Self-organizing Documentation Capture and Retrieval for Robotic Teleoperations Support

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Abstract

The teleoperation of robotic rovers in hostile extra-terrestrial environments is and will continue to be one of the key enabling technologies for human exploration of space. The actuated-sensors of the robotic rover may explore and traverse the terrain of an alien environment, but the intelligence of the rover resides in the mission scientist team. They alone are the intellect that powers the examination of empirical results and programs future actions. High-level, human-readable results are generated from multiple data streams using a heterogeneous collection of software subsystems running on a distributed computer network. These results include data plots, summary histograms, instrumentation flow-charts, conceptual diagrams, time and resource allocation schedules. For collaborative teamwork, they are often printed out, marked up, discussed and augmented by physical models, and sketches made within the science team meetings. Finally, and most importantly, conclusions are drawn from work-in-progress and used to synthesize next iteration rover programming.

Robotic teleoperation teams are challenged by the need to simultaneously focus on the task of operating the robot and the task of recording their thinking and actions as points of reference for future generations. Due to ubiquitous time pressure, which ultimately relates to the expense of running a mission, documentation of key decisions is often inadequate, and is known to decay rapidly from decision rationale to decision rationalization. The immediate value of captured data is limited, too, by the ability of the science team to access the data in real-time. The combination of needs for strong documentation with low overhead is particularly relevant with missions that have: 1) rotating personnel, 2) semi-autonomous robots that can be given extremely high-level commands, 3) high-latency network links for uploading commands and receiving results and 4) extended duration.

The paper describes the findings of an ethnographic study, the subject of which was the documentation process in the teleoperation of Mars Exploration Rover 2003 (MER2003). Our findings were extended to formal documentation design requirements intended to guide future mission activities. The key requirement was to automate documentation, including streamlined multimodal information capture, automatic filtering and conversion of data, and self-organizing data objects for retrieval. An experimental system was created, tested, and found to be successful in limited simulations of mission activities. Our primary result is, then, a partially validated set of design recommendations for the interface to an auto-documentation system for robotic teleoperations.