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SIMULATION OF NEAR-EARTH OBJECTS AND RELATED LANDER GUIDANCE SYSTEMS

Abstract

ESA and JAXA are currently studying a sample return mission to a Near-Earth Object (NEO). The Marco Polo mission will travel to a primitive NEO, survey it from orbit, approach and land on the surface, retrieve samples, and return them to Earth. The NEO to be visited is thought to be a primitive remnant left over from the formation of the planets.

A controlled landing on a Near-Earth Object (NEO) requires sensors that are able to track the motion of the object and that of the lander approaching it. Computer vision is a strong candidate for this task possibly in conjunction with laser range finders and/or radar ranging devices. One or more cameras may be employed to provide monocular or stereoscopic vision capability. Computer vision is attractive because it uses passive sensors which each sample multiple points on the surface of the target body. The difficulty comes in the algorithms to be used to extract navigation information from the images and in the trade-off between performance, accuracy and robustness. The development, testing and validation of possible computer vision algorithms require a simulation environment that can provide realistic images of NEOs. Shadows need to be dynamic since the NEO may well be tumbling in its orbit and the reflectance properties of the NEO have to be modelled realistically. The lander and its shadow need to be simulated. Simulated images from cameras on the lander have to generated and passed to the image processing system. Ideally the simulation has to operate in a closed loop with the spacecraft model being positioned according to the dynamics of the spacecraft. This has to take into account any control operation initiated by the guidance and navigation control system using information from the processed images.

The PANGU (Planet and Asteroid Natural Scene Generation Utility) is a software tool developed by the University of Dundee 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.

This paper reports recent work on the PANGU system which is particularly relevant to NEO landing systems. It aims to provide project managers and systems engineers working on NEO rendezvous and landing missions with an overview of the relevant capabilities of PANGU. It will be illustrated by images (and video clips) of highly realistic synthetic NEOs.