SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Upper Stages, Space Transfer, Entry and Landing Systems (3)

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VISION BASED HAZARD DETECTION FOR PLANETARY LANDING: GROUND EXPERIMENTAL VALIDATION

Abstract

Nowadays space exploration is moving further towards robotic missions with in situ analysis and planetary samples return. Among others, the safe, re-targetable and precise landing is a mandatory requirement which entails a strong level of on board autonomy to make the maneuver timely, effective and robust, no matter of the Earth-planet distance, which may significantly affect the communication chain delays, with potentially catastrophic consequences for the safe touchdown success. Moreover, planetary surface morphology is often roughly characterized before being in the natural object proximity. Therefore while the landing site is precisely identified according to its scientific and commercial benefits, it turns out to be largely affected by uncertainty on its surrounding morphology and hazardousness, an awareness that is needed to smoothly drive the lander to its target. It is straightforward that an autonomous landing system capable of safe pinpoint landings would improve in situ exploration missions' flexibility and performance. Several building blocks constitute an autonomous landing system, among which one of the most critical is hazard detector. This system works on data fused from the on board Terrain Relative Navigation (TRN) sensors, being those typically optical sensors: LIDARs allow directly reconstructing the 3D terrain maps, being heavy and expensive sensors; cameras, either in mono or stereo configuration, adopt simple image processing techniques to recognize hazards but they typically struggle in non-sharp terrain features, such as smooth slopes, recognition. The paper described the algorithm implemented at Politecnico di Milano (PoliMi), based on single camera data acquisition and image processing through a tailored Artificial Neural Network (ANN) architecture: the algorithm, based on single camera, outputs the hazard map, together with the target landing site. At the time being, the algorithm has been tested and verified with real images both from NASA – LROC and Rosetta NAVCam missions. The tool is computationally light enough to run on board during the landing phase and it is cost effective and power efficient. To further increase this technology readiness level, the algorithm is being tested on a dedicated ground facility under developed at PoliMi, which includes real hardware in the loop for proximity maneuvering testing. The paper critically discusses the latest results obtained by enhancing neural network architectures and assesses its performance in various environmental conditions. The experimental tests strategy and preliminary results obtained at PoliMi premise are shown.