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TOWARDS FINE LUNAR TERRAIN RECONSTRUCTION WITH NEURAL RADIANCE FIELDS AND BRDF MODELING FROM LRONAC DATA

Abstract

Fine lunar terrain reconstruction is of great interest for research purposes as well as mission planning. Such information is particularly crucial for landing site selection and precise landing designing. Lunar rovers could also benefit from high quality global terrain maps. Despite the Narrow Acquisition Camera (NAC) of the Lunar Reconnaissance Orbiter (LRO) providing lots of very high resolution images at 50cm ground spatial distance of the lunar surface, automatic fine 3D reconstruction using traditional techniques, like multi-view stereo matching or shape-from-shading, remains a challenge. The Moon exhibits relatively homogeneous features making correlation steps difficult, no atmosphere, which reduces visible information especially in shadowed areas that can be large or permanent, in particular at the poles. Recent works have shown the potential of Neural Radiance Fields (NeRF) networks for multi-view stereo 3D reconstruction from satellite imagery on Earth. However, to our knowledge, few works have been conducted on the Moon, and existing works exploit mainly synthetic data.

Thus, this work is twofold. First, it aims at constructing a dataset of bundle-adjusted LRONAC data at the South Pole where there are more acquisitions available in addition to LOLA Digital Elevation Models (DEM) with a better spatial resolution. It is also an area of interest since it contains craters that never receive light from the Sun and therefore are very likely to contain ice, useful for the settlement of inhabited lunar bases. Then, NeRF networks are adapted to account for lunar images' specificities and exploit the radiometric knowledge of lunar regolith. Their potential for fine lunar terrain reconstruction is evaluated. More precisely, a comparison is carried out between a simple modeling of the scene's color as a combination of an albedo and a sun visibility, and the modeling of an Hapke Bidirectional Reflectance Distribution Function (BRDF) whose parameters are learnt by the network. In addition, LOLA DEM is used as a prior for depth supervision.

Preliminary results show that NeRF are able to synthesize realistic novel views of the Moon, even on shadowed areas, and that an accurate modeling of the light reflectance greatly improves results. Depth supervision with LOLA DEM improves the terrain reconstruction. However, the accuracy of LRONAC geometric models, associating an image pixel to its ground coordinates, seems to hinder the fine reconstruction capacities of the network.

The dataset and the code will be released.