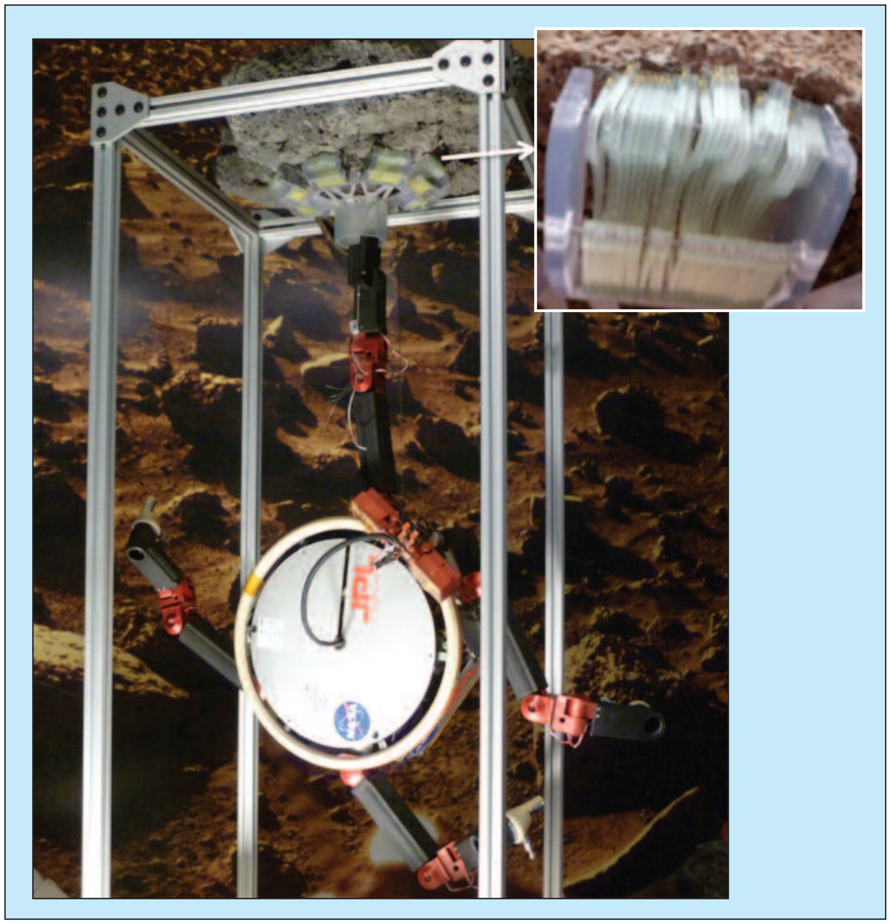
Rock Gripper for Sampling, Mobility, Anchoring, and Manipulation

This spine/claw-based technology has applications in military robots that need to climb natural rock surfaces or caves for reconnaissance purposes, or for revealing buried explosive devices.

NASA's Jet Propulsion Laboratory, Pasadena, California

A new gripper mechanism can be used as an end effector for a long arm that reaches out from a nearby spacecraft for a touch-and-go type of mission. The gripper would stabilize the arm and allow samples to be collected and in situ science to be done from a fixed platform. In the long term, this style of gripper could even be used as handholds for astronauts trying to move about on/near small asteroids. The prototype developed has demonstrated a 120 N gripping force, and improvements continue to be made.

The gripping mechanism is useful not only for low-gravity bodies, but for steep surfaces on Mars and the Moon. The clawed toes used in the gripping mechanism were originally developed for climbing rough surfaces like brick and tree bark, but have been expanded in this work to attach to natural rock surfaces. Using an opposed gripping mechanism provides the maximum stability for this type of system, where reliability is critical. In a similar application on Earth, these grippers allow the exploration of cliff faces, cave ceilings, glacial ice features, and underwater reefs and sea floor. This gripper can also be used as an under-actuated robotic hand for grasping, manipulating, and probing rocks on the surface of a planetary body.



The **Lemur IIb Robot** hangs its weight off of a vesicular basalt rock using a prototype gripper.

The gripper uses several hundred microspine toes that each have an independent suspension system, allowing them to conform to a rock surface and find a suitable asperity to grip. Each microspine toe consists of a steel hook embedded in a rigid frame with a compliant suspension system. By arraying tens or hundreds of these microspine toes, large loads can be supported and shared among many attachment points. The hooks can attach to both convex and concave asperities like pits, protrusions, or even sloped rock faces.

This design is scalable to loads as small as a few Newtons and as large as 1,000 N or more, as demonstrated by previous work in climbing configurations. To create an omni-directional anchor, eight rows of 30 toes each were attached to an octagonal center housing. Each row of toes is held in place by a leg that acts as a lever with the pivot point at the outer rim of the housing. Several lever dimensions were tried empirically to determine a good ratio of lengths. The center of the housing is hollow, providing an accessible location for mounting the anchor to the leg of a robot or placing a sampling tool like a coring drill.

Microspine technology is extended with the development of mechanisms that create internal forces at the foot-scale for arrays of microspine toes in opposed configurations. Locating internal forces at the foot-scale decouples the limbs, allowing each leg to attach/detach independently. This reduces the control demand on the robot and lowers cost and weight.

This work was done by Aaron Parness of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.

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