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SPACE EXPLORATION SYMPOSIUM (A3)
Space Exploration Overview (1)

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TESTING ADVANCED NAVIGATION SYSTEMS FOR PLANETARY LANDERS AND ROVERS

Abstract

The autonomous guidance of a spacecraft down to a pre-designated target landing spot avoiding any boulders, small craters or other obstacles in the vicinity of the landing site is not an easy job. Vision-based navigation techniques and vision and lidar-based obstacle avoidance techniques are being studied and developed by ESA to provide precise, robust lander guidance. With the development of new lander guidance concepts comes the need for extensive testing of these new systems. Ideally a test site covering tens of kilometres is required, with characteristics that are very close to the planet to be landed on, which can be modified quickly to support Monte-Carlo testing on many similar surfaces, and which has lighting and atmospheric conditions like the target planet. A test vehicle is also required carrying multiple sensors of different types so that data fusion techniques can be investigated to provide the optimum set of sensors for a specific landing requirement. Such a test system is not practical unless virtual reality techniques are adopted and virtual planets and spacecraft are developed.

The PANGU (Planet and Asteroid Natural Scene Generation Utility) is a software tool for simulating and visualising the surface of various planetary bodies. It has been designed to support the development of planetary landers that use active or passive computer vision to navigate towards the surface and to avoid any obstacles near the landing site. PANGU can be used to generate an artificial surface representative of the Moon, Mercury, Mars or asteroids and to rapidly provide images of the simulated planetary body. PANGU builds a planet surface model starting with a predefined surface (e.g. an existing digital elevation model if available) or a fractal surface generated by PANGU. Large scale features like craters are placed on the terrain according to a user defined feature size-density distribution. These crater models combine idealised mathematical impact crater models with fractal techniques to produce a realistic appearance. Boulders, sand dunes and other small scale features may then be added according to the characteristics of the target planet surface.

Given the position and orientation of a camera above the surface, PANGU generates the corresponding image. The position of the sun and other illumination conditions can be modelled. PANGU has been designed to give a high degree of realism while operating at near real-time speeds to enable closed loop simulation of complete vision-based navigation systems. As well as cameras, scanning LIDAR and radar altimeters may also be simulated. These simulations allow comprehensive evaluation of various navigation sensor combinations for planetary landers. The effectiveness of redundancy schemes involving different sensors may also be explored.

PANGU was developed by the University of Dundee for ESA and is now being used on several ESA studies and development projects aimed at producing precise, robust planetary lander guidance systems. The full paper will aim to provide project managers and systems engineers working on planetary lander missions with an overview of the capabilities of PANGU. It will be illustrated by images (and video clips) of highly realistic synthetic planet surfaces. Simulation of cameras, lidar and radar altimeters will be demonstrated. Results from the use of PANGU on the guidance systems tested will also be presented. Recent work on the use of PANGU for rover navigation simulation will also be presented.