MICROBOTS FOR LARGE-SCALE PLANETARY SURFACE AND SUBSURFACE EXPLORATION

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ABSTRACT: This proposal presents a new robotic planetary exploration concept based on the deployment of a large number of small spherical mobile robots (microbots) over vast areas of a planet's surface and subsurface, including structures such as caves and near-surface crevasses (see Figure 1). This strategic exploration architecture can enable extremely large-scale, *in situ* analysis of scientifically interesting properties thus enabling a new paradigm for Solar Systemwide exploration, mapping, and scientific study. This approach represents an important alternative or augmentation to current rover and lander-based planetary exploration, which is limited to studying small areas of a planet's surface at a small number of sites. The proposed approach is also distinct from balloon or aerial missions, because it allows *in situ*, direct-contact measurements. Once developed, such units can be custom-tailored to specific mission targets with minimal additional cost. In the proposed mission concept, a large number (i.e. hundreds or thousands) of 10 cm-scale, sub-kilogram microbots would be widely distributed by orbital craft, from aerial platforms, from a lander, or even by lunar or Mars astronauts. The microbots employ hopping, bouncing, and rolling as a locomotion mode to reach scientifically interesting features in very rugged terrain. The units will be powered by high energy-density polymer muscle actuators, and equipped with a suite of miniaturized instruments selected for each specific mission, e.g., imagers, spectrometers, or chemical detection sensors. Multiple microbots will share information and cooperatively analyze large portions of a planet's surface or subsurface. Numerous units allow for considerable mortality without jeopardizing the mission. In this proposed Phase II study, a detailed microbot mission scenario will be developed for a planetary reference mission suite. Enabling technologies for actuation, power, sensing, and communication will be surveyed. Fundamental research on muscle actuators and microbot mobility mechanisms, and efficient coordination algorithms will be developed. A small number of prototypes will be produced and tested in field conditions in New Mexico. Work will be conducted by a multi-university team of engineers and scientists at MIT, New Mexico Institute of Mining & Technology, and Stanford.