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HIGH-FIDELITY ROBUST 3-D LUNAR ENVIRONMENT GENERATION PLATFORM FOR MICRO-ROVER SIMULATION-BASED TASKS

Abstract

The emergence of self-driving vehicle technologies to seamlessly navigate through complex road systems have introduced several approaches to apply similar concepts to lunar rovers. Self-driving cars rely on advanced localization and mapping technologies enabling the cars to recognize different objects en-route, and act accordingly based on the traffic rules and safety. The control algorithms of the self-driving cars on Earth are trained using imitation learning, which incorporates the driver's decision and behavior as one of the inputs. On the other hand, lunar locomotion not only needs to rely only on visual and vehicle odometry input, but it is also hard to imitate the lunar environment that is realistic and versatile enough to transfer from simulation to real applications. Digital elevation maps of up to 0.5 meter-per-pixel resolution can be acquired from the Lunar Reconnaissance Orbiter Camera (LROC). They can be used for locomotion and navigation studies, such as accurate landing control, and large-scale mission planning. However, when it comes to micro-rovers simulations, much more realistic and delicate models that include obstacles such as small craters and rocks are required to enable accurate simulation results. To create just one such environment is a tedious task. Therefore, a High-fidelity Robust 3-Dimensional Lunar Environment Generation Platform is built using an open-source 3D software Unity to solve this problem. It generates terrain with up to 0.01 meter-per-pixel resolution using either noise function alone, or a portion of LROC data. The environment is also decorated with topologically accurate craters and rocks with their distribution derived from LROC data. The crater models are derived from established mathematical studies on planetary surfaces. With its highly configurable properties, it can be set to rapidly generate many different 3D models in formats that are generally compatible with other simulation platforms. The program provides a significant dataset generator to aid machine learning tasks with creating a robust system, and further improves autonomous lunar locomotion systems. One notable application is that it successfully helped to train a reinforcement-learning based visuomotor navigation system of a micro-rover and yielded significantly better results than the general bug algorithm.