GENERATING SYNTHETIC IMAGERY FOR TRN USING PANGU AND UNREAL ENGINE

SHEN GE, JUSTIN WESTMORELAND, LILLIAN HONG

ABSTRACT

To test navigation algorithms planned for use in future spaceflight missions, Intuitive Machines uses a suite of proprietary and custom tools, notably Planet and Asteroid Natural Scene Generational Utility (PANGU) and Unreal Engine 4 (UE), to model the Lunar surface and cameras as realistically as possible.

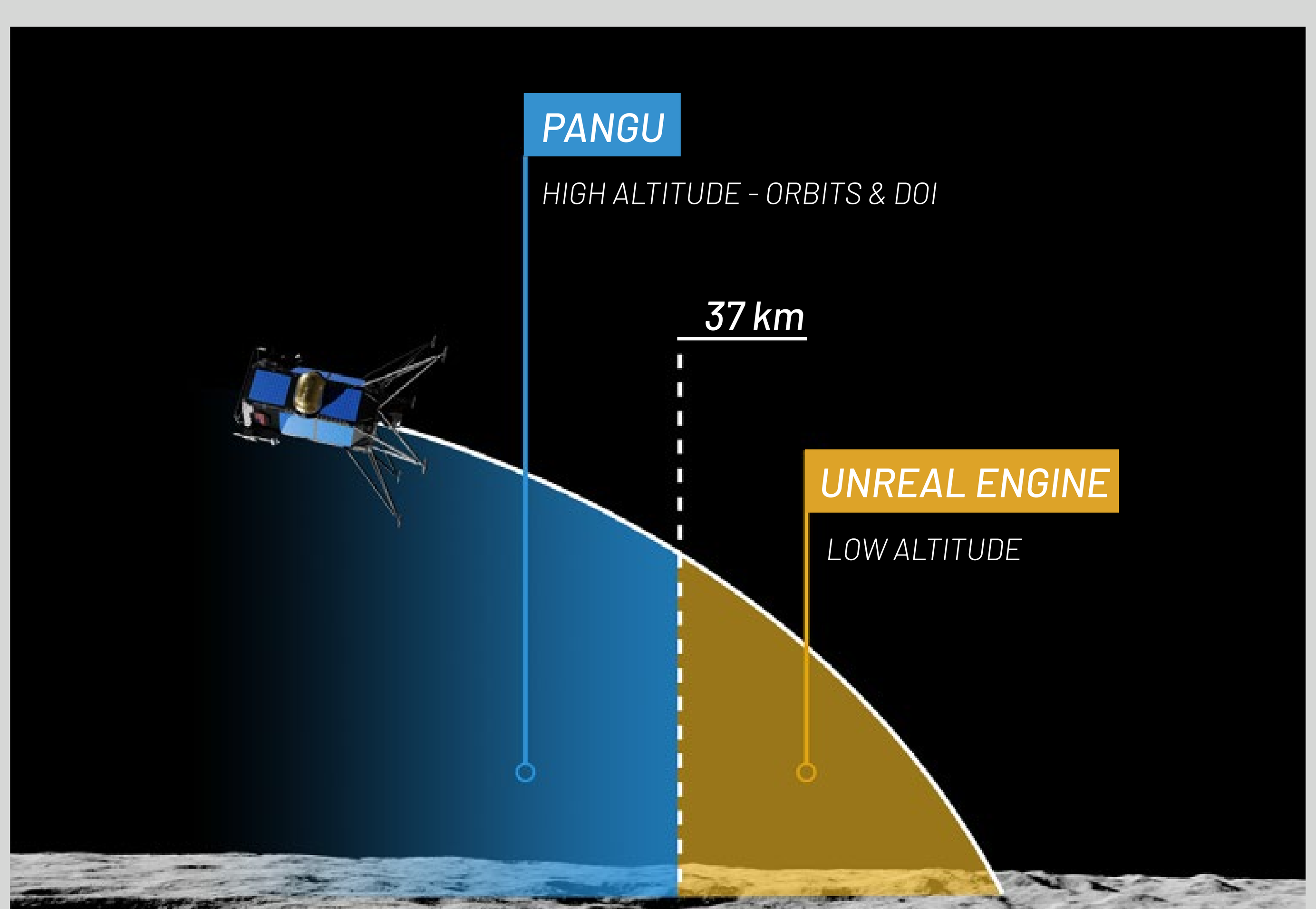
PANGU is physics-based, non-raytracing proprietary software developed by Star Dundee for missions requiring optical navigation. It can model the surface of the Moon by importing data from digital elevation models (DEMs), create finer synthetic meshes on top of DEMs, and add craters and boulders. The surface can also be added with a bi-directional reflectance distribution function (BRDF) model and either synthetic or real albedo maps. Models were created using the 7.4 m/px Kaguya DEMs and a Lunar albedo map based on LRO's normalized Hapke data. Afterwards, the models are driven by SPICE kernels and camera parameters to simulate images taken by our spacecraft cameras at high altitudes, i.e., low Lunar orbit and after descent to 37 km altitude.

Below 37 km where DEM resolution starts to fall short, Intuitive Machines has developed tools to bridge the gap where DEM data does not exist and add synthetic detail, including craters and hazards, to existing data. To improve synthetic imagery resolution, Unreal Engine is used to apply high-definition Lunar surface shaders and additional crater normal maps on top of the pre-existing Kaguya DEMs.

UE is a physics-based game engine developed by Epic Games used widely for games, visualizations, cinematics, and more. It uses a physically based rendering (PBR) system for material shaders and allows integration of additional synthetic features, dynamic lighting, and real-time rendering.

Imagery is validated quantitatively by data from a suite of Intuitive Machines internally developed custom scripts as well as qualitatively by visual confirmation with Narrow Angle Camera (NAC) images. With imagery generated and validated, Terrain Relative Navigation (TRN) uses synthetic images to identify positions of craters. These crater positions are further validated by visual confirmation with NAC images.

The synthetic images generated are currently being used as inputs to test Intuitive Machine's optical navigation algorithms. These will ultimately culminate in demonstrated TRN capability enabling a successful lunar landing in November 2021.



APPROACH

FEATURES & ADVANTAGES

- Capability to integrate with SPICE kernels, 6-DOF Trick Simulation, and other development tools
- Ingestion of camera parameter inputs which utilizes real hardware data
- Capability to render from any camera orientation and lighting condition
- Multi-tool approach enables modeling of imagery encompassing a broad range of FOV areas
- Ease of verification of imagery with LROC images

IMPROVEMENTS

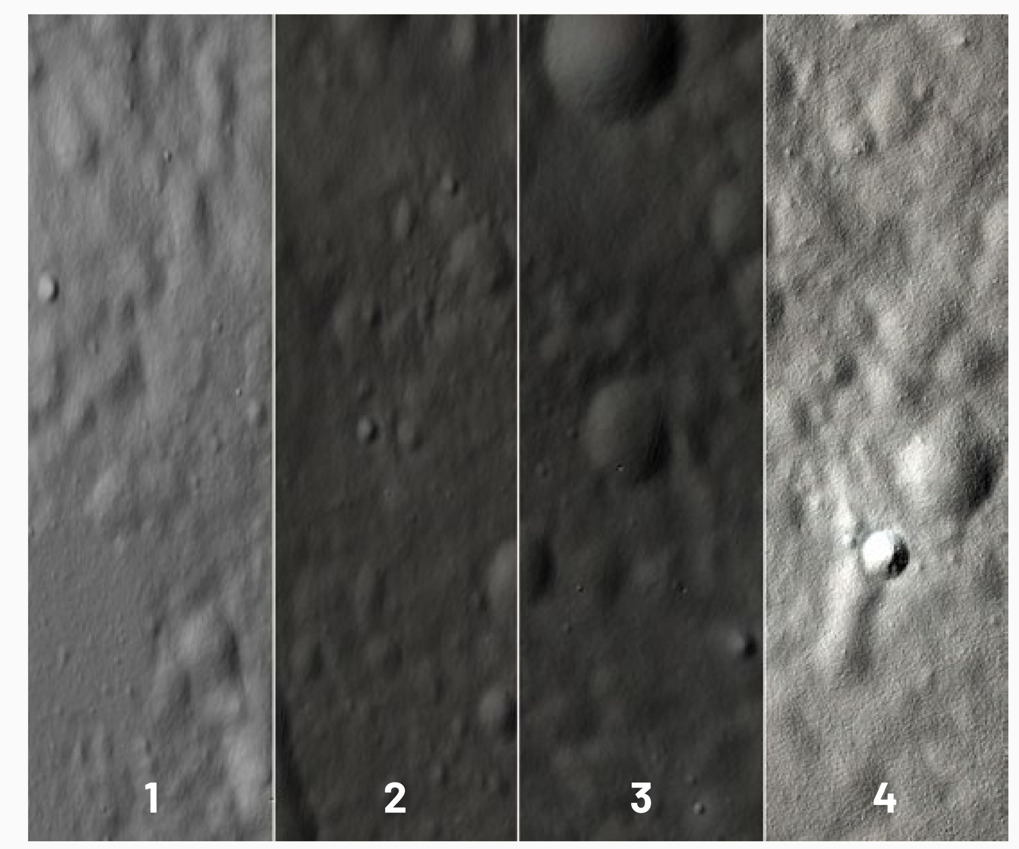
- Handling large sets of data
- Verification and validation
- Dispersions

DATA CREDITS

A special thanks to the NASA LRO team and the JAXA Kaguya team for the extensive database of resources that were used throughout our development process.

HIGH ALTITUDE — ORBITS & DOI TO 37 KM — PANGU

INCREASING IMAGERY REALISM

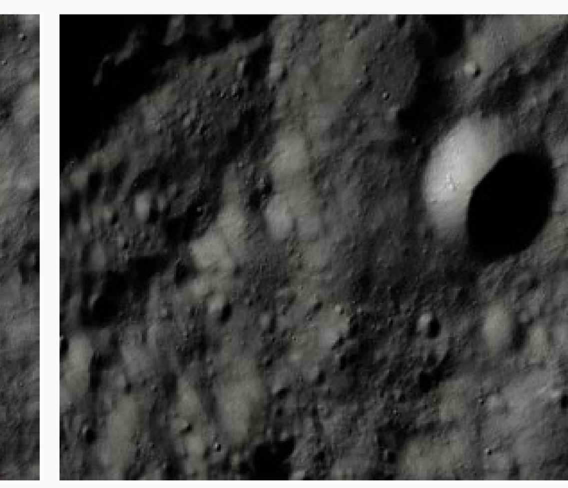


1. LOLA 59 mpp DEM
2. LOLA 59 mpp DEM + Albedo
3. Kaguya 7.4 mpp DEM + Albedo
4. Kaguya 7.4 mpp DEM + Albedo + Camera Model

Imagery improvements with runs include adding albedo map, using higher resolution DEMs, and adding camera parameters.

DYNAMIC SHADOW ADDITION

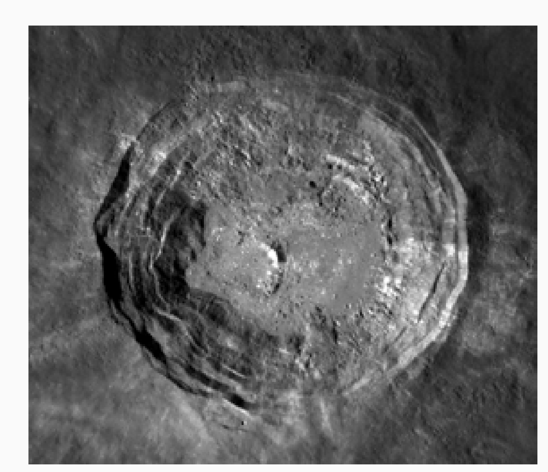
PANGU Rendered Image No Dynamic Shadows



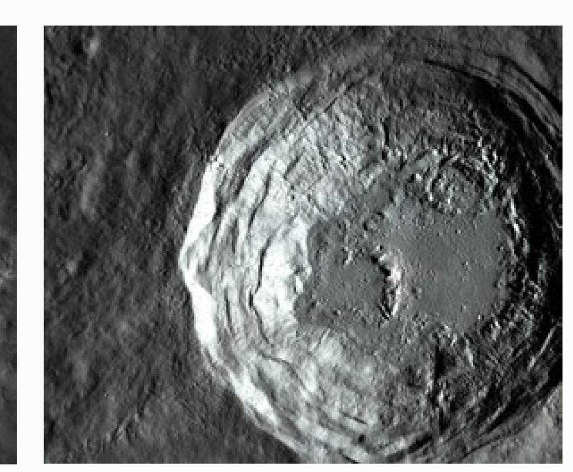
PANGU Rendered Image With Dynamic Shadows

REAL IMAGE COMPARISONS

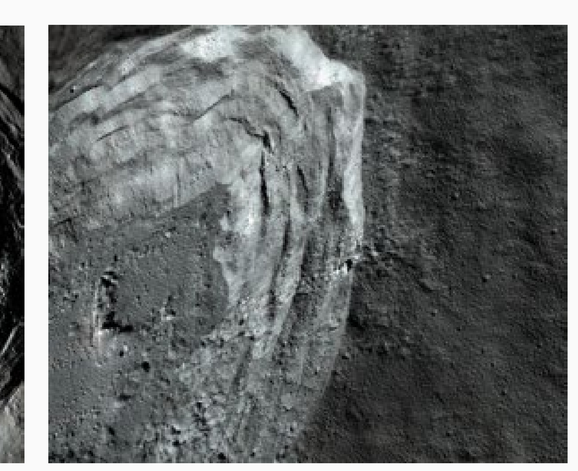
ARISTARCHUS 23.6°N, 47.5° W



LROC Wide Angle Camera

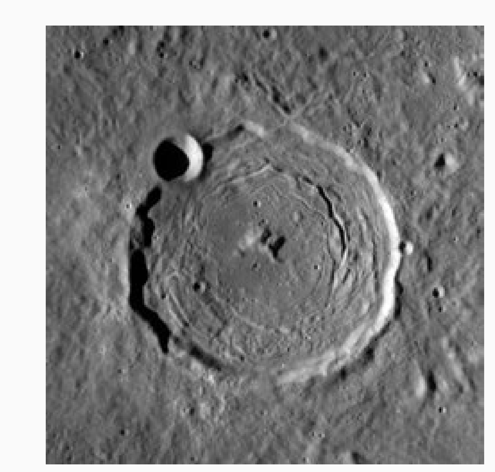


PANGU Rendered TRN Image

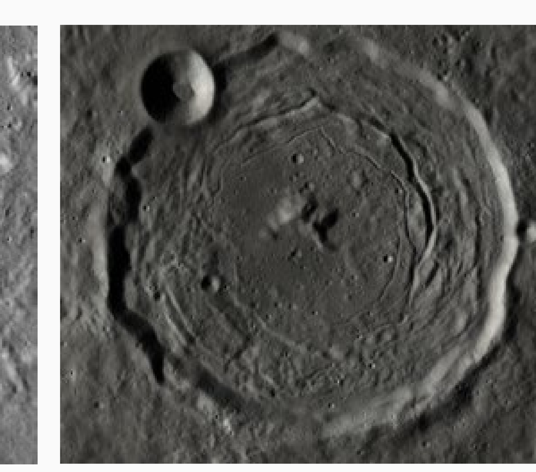


PANGU Rendered Additional Camera Angle + Lighting Condition

TARUNTIUS 5.6°N, 46.5° E

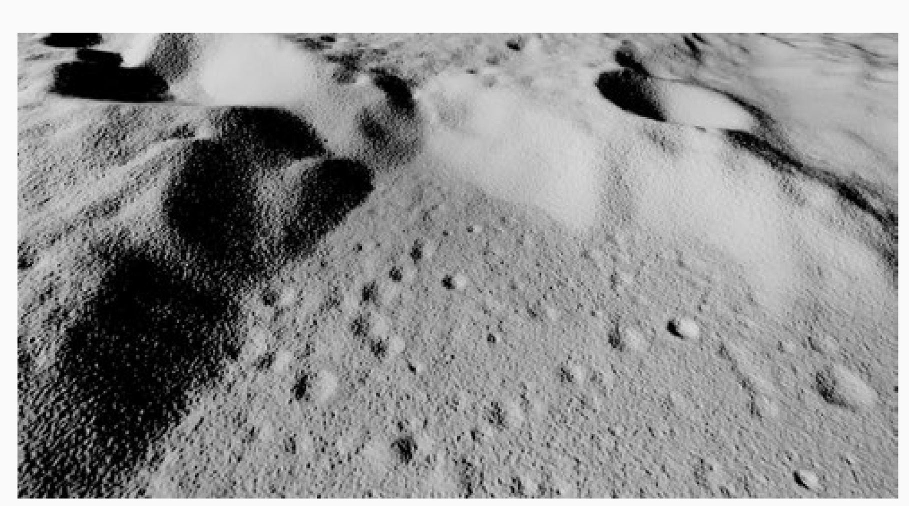


LROC Wide Angle Camera



PANGU Rendered Image

LOW ALTITUDE — 37 KM TO LANDING — UNREAL ENGINE



Kaguya 7.4 mpp DEM

Kaguya 7.4 mpp DEM + UE Shader

Kaguya 7.4 mpp DEM + UE Shader + Normal Map

Shaders and craters are applied on top of Kaguya 7.4 mpp DEMs to improve synthetic imagery resolution.

Unreal Engine uses a PBR system for material shaders, which layers base color, roughness, and normal maps together to define surface properties and allows integration of additional synthetic features.

To create more distinct craters based on NAC images at 0.50 mpp, additional normal maps are generated in Substance Painter, a 3D computer graphics tool.

sge@intuitivemachines.com jwestmoreland@intuitivemachines.com lhong@intuitivemachines.com