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CONFIGURABLE ARCHITECTURE FOR FULLY AUTONOMOUS ROVER OPERATIONS

Abstract

The next decades will bring a significant increase in space exploration activities to accomplish ambitious goals, such as supporting a stable human outpost on the Moon and launching the first manned missions to Mars. In this view, robotic missions will be crucial for technology demonstrations and developing supporting infrastructure. Besides, science rover missions are expected to continue with increasingly demanding objectives.

The current approach to rover autonomy is insufficient to sustain the foreseen growth in the number, variety, and complexity of future robotic missions. Conversely, a paradigm change is needed at both system and algorithmic levels. First, autonomy software must be general and configurable to maximize reusability across several missions with diverse requirements. Second, autonomy capabilities must level up toward full mission autonomy. This would allow reducing development effort for each mission while: i) improving mission return, ii) enabling new mission concepts, iii) reducing dependency from ground control.

The paper will present a configurable architecture for fully autonomous rover operations in terms of situational awareness, planning, and navigation. The system is conceived as a library of interconnected but independent modules, each one implementing a single function that can be included, removed, and tailored to meet the requirements of each mission. For instance:

- different modules can cover the path planning requirements of different operating modes (e.g., travel between waypoints or sweeping an area for regolith collection);
- on-board processing modules associated with payload data streams generate actionable information for decision-making, as well as servicing autonomous payload operations (e.g., accurate targeting for drilling/sampling operations via analysis of close-up images);
- service functions for navigation, such as localization or terrain analysis are modular and can adapt to different sets of available sensors (e.g., availability of absolute localization data, ground-penetrating radar for sub-surface prospection).

Artificial intelligence is envisioned to boost algorithms' performance with respect to classical approaches in critical tasks, such as trajectory control with obstacle avoidance, both static (rocks) and dynamics (other rovers or astronauts).

As the software is still under development as internal research in AIKO, the presentation will focus on the overall system description, algorithmic solutions for each module, and expected benefits of such architecture with respect to currently available solutions.