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Author: Dr. Iain Martin
University of Dundee, United Kingdom, i.martin@dundee.ac.uk

Prof. Steve Parkes
University of Dundee, United Kingdom, sparkes@computing.dundee.ac.uk
Dr. Martin Dunstan
University of Dundee, United Kingdom, mdunstan@computing.dundee.ac.uk
Dr. Nicholas Rowell
University of Dundee, United Kingdom, nickrowell@computing.dundee.ac.uk

LOW ALTITUDE DESCENT SIMULATION FOR AUTONOMOUS LUNAR LANDINGS

Abstract

Future autonomous lunar landers will require robust guidance and navigation systems to safely descend to target landing sites in challenging terrain. Vision or LIDAR based terrain relative navigation can fulfill this role but require extensive testing and tuning so simulating descent scenarios is vital to develop and prove the algorithms and systems. A variety of descent trajectories have been proposed including a low altitude descent which presents a difficult simulation challenge because of the large region of terrain to be modeled. Digital Elevation Models of the lunar surface obtained from previous missions can be used as a basis for terrain models but their resolution needs to be enhanced with synthetic terrain to simulate the full descent. This paper outlines the surface modeling challenges to simulate a low altitude descent sequence and presents a novel, flexible multi-resolution terrain modeling system that can simulate the resolution range of kilometers to centimeters for a surface lander for a variety of descent trajectories

A large area of the Moon is simulated by obtaining the best available DEMs which are then extended into a multi-resolution model through resolution increase and decrease. Low-resolution regions at the outer edge of the model are created by sub-sampling and increasingly higher resolution regions are defined along the simulated descent trajectory with additional synthetic terrain generated by fractal techniques and by adding crater models in realistic diameter and age distributions. The size, position and resolution jumps of the model regions can be specified to optimize the model resolution for the required descent trajectory. Surface patch regions are defined in both high and low-resolution form in a bi-resolution tree to improve performance and avoid over rending issues. The rendering system can traverse the tree to select the most appropriate resolution patch to render based on the depth to the surface. The terrain models are evaluated by applying a feature tracking algorithm to images from a descent sequence to simulate surface relative navigation and the range of models that can be generated by the system are characterized to specify the types of lander descent that could be reasonably simulated.

The paper will be illustrated by images and video clips of a low altitude descent simulation towards the lunar South Pole. The models are visualized by the PANGU surface modeling tool which was developed by the University of Dundee for simulating and visualising planetary surfaces.