SPHERICAL ROVER FOR LUNAR AND PLANETARY EXPLORATION. Jordi L. Gutiérrez[1] and Joshua Tristancho[2], [1]Departament de Física Aplicada, Escola d'Enginyeria de Telecomunicació i Aeroespacial de Castelldefels, Universitat Politècnica de Catalunya (jordi.gutierrez@upc.edu), [2]Escola d'Enginyeria de Telecomunicació i Aeroespacial de Castelldefels, Universitat Politècnica de Catalunya (joshua.tristancho@upc.edu).

Introduction: Historically, planetary and lunar rovers have been wheeled-driven. While this is usually seen as an advantage –due to the flight experience– in some cases, the unavoidable presence of gears and mobile parts can be a significant hazard to the mission. The abrasive lunar regolith has been the origin of substantial problems with the Apollo rovers.

Here we propose a completely different scheme: a spherical rover in which all the moving parts are protected from the environment by an external spherical shell.

Roving mechanism: The rover moves by displacing a mass from its equilibrium position. Once perturbed, the rover rotates to gain its equilibrium orientation. By perturbing this equilibrium the rover can move, and even climb slopes. There are two important figures of merit of these kind of rovers: the ratio between the counterweight mass and the total mass (μ), and the ratio betwen the position of the center of mass and the radius of the spherical shell (δ). Then, the maximum slope that can be climbed is

$$\beta_{max} = \sin^{-1} (\delta\mu) \qquad (1)$$

It must be noted that both δ and μ are less (or equal in the extreme, unfeasible, case) than 1, and that to obtain this expression we have assumed that the sphere does not slide. For typical cases, $\delta \approx 0.7$ and $\mu \approx 0.5$, which allows the rover to ascend slopes of less than 21 degrees. Our goal is to design the rover in such a way that it would be able to climb slopes up to 35 degrees, near the limit slope for regolith. This can be done, for example, by substitutind the dead counterweight mass with batteries and/or other massive components.

The rover can also steer by displacing the counterweight sideways of the translation path. In this way we can control the direction in an effectively manner.

By its simplicity, the propulsion mechanism is very robust, and hence it offers a high level of safety at a minimum cost.

There are several similar, indipendent designs in the literature, as can be seen in [1,2].

Open issues: There are still some open issues. The most important is related to the endurance, as the spherical shell is not very apt as a solar cell substrate. In any case, even if we had solar cells on the surface of the rover, they would be covered by regolith, and their efficiency would be severely dimisnished. To deal with this problem we are exploring the possibility of employing wireless power transmission [3,4]. In this case, the lander (mandatory for our rover design) would act as the energy provider; the energy could be relayed by laser means (with the problem again of the regolith covering the outer surface of the spherical shell) or by resonant inductive coils [3,4,5]. To do so witha good efficiency, it is essential that the resonant coils are alineated; this is not a problem, as the classical ball-plate problem has been satisfactory solved, and efficient algorithms are provided by [6].

There is also an issue with communications, that we have solved by using small antennas whith controlled phase shifts to modify the antenna pattern and make it more directive. The lander, provided witha high gain antenna, would then be used as a radio relay.

Thermal control will be provided by a completely passive system employing surface coatings (affected again by the regolith and its thermal properties) and by an interior shell of aerogel.

Applications: this kind of rovers can be used in several ways. The first one is as stand-alone exploration rovers, carrying experiments and cameras to points up to several hundreds of meters to the lander. Even if the lander is the main scientific vehicle, the landing procedures will perturb the state of the regolith near to the lander, thus modifying to some degree the scientific results. Having the possibility to move a few tens of meters (well beyond the reach of robotic arms) would ensure the access to pristine materials. They could laso act as scouts –or navigation aids– for larger, more advanced rovers. These rovers, probably wheel-driven, or leg-drive, have a typical speed much lower than spherical rovers, and safety issues would preclude its use on rough environments, like inside craters, where these small rovers could extend the mission's operational capabilities. In all cases, the algorithms [6] used to align the coils in the case of using resonant inductive coupling would easilly allow to point the experiments carried on the spherical rover if necessary.

References:

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