Virtual Reality Tools for Mars Exploration: MarsVR.

Jessalyn E. Shiner[1], Eldar Noe Dobrea[2], Nicole N. Román-Correa[3,4] and Alejandro J. Romero[4,5], [1]Ohio University, Athens OH 45701 (JessalynShiner@Outlook.com), [2]Planetary Science Institute, Tucson AZ 85719, [3]University of Puerto Rico at Mayagüez, P.R. 00681[4]NASA Ames Research Center, Moffett Field CA 94035, [5]Brown University, Providence, RI 02912.

Introduction: MarsVR is a virtual reality program created with the purpose of providing an immersive way to explore Mars and query Mars data. It is designed for use as an education and public outreach (EPO) tool, as well as a tool to support research (Figure 1). The current iteration supports exploration of the Mars Science Laboratory's (MSL) field site, Gale Crater.

Virtual reality has been rising in popularity for years now, and is starting to cement itself in common culture. It provides an immersive experience that is second only to actual presence. The ability to freely move around in a 3-dimensional environment instead of looking at 2-dimensional pictures on a screen provides a more intuitive way to explore, and can be an awe-inspiring experience in itself. We hope that our program will help scientists and the public explore Mars data in a more realistic environment.

Program Specifics: MarsVR was written in Unity and is supported with scripting in C# codeand Unity's XR Interaction Toolkit. MarsVR was designed to be portable to a wide variety of VR headsets.
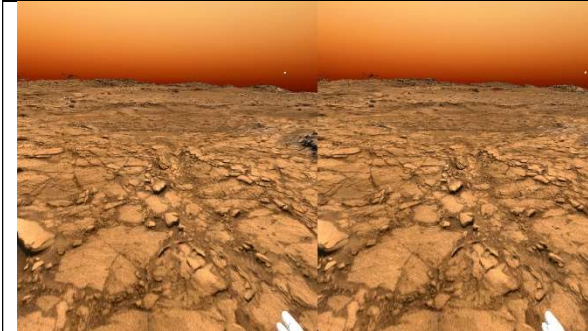

Figure 1. A stereoscopic view of the Mars scene from Sol 1094, through the HTC Vive VR headset.

Datasets: MarsVR uses data acquired by the Mars Science Laboratory (MSL) Rover, Curiosity, as well as orbital imagery and derived topography acquired with the Mars Reconnaissance Orbiter's (MRO) High-Resolution Imaging Science Experiment (HiRISE). Both orbital and rover data are used to produce the virtual reality space. Local scenes are produced from MSL NavCam imagery. These are superposed on orthorectified mosaics and associated digital terrain models (DTMs), derived from imagery acquired by the Mars Reconnaissance Orbiter's (MRO) High Resolution Imaging Science Experiment (HiRISE), rendering a spatially extensive VR space (Figure 2). Originally in
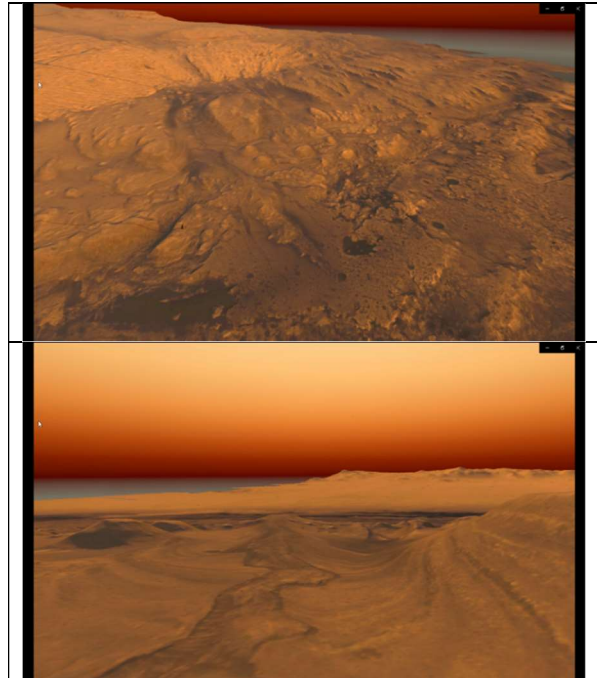

Figure 2. Bird's-eye (top) towards the fan at the base of Aeolis Mons, and (bottom) from Aeolis Mons valley towards the rim of Gale Crater

grayscale, the NavCam and HiRISE data are colorized to match the color tones of the Martian landscape.

Mesh Creation: Depth-maps derived from NavCam data [1] are processed using Blender [2] and a combination of python scripts to produce meshes that can be subsequently be imported into Unity. At the heart of the mesh-creation is the Blender Navcam-Importer add-on [3], which reads NavCam depth maps 3D terrain (Figure 3). Additional processing needed for export to Unity is performed using homemade scripts.

User Experience: Users can interact with the program via direct locomotion through the environment, and via a menu-driven interface that provide various functionalities.

Locomotion: Standard VR methods of locomotion such as near-field teleportation, walking, and flying are implemented. Users can also teleport directly to specific Sol locations via a menu-driven interface.

Menu: The menu itself is coded to be customizable. It follows the player by default, but its position can also be switched to follow the player's gaze, remain stationary in place, or be manually placed in-game (Figure 4).
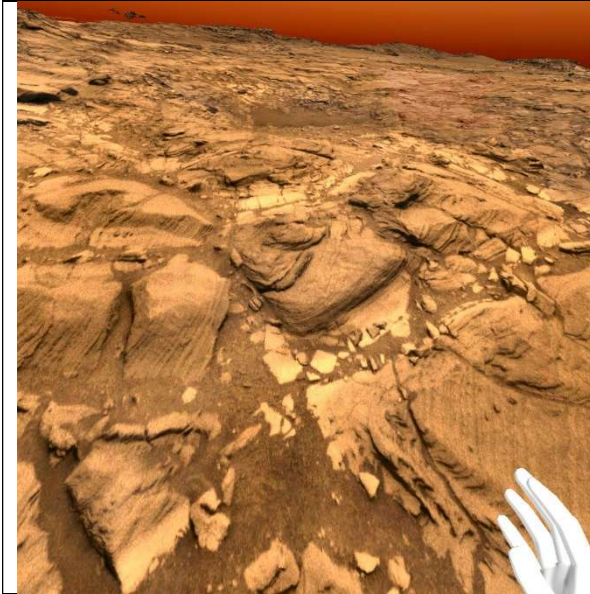
Figure 3. Mesh creation using NavCam depth maps allows accurate representation of the martian terrain.
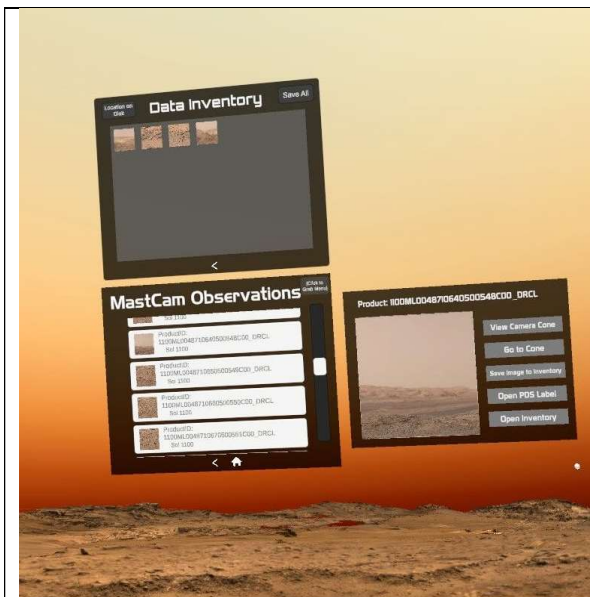

Figure 4: The MastCam Image Previewer allows a user to query, view, and download data acquired with MastCam. Future version will allow querying and analysis of other MSL data sets.

Data querying: One of the key features of MarsVR is the ability to query data acquired by the rover. Currently implemented is the MastCam Image previewer and downloader, which allows the user to query the MSL database available in the PDS Imaging Node. Users also have the option to retrieve and view the PDS label of the specific image in-game, or save the image to their data inventory. The data inventory offers the option to download images as well as the associated PDS

label to the hard drive. In the future, this capability will be enhanced to allow visualization and analysis of ChemCam, DAN, CheMin, APXS, and MAHLI data as well.

Data Localization: Another feature of MarsVR is the ability to visualize the camera's field-of-view (FOV) at the time of image acquisition. These FOV cones can be queried via menu or by direct interaction with the terrain. In addition to viewing camera cones, the associated file name of the data product can be displayed for ease of retrieval.

Mars Buddy: The Mars Buddy is an interactive model of a friendly Martian created in Maya to aid MarsVR's educational outreach (Figure 5). Mars Buddy is a friendly face who is capable of interacting with the user as it accompanies them on their journey across Mars. He is designed with a cartoon aspect to further appeal to children and encourage exploration and learning.
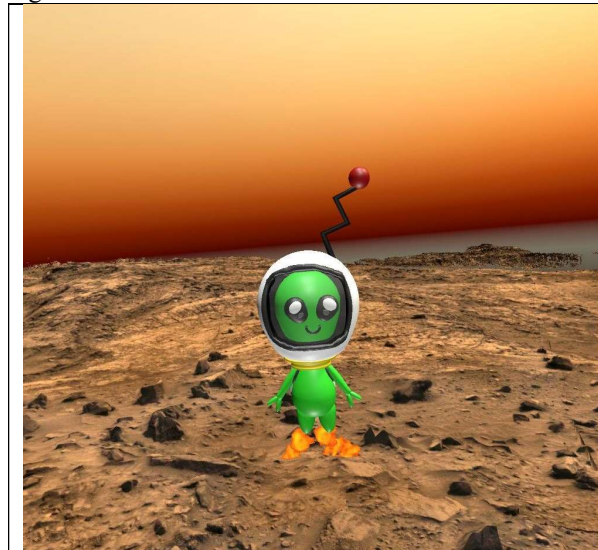

Figure 5: Mars Buddy is a kid-friendly guide to the Red Planet. Users can physically interact, even play ball with it.

Future work: Future versions will incorporate additional data sets from MSL as well as data from the Mars 2020 Rover, Perseverance. The Perseverance rover is scheduled to land on Mars on 18 February 2021. Additionally, we intend to have Mars buddy lead a tour of Mars, complete with voiceover. MarsVR is freely available. It is currently available on both the Oculus and HTC Vive platforms.

References: [1] https://pds-imaging.jpl.nasa.gov/data/msl/MSLNAV_0XXX/DOCUMENT/MSL_CAMERA_SIS.PDF; [2] https://www.blender.org/; [3] https://github.com/phaseIV/Blender-Navcam-Importer