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TESTING VISION-BASED GUIDANCE AND NAVIGATION SYSTEMS FOR ENTRY DESCENT AND LANDING OPERATIONS

Abstract

Planetary landers and rovers which use vision-based navigation systems have to be verified and validated before launch. It is very difficult to do this with a physical mock-up, particularly for lander navigation applications, and high fidelity, real-time simulation is necessary. PANGU (Planet and Asteroid Natural Scene Generation Utility) is a software simulation tool that models planet surfaces and provides photo realistic images at high frame rates. PANGU models the surface of planetary bodies such as Mars, the Moon and asteroids and generates high resolution images of those surfaces. PANGU provides a high degree of realism while producing images in real-time at frame-rates expected of navigation cameras on a planetary lander. These images are used for off-line, closed-loop and hardware-in-the-loop simulations of planetary landing, surface roving and in-orbit rendezvous operations. PANGU supports verification and validation of vision-based navigation systems throughout the design and qualification phases of ESA programmes. PANGU is being used to support missions to the Moon, Mars and asteroids. This paper describes the enhancements and additions to PANGU v4. Extensive improvements have been made to PANGU's surface modelling features, achievable model size, model complexity and surface resolution, enabling simulations that start from orbit and end on the surface. Whole planet and small-body importing, modelling and enhancement capabilities have been added. The quality of the rendering has been improved to photo-realistic level and the performance has been improved to enable real-time hardware-in-the-loop simulation, which is important for the latter stages of navigation equipment validation. A powerful camera model has been developed to allow the characteristics of real cameras, including radiation effects, to be included in the simulation. PANGU v4 is able to operate with the NAIF/SPICE system to support accurate simulations of real world historical events and easy integration with other simulation systems. Both the PANGU v4 tool and images generated were extensively verified and validated in preparation for use in all phases of operational missions. PANGU v4 has been extensively verified and validated at unit and integration level. A series of absolute validation tests have also been carried out to compare the simulated images against real planet and asteroid images and against images taken with real cameras using physical elevation and shape models. Independent planetary scientists were involved in the validation to ensure that the models and images were realistic.