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SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
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DEEP MACHINE LEARNING IN VISION BASED HAZARD DETECTION FOR AUTONOMOUS PLANETARY LANDINGS: ADVANCEMENTS AND GROUND VALIDATION

Abstract

In the next decades, space exploration missions will require a step forward in navigation and landing precision. Interesting areas on planetary surfaces are often surrounded by dangerous terrain portions, making impossible for current landers to approach safely those zones. The distance between the probe and the ground control segment imposes a major level of autonomy as well, due to the impossibility to respond to unexpected events and uncertainties. Nonetheless, landing sites areas are often not enough detailed before the probe approach, jeopardizing the scientific or commercial goal achievable by the mission. Among the most promising techniques under development, a visual based approach represent one of the most promising, especially considering, but not limiting to, all those missions in which LIDARs cannot be exploited due to the mass and power constraints. The following paper describes an hazard detection system with target landing site selection capability that operates by means of a mono-camera acquiring images in the visible spectrum. The image is processed by a deep learning neural network, properly trained on ground with synthetic images. The neural network output represents the hazard map, in which each pixel indicates the hazardousness of the corresponding terrain surface in the image. A target landing site selection subroutine computes all the suitable landing sites present on the hazard map, taking into account the lander geometry. The sites are then ranked in terms of distance with the nominal landing site of the mission, the hazardousness and the landing surface: the first in ranking is the designated target landing site, the second is the backup landing site. To verify, validate and test the aforementioned hazard detector and more in general vision based navigation systems, at Politecnico di Milano - Dept. of Aerospace Science and Technology (PoliMi - DAER) premises, an experimental facility has been built and set-up. It is composed by a 7 degrees of freedom robotic arm carrying the sensor suite and simulating the lander dynamics; a planetary diorama spanning 2.4 x 2 m; a lightning system reproducing the correct planetary environmental lights; acquisition and control systems. The paper critically analyzes the performances of the hazard detector with synthetic photo realistic images, real images of the lunar surface. First validation tests of the hazard detector by means of the experimental facility are shown.