

Digital Lunar Exploration Sites (DLES) Terrain Crafting

Humans will soon be returning to the surface of the Moon with NASA's Artemis program. The Artemis program is an international collaboration that will consist of a complex series of space systems and missions to explore the lunar surface and pave the way for the future exploration of Mars. NASA and its partners rely heavily on simulation for lighting and navigation studies as well as training astronauts, flight controllers, and mission support staff. The NASA Exploration Systems Simulations (NExSyS) team in the Simulation and Graphics Branch (ER7) in the Engineering Directorate at NASA's Johnson Space Center has built up many simulation products to support this effort, one of which is the Digital Lunar Exploration Sites (DLES). DLES is a collection of products used to simulate and render the lunar surface in a digital environment. We discussed and presented an overview of the DLES products at the 2022 IEEE Aerospace Conference in Big Sky, MT with a paper titled "Digital Lunar Exploration Sites". This "DLES Terrain Crafting" paper will expand on the information previously provided in "DLES" paper and dive deeper into the details of the terrain crafting process and the toolsets used to support this task.

The best digital data currently available of the lunar surface is provided by the Lunar Reconnaissance Orbiter (LRO). Its Lunar Orbiter Laser Altimeter (LOLA) achieves an impressive resolution of 5m per pixel at the Lunar South Pole (LSP) and can generate datasets covering a large continuous region near the LSP. There are a few additional methods, such as Shape from Shading which can infer higher resolution data (up to 1m per pixel) from the LRO Narrow Angle Camera (NAC) images. However, surface-based simulations require higher-resolution data, and this paper will discuss the process of enhancing the terrain to meet that need. The process begins with capturing statistical data of craters in the regions of interest using images provided by the LRO NAC. This data is then used to scatter artificial features which are not captured in the truth data, resulting in an enhanced DEM with a much higher resolution of 20cm per pixel.

Many tools were built up to assist in the creation of these artificial Digital Elevation Models (DEM), which this paper will discuss in detail. DEMs themselves are a very powerful representation of a planetary surface, and many operations and tools can utilize the data they contain. This paper includes a description of the rendering of the lunar surface in a graphics engine, generation of contact patches to simulate tire to ground interaction, and ray tracing utilities to model Line of Sight (LOS) interactions with the terrain. This paper will also explore some new tool sets currently under development which aim to utilize Machine Learning (ML) to assist in the identification of craters from LRO NAC imagery. While this is not a novel idea, the NExSyS team is developing a unique approach which may result in more robust identification of crater characteristics.