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Proof of Concept Study for Small Planetary Rovers using Tensegrity Structure on Venus

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ABSTRACT

Venus is a planet that we would very much like to further explore and understand. However, the surface of Venus is very hostile environment with a surface temperature averaging 452 degrees centigrade at an atmospheric pressure of 93 bar, with the atmosphere composed mainly of carbon dioxide with clouds of sulfuric acid. Missions to the surface of Venus have succeeded, but mission lifetime is extremely short, on the order of minutes to hours, until materials melt and electronic components fail due to the extreme conditions. A small rover that would be capable of exploring the surface would be scientifically valuable, but requires unconventional thinking to be able to survive the environment. We present a study of means by which to design a small planetary rover that uses a bio-inspired flexible tensegrity structure and operates mechanically to utilize the conditions of the Venusian surface in its operation.

Tensegrity robots make use of geometrically-inspired and bio-inspired structures that allow multiple degree of freedom movement. These structures are sparse, composed of linked tension and compression members in a similar manner to a truss, and are very lightweight compared to traditional mobile robots and retainin the ability to flexibly adapt to terrain and fold for transport. The use of a tensegrity structure also has benefits in terms of simplicity of structure, in the sense that structural elements are simple and repeatable, held in place only by the tension of materials. This allows tensegrity rovers to utilize smart materials and structural properties in operation, without the use of complex joints and bearings to allow full-body movements. The use of flexible structures allows the rover to transform and re-configure itself to a limited extent in the field in response to environmental factors.

In this paper, a concept and feasibility study of a small tensegrity rover that utilizes mechanical operation will be examined for Venus exploration, with consideration of previous missions and their lessons. The use of the rover for scientific exploration will also be justified. The results of this study will also benefit terrestrial applications that require robotic operation in the presence of extremes of temperature and pressure. The work will be used for the development of space technology for very harsh and hot planetary exploration.