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SPACE EXPLORATION SYMPOSIUM (A3)
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HYBRID ARCHITECTURE AGENT FOR EXOMARS ROVER-LIKE MISSION AUTONOMY

Abstract

The space community is paying increasing attention to the space exploration vehicles autonomy enhancement as an obliged path to gain better performance, flexibility, higher quality product return and even mission feasibility. In common with other Mars exploration missions, human supervision of Europe's ExoMars Rover will be mostly indirect via orbital relay spacecraft and thus far from immediate. The gap between issuing commands and witnessing the results of the consequent rover actions will typically be on the order of several hours. In addition, it will not be possible to observe the external environment at the time of action execution. This lengthens the time required to carry out scientific exploration and limits the mission's ability to respond quickly to favorable science events. To increase potential science return for such missions, it will be necessary to deploy autonomous systems that include science target selection and fast planning/scheduling problem solving. The paper discusses the design of hybrid architecture agent aimed to harmonize high level decision making processes and uncertainties facing to better simulate the human reasoning. A top-down reasoning to generate a feasible activities schedule from given goals and system knowledge together with bottom-up strategy to assure robustness to unavoidable uncertainties are applied to make the agent be reactive, on the very short term, and deliberative, on the long term scenario. The proposed architecture is made of a Planner/Scheduler, for enabling dynamic actions schedule generation, exploiting a Graphplan-like algorithm to search for a feasible plan, search for the actions, pre-loaded into the System KnowledgeBase, that satisfies the states required by each goal. Once the plan is created the agent uses the Simple Temporal Network representation as temporal reasoning engine, to create a flexible schedule. To deal with flexible schedules has the difficulty of accurately estimating the amount of resource that a flexible plan may need across all of its possible executions, in this work this problem is solved by computing the maximum resource envelope: for any possible time-value the maximum possible consumption among all possible schedules is computed. The Executer is devoted to map the Planner/Scheduler solution space formalized in time into the system hyperspace, the basis of the behavior-based system formalism; the Reconfiguration module is in charge of managing deviations from both the desired system state and the presumed environment conditions respectively. The hybrid architecture agent, presented in this work, has been tested on different, increasing in complexity, ExoMars rover-like simulated mission scenarios.