SPACE EXPLORATION SYMPOSIUM (A3)
Moon Exploration – Part 3 (2C)

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VALIDATION OF A LIDAR-BASED HAZARD DETECTION AND AVOIDANCE SYSTEM FOR AUTONOMOUS PLANETARY LANDING

Abstract

Interest is currently growing among international space agencies in order to realise future Moon and Mars exploration missions. Along the critical path to achieve this goal, advanced guidance, navigation and control technologies are required in order to guarantee manned and unmanned spacecraft safety and accuracy when orbiting and landing on the surface of celestial bodies. To successfully achieve these objectives, the spacecraft must have the ability to autonomously perform critical landing operations. These operations include self-localization based on landmark tracking, trajectory guidance and detection of surface hazards and guidance toward safe landing areas. Such technologies are clearly identified as critical for the success of upcoming international lunar landing programs to the Moon such as ESA NEXT Lunar Lander, NASA ALHAT and JAXA SELENE-2.

Many challenges exist in the validation of autonomous Guidance, Navigation and Control (GNC) and Hazard Detection and Avoidance (HDA) systems for planetary exploration. This validation must guarantee the system can operate autonomously in real-time and is robust to a specified envelope of dynamical and environmental conditions.

The first validation step is typically computer simulation, where the hardware and the environment are modeled in software. However, this type of validation is somewhat limited as the interaction of navigation and HDA sensors (such as camera or a Lidar) with the landing environment and the impact of Lander motion on the quality of the sensor data are difficult to model with a high level of fidelity and computationally too intensive to allow real-time validation.

The second step is hardware-in-the-loop simulations. In this context, the simulated sensors are replaced with actual sensors, so the software processes actual sensor data. To support this validation layer, a Landing Test Facility (LDTF) has been developed by the authors. This facility has the capability to reproduce in closed-loop the scaled motion of a lander in a laboratory environment, thus emulating the environment and the dynamical conditions of the sensors in a landing sequence. It also includes mock-ups of the Mars and Moon surfaces to adequately reproduce the sensor measurements in a laboratory environment.

Finally, the last step is closed-loop full scale simulations. These simulations are typically performed either with helicopter platforms, sounding rockets or prototype lander platforms.

The paper first addresses the different methodologies which have been established to validate autonomous GNC and HDA systems. Then, examples of laboratory and helicopter validation results of Lidar-based HDA systems for autonomous landing on the Moon are presented.