Mars Data Exploration

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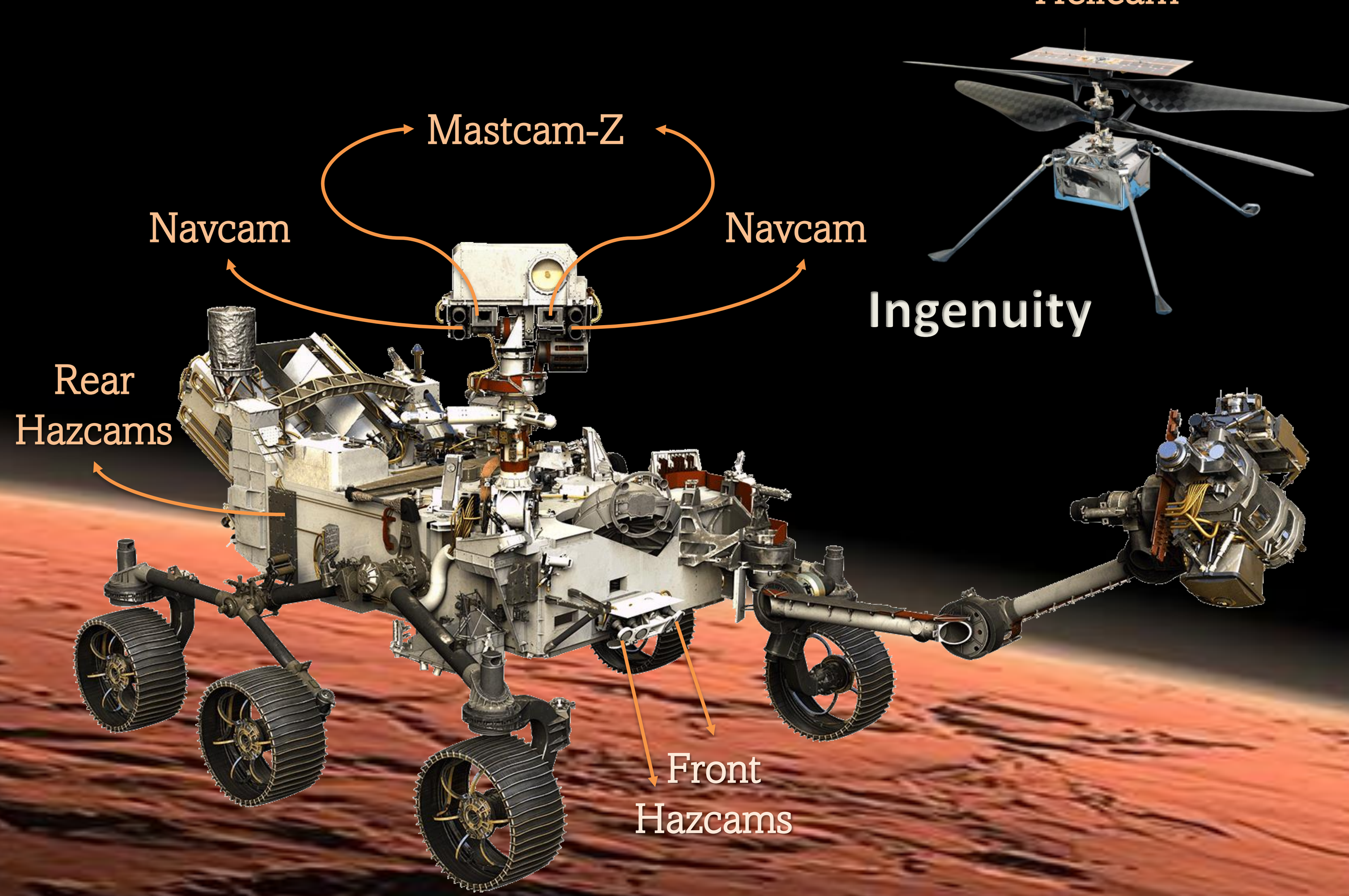
PERSEVERANCE ROVER



Problem Statement

3D Immersive views of Martian terrain are essential for NASA mission engineers to plan rover activities. Inspired by this use case, we built a pipeline to generate 3D terrain meshes for use in Augmented Reality (AR) and Virtual Reality (VR) to enable spatial understanding of a Martian terrain scene. Cameras onboard NASA's Mars rovers take high fidelity images that provide realistic views into the scene. Photogrammetry techniques transform these images into digital twins for a first-person navigable view. 3D immersive views of the terrain enable scientists and engineers to spatially understand the terrain and communicate their findings.

Step I : Downloading Data and Performing Image Conversions

Perseverance rover images are downlinked and stored in NASA's Planetary Data System (PDS) as .IMG format, which is a bitmap file containing binary image data. As a result of the formatting, the images in the files are not viewable. Thus, we built a web scraper and image formatter to our photogrammetry pipeline to download and convert images to the .PNG format. Image processing techniques such as Debayering, Image Enhancement and Restoration were applied to get the desired image format and quality.

Step II : Interpreting Camera Parameters

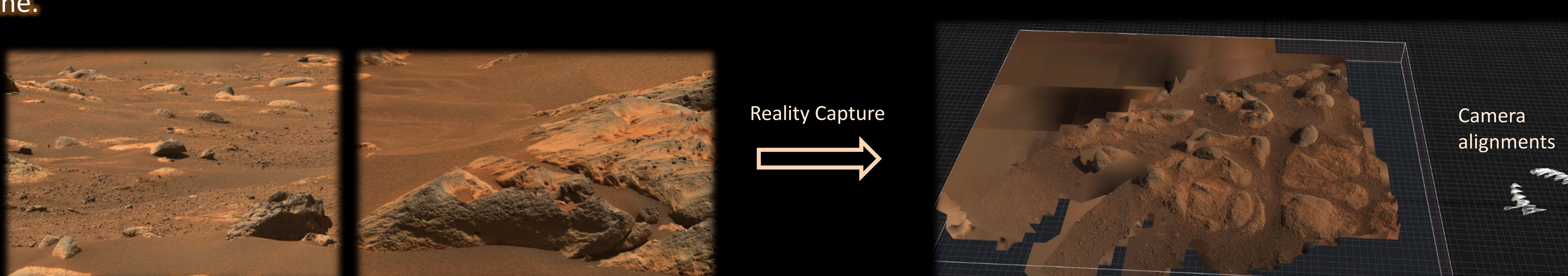
Next, the intrinsic and extrinsic camera parameters are extracted from the image metadata to create .XMP files. Camera parameters are derived using the CAHVOR camera model which is used for the photogrammetric mapping of images.

Step III : Sorting Data by Site and Drive

Rover drives are indexed by site and drive to denote when and where the rover has moved. Thus, images from the same site and drive often go together. This assists the alignment of images in the photogrammetry process. Once all the image data for the sols have been scraped, they are sorted by site and drive for better photogrammetric results.

Step IV : Photogrammetry Process

Image data along with their respective metadata files i.e. *.IMG* and *.XMP* files, are fed into a photogrammetry software called Reality Capture. Reality Capture, a commercial photogrammetry software, reads these files and interprets the respective camera parameters of each image. The result is a 3-D mesh and high-resolution texture that can be exported as a 3D object for use in the Unity 3D game engine.



Input – .PNG and .XMP files

3-D mesh of Martian Terrain

Research Challenges

- How to choose which images are necessary for a high-fidelity 3-D mesh of the Martian terrain?
- What is the true scale and orientation of each 3-D mesh generated using photogrammetry?
- What are the uncertainties associated with the accuracy of the mesh?
- How can we convey the uncertainties and maintain data trust among users?

Future Work

- Integrate cloud streaming of data assets into our application.
- Use Artificial Intelligence and image processing techniques to predict missing data in the 3-D terrain meshes.
- Spatially convey ancillary information of each image from a mesh.
- Design and build interactions to make spatial uncertainties clear.

Acknowledgments

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