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DEFINING THE SOLUTION SPACE FOR AUTONOMOUS CONTROL OF IN-SITU ASTROBIOLOGY MISSIONS

Abstract

In-situ astrobiology missions, particularly those studying planetary bodies in the outer solar system and beyond, pose a unique challenge in terms of command, control, and communication. In addition to facing signal delays when attempting long-distance communications, many in-situ missions must also cope with long stretches of periodic signal outage during planetary nighttime during which the in-situ probe is unable to communicate with Earth-based ground control at all. Thus, relying solely upon user input to control the system is not only impractical, but potentially detrimental in cases where a fault in the system requires immediate action. Autonomous control offers a solution to this issue by means of partially relegating control to an algorithm or set of algorithms responsible for monitoring mission health, taking preliminary action in the case of a fault, optimizing data transmission, and potentially making mission decisions based on scientific data analysis.

Though autonomous control systems for navigation, propulsion, and robotic motion are moderately well-documented in the deep-space context, autonomous control for science tasks, particularly sample analysis on astrobiology missions, poses a more daunting challenge. This is due to the large level of critical thinking – traditionally relegated to humans - involved in analyzing data and making preliminary assessments of what further science tasks need to be done. The author presents an analysis of the levels at which autonomy can be implemented across several subsystems in order to mitigate risk, as well as a risk analysis of the utility of autonomous functionality for astrobiology mission-relevant use-cases.