An Ultra-Light Weight Perching System for Sloped or Vertical Rough Surfaces on Mars

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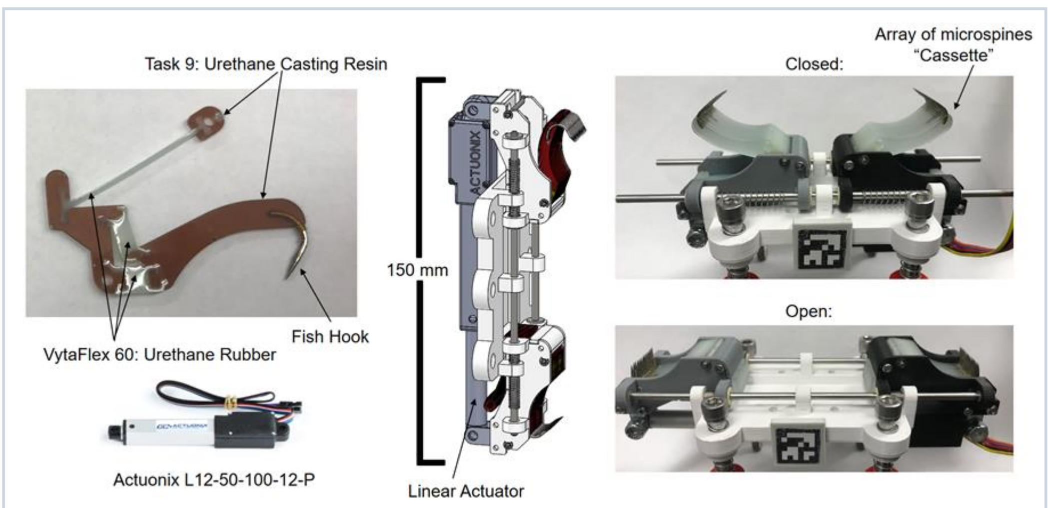
Project Objective:

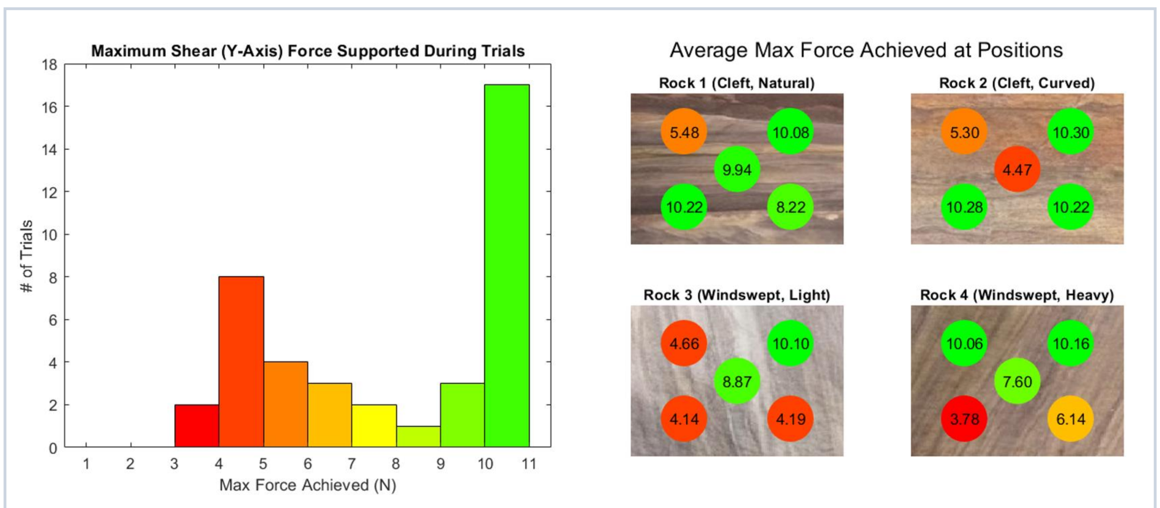
- Developing an ultra-light weight (< 10 percent of total system mass) perching mechanism and perception system that empowers a Martian flying vehicle to perch on steeply sloped or vertical walls to study and gather samples from otherwise inaccessible science targets.
- Steep slopes are often associated with geologically and astrobiologically interesting features, being sites of active modification (e.g. landslides/avalanches, slope streaks, RSL), exposed bedrock and/or ice, as-yet unmodified young features (e.g. walls of fresh craters or polar pits that are actively expanding), and sites of flowing water.

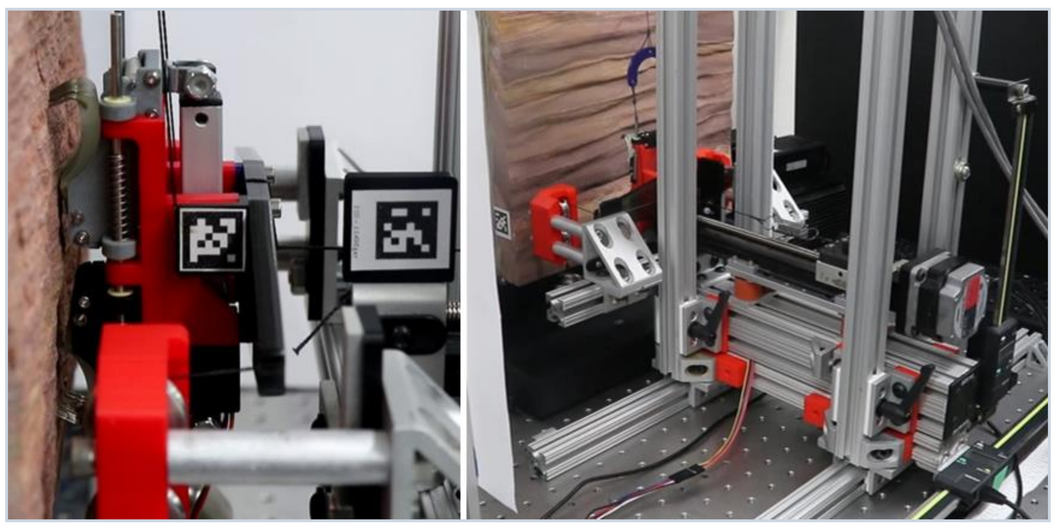
FY19 Results:

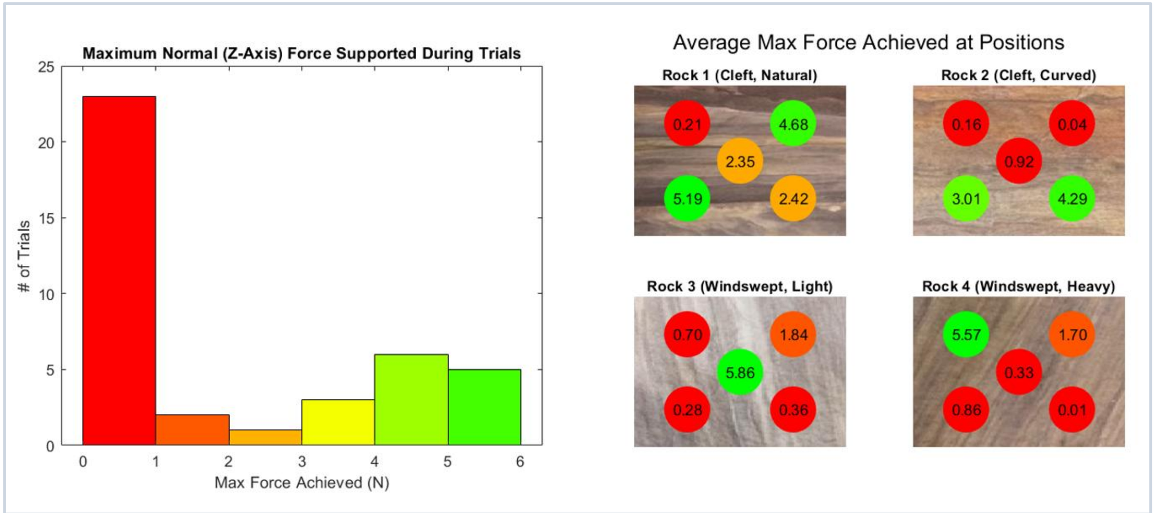
Gripper Prototype and Testing

- Designed and prototyped a light weight perching gripper composed of two opposed sets of spines to resist forces in all directions. The gripper itself relies on elastic averaging to share loads between spines.
- Experimentally characterized gripper prototype on a test bed by measuring the adhesion forces on a series of representative target surfaces of different shapes (curvatures and slopes) and roughness profiles.
- The gripper was attached to the test surface and slowly subjected to an increasing amount of force until it reached a desired maximum force threshold (10 Newtons in shear and 5 N normal to the surface).







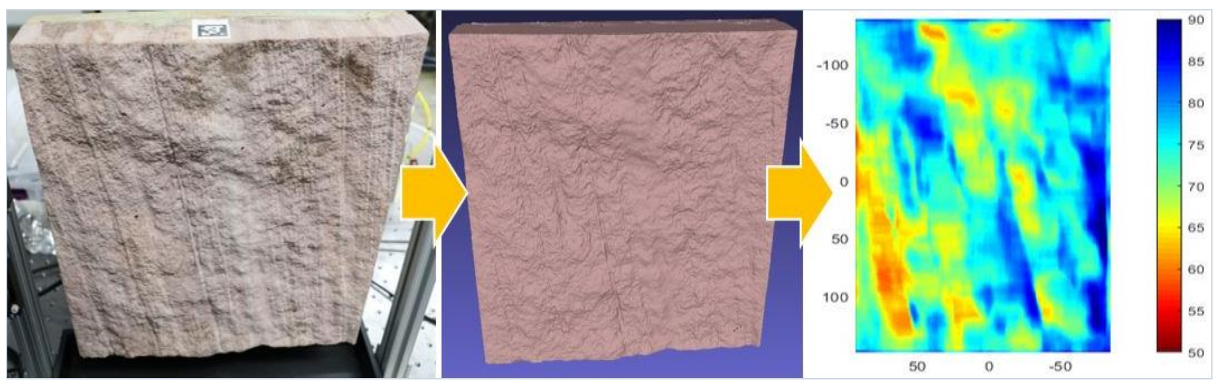


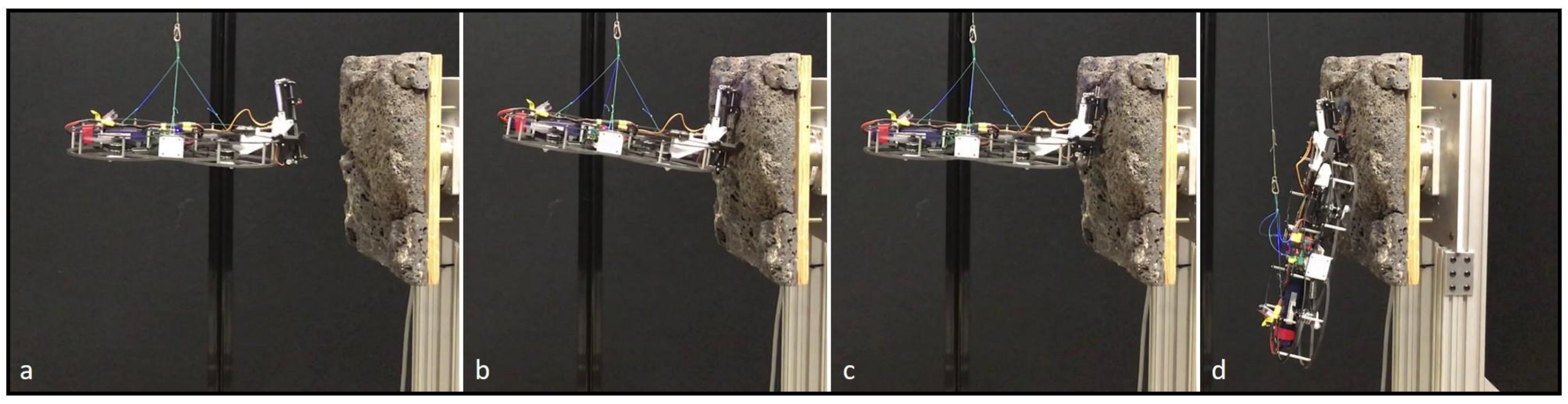
Perching Test

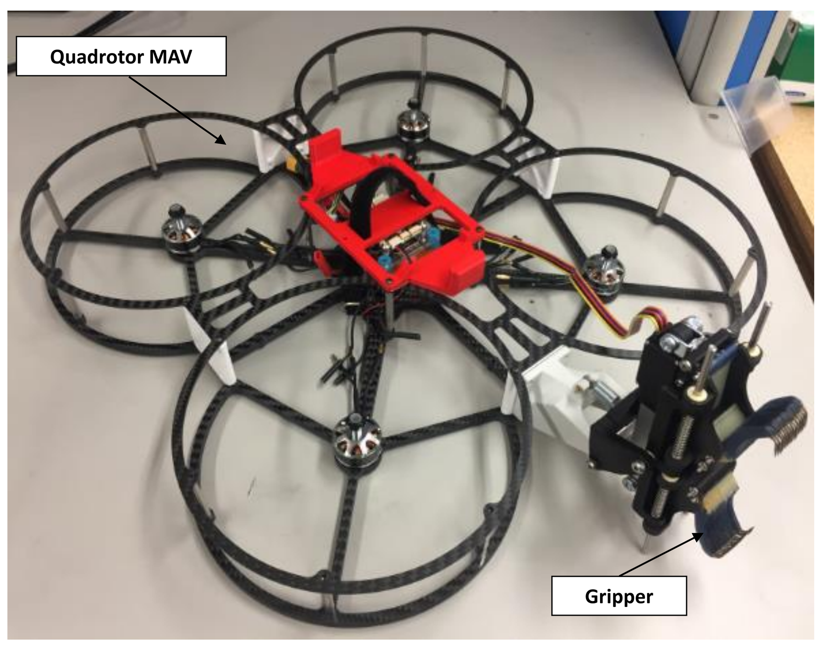
Tele-operated flight testing of the vehicle with integrated gripper demonstrated successful perching on vesicular basalt, a highly graspable rock type. The UAV perched successfully four times in a row, suggesting that the concept (outside the gripper itself) is suitably deterministic.

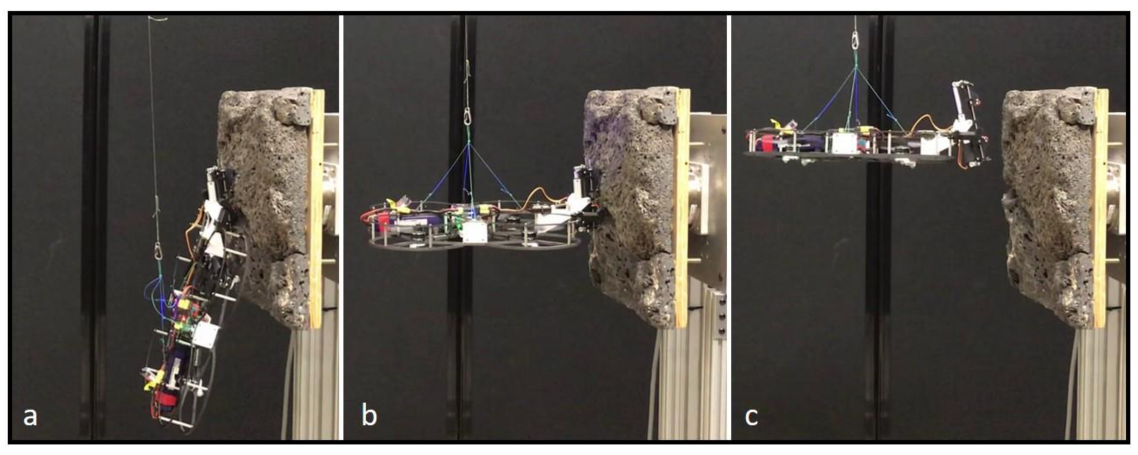
Perch-ability Prediction

Methods to predict grasp quality based on surface scan data are being explored.
Example: grasp quality metric based on the orientation of surface normals relative to the spines. Inclined (redder) regions are expected to exhibit the best grasp performance.



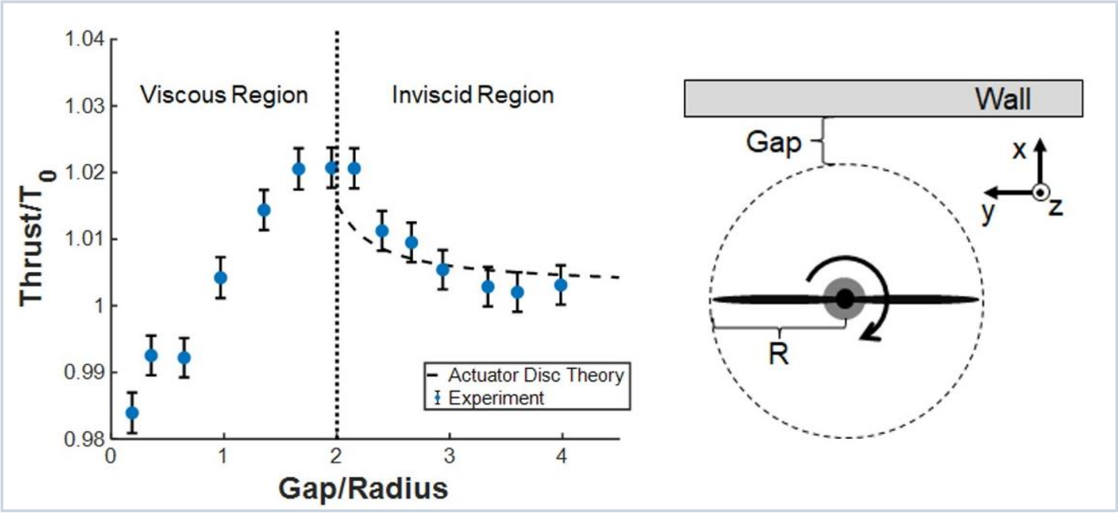






Aerodynamic Effects

Aerodynamic considerations can impact both gripper site planning and the real-time operation near the wall. Initial developed actuator-disc models predict thrust variations on the order of 2-5%, which is in agreement with experimental results up to one rotor diameter from the wall. Predictions closer than one diameter are an ongoing investigation.



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

The developed perching system will significantly impact JPL by enabling new missions to investigate large sections of steeply sloped or vertical terrain (e.g., Valles Marineris, craters, caves, pit or fissure walls) on Mars. The proposed mechanism can also be adapted by other flying systems (free-flyers, CubeSats, etc.) to perch onto surface of comets, asteroids, the Moon or Phobos to study the surface, extract samples, and recharge batteries.

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