National Aeronautics and Space Administration

Unified Processing for Robotic Icy Terrain Exploration

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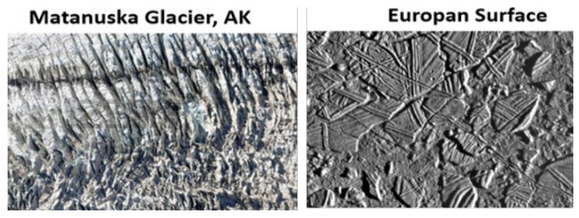
Program: Strategic R&TD

Project Objective:

Traversing similarly complex and dynamically changing environments of the Earth's strategically important Arctic as well as our solar system's Ocean Worlds is challenging problem for mobility systems.



Actively articulated rovers can leverage redundant mobility modes to traverse differently in different conditions. On board reasoning will enable a rover to switch modes base don real time feedback.

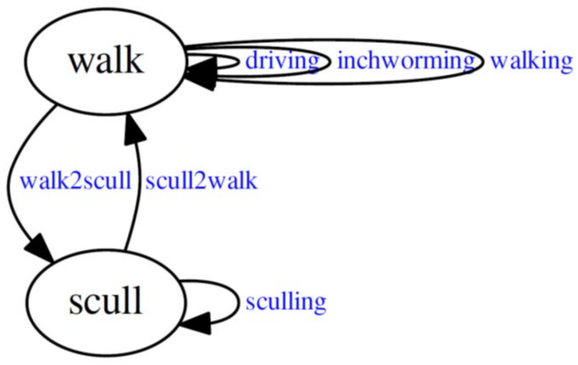
Benefits to NASA and JPL (or significance of results):

NASA and other JPL sponsors face similar challenges in robustly traversing icy terrains, particularly when communications are limited in frequency and bandwidth and system energy is severely constrained.

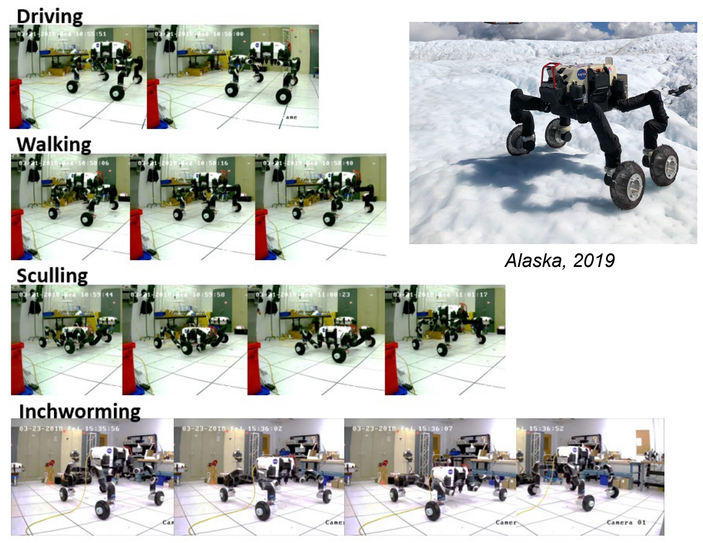
Why this is important to JPL: These capabilities will provide JPL a competitive advantage in programs related to strategic control of Arctic regions and bolster the surface system mobility technologies available for Ocean Worlds and unstable regions of Mars and other bodies

FY18/19 Results:

Reinforcement Learning on a Behavior Graph



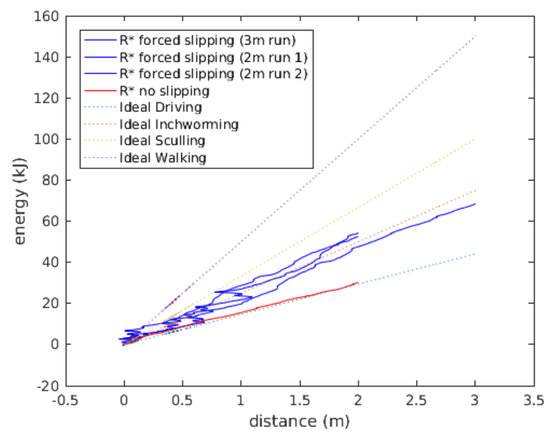
Automatically Selecting Between Redundant Mobility Modes on JPL's RoboSimian



Alaska, 2019

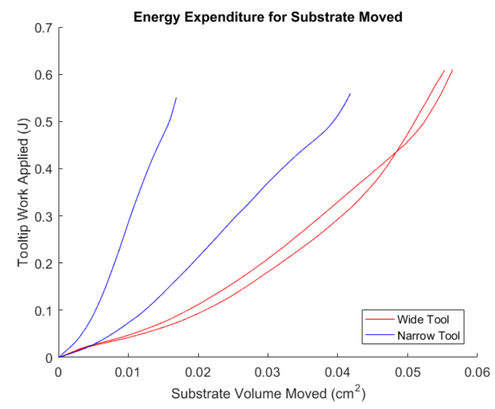
Mobility Modes:

- Mode Selection based on Energy Efficiency Feedback (m/kJ)



Manipulation Modes:

- Tool selection based on energy used per unit volume of substrate moved



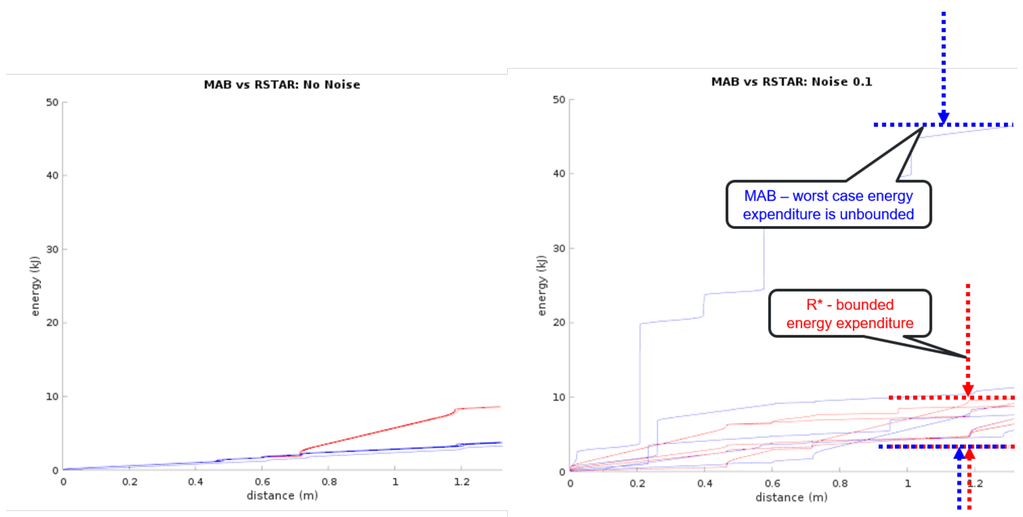
Key Quantitative Metric:

Number of decision points without human intervention

A decision point is an event when a choice is made between two equally feasible approaches to achieve a task. Each decision point corresponds to a sequence of commands being send to a robot's command executive. On RoboSimian, onboard reasoning resulted in a 40x reduction in decision points for a 10m multi modal mobility traverse.

A new validation procedure:

A new v&v procedure was developed in FY19 to validate and quantify performance of onboard learning algorithms. The central idea of the procedure is to inject noise in feedback signal and validate bounded performance.



Publications:

- P. Tavallali, S. Karumanchi, W. Reid, J. Bowkett, B. Kennedy, *A Reinforcement Learning Framework for Space Missions in Unknown Environments*, IEEE Aerospace Conference, 2020.

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