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Author: Mr. Pedro Roque
Institute for Systems and Robotics, Portugal

Prof. Paolo Fiorini
Università degli studi di Verona, Italy
Prof. Rodrigo Ventura
Institute for Systems and Robotics, Portugal

MOONHOPPER: CONCEPTUAL DESIGN OF AN HOPPING ROBOT FOR LUNAR EXPLORATION SUPPORT

Abstract

Lunar exploration has recently been gaining a significant amount of attention, both from governmental agencies and from the industry. One of the challenges in this exploration consists in the determination of natural resources for in situ resource utilization (ISRU). Robot rovers have been used for this task in the past, but their mobility is challenging due to terrain conditions. These have been typically operated remotely from Earth, demanding a human team to analyse sensor data and make decisions on where to go next. Fully autonomous rovers has been an active topic of research, but guaranteeing safety during motion in rough terrains is still largely an open problem. However, an alternative locomotion mechanism has been proposed in the past to cope with the challenge of navigating in rough terrains, called hopping robots. Their locomotion is based on ballistic hops powered by either elastic energy or chemical propellant. These allow for traveling larger distances in rough terrain while being less sensitive to the terrain conditions. However, this technology has not been validated outside laboratory, having reached a TRL of about 4. In this project we aim at bringing this technology to at least TRL 6, by proposing a full integrated robot platform. The platform we propose in this paper targets both remote sensing, taking advantage of the height of the hops, as well as small sample collection. The hopping mechanism is capable of trading elastic potential energy, stored in an external flexible cage, for kinetic energy to perform a controlled jump. In addition, this cage absorbs energy when the robot lands into the ground, thus protecting the internal equipment. During flight, attitude control is performed using internal reaction wheels, allowing for both orientation of the sensors to target areas, as well as setting the best attitude for landing, in order to protect critical equipment, such as cameras. Spring loading the cage is energetically demanding, so power storage is critical. We propose an origami solar panel array for battery charging. Sensors, such as cameras, are protected from lunar dust by an opening mechanism, while the altitude is low. The robot is also equipped with a spike-like mechanism for small sample collection. This paper presents a preliminary design of this robot, including mechanical design and preliminary simulations.