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INFRARED VISION-BASED NAVIGATION FOR PLANETARY LANDING

Abstract

Amongst the most helpful missions for planetary exploration are those planning to land a spacecraft for on-site analysis and experimentation. The task of landing on a planetary surface is not trivial. The lander must be provided with a fully autonomous navigation system capable of handling the extremely complex and delicate descent towards ground. A revolutionary technology in this field has recently witnessed a great successful implementation with JAXA's SLIM mission: Vision-based Navigation. By extracting salient features from the images of one or multiple on-board sensors and tracking them during motion, position and orientation of the spacecraft for each consecutive frame can be retrieved with respect to the observed scenario. This allows to provide the data necessary to carry out landing navigation and hazard avoidance with unprecedented accuracy. The strategy, however, is strongly dependant on the scene's illumination. This work investigates the possibility of freeing Vision-based Navigation from said limit by assessing the possibility of working in the infrared band. If possible, this would significantly improve the flexibility of landing strategy design for future missions. The study is a preliminary evaluation of the effectiveness of visually assessed algorithms on infrared planetary surface frames. The fundamental idea is to exploit the basic architecture of Vision-based navigation systems for planetary landing but providing infrared images as input in place of visual ones. Through a detailed review of many Computer Vision algorithms and the various approaches exploitable for a spacecraft landing scenario, a selection of the most compatible for the study is made. Realistic image sequences simulating the approach of a lander, provided with a monocular infrared sensor, to the Martian surface are created by manipulating real infrared mosaics from Mars Odyssey and used for extensive testing. Algorithms are executed on these image sequences to find out if Infrared Vision-based Navigation for planetary landing is possible and under which conditions. Specifically, robustness against motion disturbance and for various Martian regions is assessed on real infrared frames taken both during the day and at night. After evaluating feasibility, the effectiveness of some simple performance enhancement strategies is demonstrated and the algorithms most compatible with the application identified. Finally, algorithms are ran on a BeagleBone Black board to retrieve indications for realistic computational times. Results suggest that the technology requires a lot of work for optimizing both robustness and computational times but definitely has great potential and should be further investigated.