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A NEW GROUND FACILITY FOR EXPERIMENTAL TESTING OF VISION-BASED AUTONOMOUS PLANETARY LANDING

Abstract

The next generation of space missions is going to require an increasing level of autonomy in operation planning. The relatively short duration of the maneuver, the impossibility, in some cases, to characterize the landing site in advance with the required detail, and the fact that most scientifically interesting targets are often placed in hazardous areas, make the planetary landing one of the most challenging problems. Future landing systems will require a high degree of autonomous navigation, Hazard Detection and Avoidance (HDA), and retargeting capabilities. Vision-based system are a promising technology to answer the challenge, but the necessary robustness can be ensured only with in-depth testing and validation. Analog facilities, capable to simulate a landing in a scaled environment, can supply repeatable and controllable datasets.

This paper presents the design, integration, and testing activities of a new experimental facility under development at Politecnico di Milano, Aerospace Science and Technology Department (DAER). The system, focused to the simulation of planetary landing, includes a 3D terrain diorama, visually simulating the planet surface; a 7DoF robotic arm, carrying a suite of navigation sensors (mainly a camera, together with possible additional sensors required by the specific algorithm under test); an illumination system, that excludes external light sources and supplies a controllable realistic illumination; a control unit that interfaces GNC algorithms with the sensors and the robotic arm.

Sensors are moved over the diorama, providing images and other measures representative of landing maneuvers; different scale factors can be adopted, simulating different landing subphases. The facility is designed for different test activities: sensors can be moved along predefined trajectories, operating as a simple dataset generator; software-in-the-loop simulations are possible by coupling the GNC algorithms with the simulation of the spacecraft dynamics. Furthermore, the system is designed to be compatible with hardware-in-the-loop tests with minimal upgrade.

For navigation testing purposes, the camera pose w.r.t. the terrain surface must be measured with precision and accuracy at least one order of magnitude better than what is expected by the algorithms under test. In practice, the actual value depends also on the maximum scale factor considered. A sub-millimeter precision has been obtained by optical calibration of the diorama, exploiting dense matching techniques. Two different algorithms, developed at DAER, have already been tested: a vision-based navigation system, based on features extraction and tracking, and a hazard detection and target selection system, based on artificial neural networks. Preliminary results are shown and discussed.