SPACE EXPLORATION SYMPOSIUM (A3)
Moon Exploration – Part 3 (2C)

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IN-ORBIT AUTONOMOUS ASSEMBLY OF LARGE STRUCTURES AND HABITATS FOR PLANETARY EXPLORATION USING PLANNING AND SCHEDULING TECHNIQUES

Abstract

Outer planetary exploration will require flagship missions with larger spacecraft, habitats and structures. Whereas these assemblies launched in low orbit may not need as much fuel or shielding and could be stronger built for the sole purpose of space travelling and living (e.g. ESA Moon Village concept) and hence, potentially capable of withstanding longer distances. Following this trend the space community has already build-up several structures like the Russian MIR station or the International Space Station (ISS), assembled from components launched on forty different launch vehicles.

Nowadays the challenge is to provide robust and autonomous software controllers being able to decide in-situ the best strategy to perform the assembly process. Such process will be dominated by the need of having different collaborative robotics spacecraft working together with adaptable levels of autonomy, ranging from ESA ECSS level 1 or teleoperation up to level 4 or goal-oriented. The proposed robotics autonomy approach will required an extended number of advanced artificial intelligence (AI) capabilities such as goal-based commanding, consistent and verified action-based planning, dynamic re-planning based on the received observations and new desired goals posted by internal intelligent systems or external on-ground new objectives, scheduling and execution of the plans interleaved with the decision-making processes ensuring an harmonic integration of deliberative and reactive behaviours.

Furthermore, robots are becoming more and more complex with higher degrees of freedom and enhanced sensoring skills. On the other hand reliable and repeatable behaviour is expected from the robots. Hence, there are a number of challenges to be further explored and assessed like the following ones:

- How can we combine the different levels of planning (task-level, motion-level, low-level controllers)? How can we harmonize planning with execution?
- How to deal with the limited on-board computer (OBC) capabilities, particularly for the space environment?
- Do we already have consolidated and verifiable planning languages such as the Planning Domain Definition Language (PDDL)?
- Which characteristics are required for safety-critical operating systems to support the typical dynamic and broad search-space needs of planning systems while maintaining its reliability, availability, maintainability and safety (RAMS) constraints?

This paper will answer to previous questions and will provide a detailed overview of the proposed autonomous goal-oriented controller system and its related designed components at deliberative, executive and functional layers. Preliminary results demonstrating successful decision-making capabilities will be described.