Developing a Virtual Reality (VR) Environment of the Apollo 15 Landing Site on the Moon

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Introduction

Though the last Apollo mission flew in 1972, virtual reality allows us to revisit the Apollo landing sites without ever leaving the Earth. The Lunar Reconnaissance Orbiter (LRO) continues our exploration of the Moon in the era after Apollo. The LRO maps the lunar surface and returns high resolution images for mission planning, instrument placement, and surface operations [2]. LRO images are used to create digital elevation models (DEMs), which represent the elevation of the lunar surface [2].

Apollo 15 mission objectives included exploration of the Hadley-Apennine region, deployment of the Apollo Lunar Surface Experiments Package (ALSEP), a set of scientific instruments that relayed data from the Moon to Earth, and various orbital tasks [3]. A point of particular interest in this region was the Hadley Rille (believed to be an old lava channel) [4], which is featured in this VR landscape.
Apollo 15 was also the first mission to use the Lunar Roving Vehicle, which helped astronauts travel farther than previous missions.

Importing the Apollo 15 DEM into Unity, a video game engine, allowed for the development of a realistic landing site environment that can be viewed with the HTC Vive, a virtual reality headset. This application of virtual reality enables us to revisit sites that have not been touched in decades, and can be used for mission planning, outreach, and training.

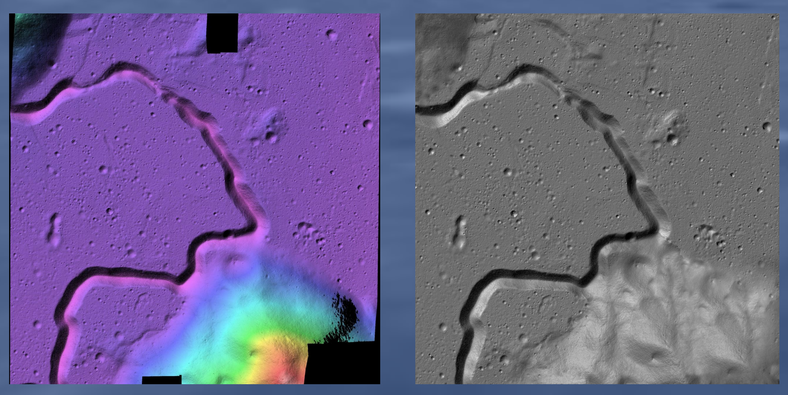


Figure 1: (left) Apollo 15 DEM, (right) edited texture for Unity

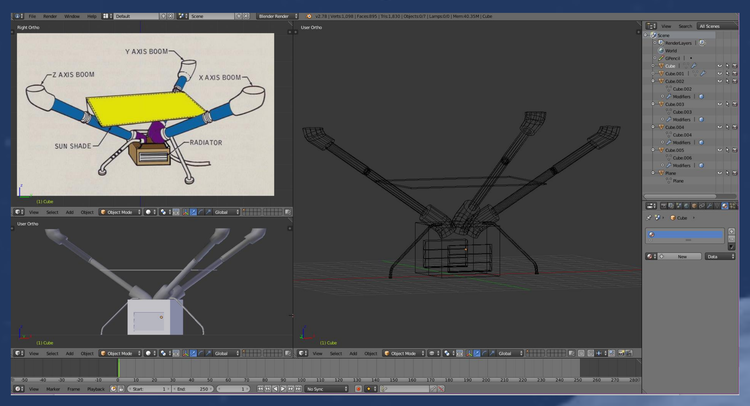
Methodology

Importing 2D DEM into Unity

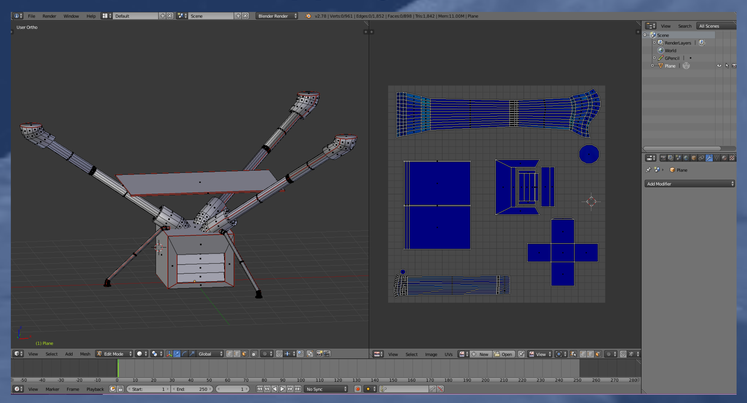
Importing the DEM allowed for Unity's terrain system to create a 3D terrain from a previously flat plane. Each point on Unity's terrain is essentially a point in a coordinate system, which can be represented with a grayscale image called a heightmap, an image that stores height values [1].

However, because the system uses the data of the DEM to calculate height, Unity saw black rectangles on the Apollo 15 DEM and calculated those as low points in the terrain, when in reality, they were sections of the NAC images where no data was collected (Figure 1). These data losses were edited in Photoshop to match the surrounding landscape. After these edits, the DEM was ready to be imported, and Unity correctly calculated the lighter areas of the DEM to be highlands and the darker areas to be lowlands of the lunar surface.

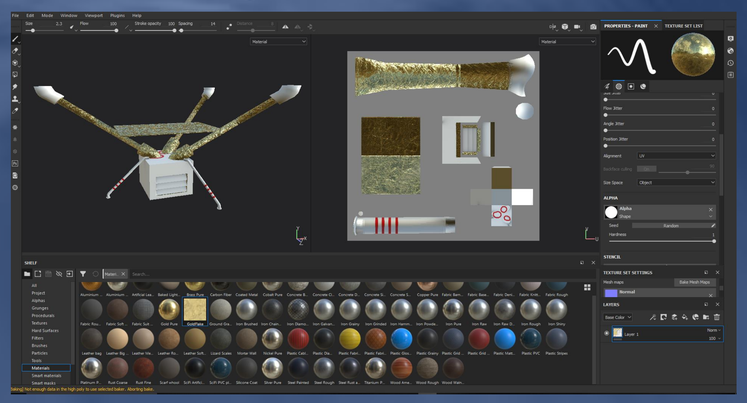
3D Modeling in Blender



UV Mapping in Blender



Texturing in Substance Painter



Importing into Unity

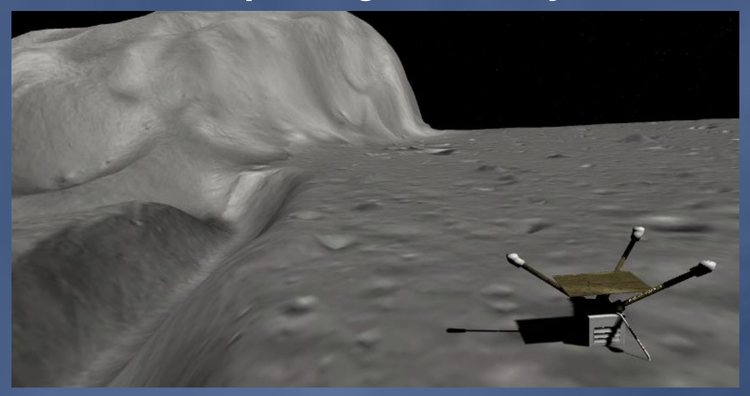


Figure 2: Asset Workflow

Methodology

Texturing the Landscape

Realistic texturing of the landscape required importation of many different images of the lunar surface and of Earth soil. Each texture was overlaid on the terrain in Unity to test how it would appear in VR. A mosaic image from the LROC NAC was chosen as the final texture due to its realism and accurate depiction of the landing site.

Creating Assets

Developing the ALSEP instruments for the environment consisted of several stages (Figure 2):

- **3D Modeling**
  The modeling process began with several reference photos of the instrument, which were imported into Blender, a 3D modeling software. The instrument was then created by manipulating primitive 3D shapes, such as cubes and cylinders.

- **UV Mapping**
  This stage prepares the model to be textured. A "seam" (displayed as a red line on a model in Blender) was marked, and then the model was unwrapped. Unwrapping the model created UV shells, which are depicted as a variety of blue shapes on a square (Figure 2). This is called a UV map, where U and V are the axes of the 2D texture, and was then imported into a texture editing software for the next stage of development.

- **Texturing**
  The UV map is imported into Substance Painter, a 3D painting software that allows for painting directly on the UV map and/or the model. Using the paintbrush tool and various textures, a final texture was created and imported into Unity as a material for the desired asset.

References

[1] "Height Tools." https://docs.unity3d.com/Manual/terrain-Height.html
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[3] "Apollo 15" https://www.nasa.gov/mission_pages/apollo/missions/apollo15.html
[4] "Apollo 15 Landing Site" https://www.lpi.usra.edu/lunar/missions/apollo/apollo_15/landing_site/

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