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VISION-BASED NAVIGATION SYSTEM FOR MARCO POLO-R ASTEROID SAMPLE RETURN MISSION

Abstract

Robotic exploration missions to small bodies require advanced technologies. One enabling technology is the Guidance, Navigation Control (GNC) system. The requirements on the GNC for these missions are very demanding. Cost shall be minimized, reducing the sensor suite. Tight orbital and landing performances are required. Furthermore, robustness is fundamental because of the high level of uncertainty of environment. An autonomous GNC system for descent and landing (DL) has been developed by a consortium led by GMV under ESA contract (4000107209/12/NL/HB). The GNC system is based on advanced algorithms, and low-cost, off-the-shelf actuators and navigation sensors with high Technology Readiness Level (TRL). The GNC includes two different vision-based navigation strategies, pure relative navigation and enhanced relative navigation. Both strategies are based on the tracking of unknown features on the surface of the asteroid. The differences are mainly in the initialization procedures. An additional activity (CCN-1) was granted to GMV for increasing the TRL vision based navigation system including the design and implementation in representative hardware. Initially a trade-off is performed to improve the image processing and navigation filter algorithms. In parallel, a trade-off of different hardware technologies (FPGA, DSP, microprocessor) and architectures is carried out. The optimal algorithms and

hardware are selected based on high-fidelity, closed loop simulations and benchmarking on representative flight hardware. Monte Carlos testing in a high-fidelity, closed-loop simulator with realistic images has validated the system to TRL-4. The validation and verification considered ESA's MarcoPolo sample-return mission in different scenarios. Additional tests for applicability to Phootprint are executed. Real-Time tests are executed with the flight-representative avionics for the vision-based navigation chain and the rest of the GNC. The real world is simulated in a real time hardware (dSpace board), and realistic images are generated in closed-loop. Then the autonomous vision-based GNC avionics is tested in GMV's optical laboratory. A camera provides the images representative of the navigation camera. The camera is stimulated in closed-loop in order to produce images as close as possible to flight. Finally, dynamics tests of the avionics are performed with camera stimulated with a scaled asteroid 3D model in a representative environment. GMV's robotic facility (platform-art©) is used to simulate the dynamic and kinematic conditions during the DL. The facility synchronizes the relative motion of the SC, asteroid and Sun. After this VV process the autonomous vision-based GNC system for Marco Polo-R is at TRL 5-6.