Commentary on: Enhancing NASA's Procedure Representation Language to Support Planning Operations

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Introduction

This paper by Pete Bonasso, Mark Boddy, and Dave Kortenkamp involves taking a language for representing procedures that is extremely similar to the language currently used by International Space Station (ISS) operators and enhancing with three features to facilitate reasoning about procedures within automated planners:

- Time – including durations and interval algebra;
- Metric resources – including usage, consumption, and production; and
- State – including pre- and postconditions.

The paper couches its discussion in the context of the interaction of PHALCON (Power, Heat and Light CONtrol) tasks and EVA (Extra Vehicular Activity) tasks when planning the removal and replacement of a DC-to-DC converter unit. In this scenario the PHALCON has to electronically isolate the unit from the rest of the ISS, astronauts then go outside to replace it, and finally the PHALCON electronically connects it into the rest of the ISS. As such, this scenario involves two control disciplines to perform the task.

Given this scenario, the authors analyzed how PHALCON and EVA tasks are planned. It turned out that the PHALCON derived tasks from a number of Microsoft Word files that form a repository of flight control procedures. On the other hand EVA tasks are developed from scratch due to their uniqueness. In each case, the procedure is couched as so many instructions with no formal information on how they change the status of the ISS.

To add this information, the authors chatted with cognizant flight controllers in order to rewrite the procedures with more domain knowledge. Since the objective is to eventually assist in the planning of these procedures, the authors then developed a mapping between the enhanced procedure representation language (PRL) and the planning language ANML in order to formalize semantics. The authors chose ANML for its strong notions of action and state with a variable/value model and support for temporal constraints and hierarchical tasks.

Lingering Questions

How are the original ISS procedures checked?

When analyzing the procedures used to support this scenario, the authors note that procedures are represented using human-executable Microsoft Word files. As such, they have more the flavor of a user guide than anything else. How are they checked for correctness? In the unmanned side of NASA, command uploads are typically simulated prior to radiation in order to check for correctness. Is this not the case on the manned side of NASA?

Won't the extra translation step limit a translation?

PRL to ANML and then ANML to Aspen or NDDL or PDDL… Might the intermediate ANML step restrict ways to represent PRL features in ultimate target languages?

Is every procedure on the ISS represented in PRL?

There seems to by multiple interacting planning domains on the ISS: PHALCON, EVA, … Do they all use the same PRL language? What about the flight controllers that map out an astronaut's day?

Conclusions

This paper was quite interesting, but the most interesting part was the statement that the PHALCON and EVA flight controllers typically plan with actions that are actually sub-procedures of the formal procedures maintained online. This suggests that the authors have good a chance at making a real impact once they figure out how to enhance the online procedures to determine which sub-procedures are relevant for execution when. Of course, the issue of maintaining a model of the entire ISS with resources, locations of tools, and all of its state information is a non-trivial undertaking.

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