commands. A second filter layer is applied by selecting an object instance. These filters reduce the multitude of available commands to an amount that is meaningful and handleable for the operator. Robot-specific direct teleoperation skills are accessible via their respective AT, and can be mapped dynamically to available input devices. Using AT-specific parameters provided by the robot for each input device allows a robot-agnostic usage, as well as different control modes e.g. velocity, model-mediated, or domain-based passivity control based on the current communication characteristics.

The concept will be evaluated onboard the ISS within the Surface Avatar experiments.