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Multi-Resolution, Nested Orbital 3D Images of Gale Crater for Fused MSL Rover-Orbital Image Simulations

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Abstract

A combined HiRISE, CTX, and HRSC digital terrain model (DTM) of Gale Crater was processed using CASP-GO and the KM09-VICAR system. "Rover eye" Navcam views over the MSL rover traverses have been visualized in a 3D environment. These simulated views demonstrate a useful combination of different resolution imagery for rover mission planning, localization, and science targeting.

1. Introduction

Rover landing site selection for future rover missions (e.g. Mars 2020 and ExoMars 2020) requires high-resolution imaging to identify potential hazards and regions of scientific interest. Combining HiRISE, CTX, and HRSC imaging provides localized, high-resolution features with detail of longer-wavelength topography to contextualize rover-scale geology.

A multi-resolution, nested digital terrain model (DTM) of Gale Crater was combined with standard resolution orthorectified images (ORI) and super-resolution restored (SRR) HiRISE images, and MSL Navcam views were simulated from these products along the rover traverse towards Mount Sharp.

2. Methods

Three sets of DTMs and ORI were first processed into:

1) a 30-m HRSC digital terrain model (DTM) mosaic of Gale Crater, produced using the Kim and Muller (2009) [1] modification to the DLR-VICAR stereo pipeline, and which is tied to the MOLA global DEM;

2) an 18-m CTX DTM mosaic of Gale Crater, produced using CASP-GO [2] using the stereo pairs IDs in [3], and co-registered to and gap-filled with the HRSC DTM mosaic using Ames Stereo Pipeline (ASP) [4], with 6-m CTX images orthorectified to these DTMs using ASP; and

3) 1-m HiRISE DTMs from UA [5] that cover MSL's traverse to-date, mosaiced and then co-registered to the CTX DTM mosaic with ASP and their 25-cm images orthorectified with GDAL.

The HRSC DTM was statistically validated with MOLA global DEM, and the CTX DTM mosaic validated with the HRSC DTM. Both analyses show strong vertical and planimetric agreement in topographic profiles and random point analysis. The HiRISE DTM mosaic was finally validated with the CTX DTM mosaic and additionally shows smooth transitions to the CTX along the edges of the product.

The 3D products were then fused into a multi-resolution orbital DTM of Gale Crater using ASP, and the boundaries of each constituent DTM were found to be smooth, with no artefacts. We thus which demonstrate successful HiRISE-CTX-HRSC-MOLA co-registration and fusion.

A 25-cm shape-from-shading DTM of Yellowknife Bay [6] was additionally co-registered to and fused with the 1-m HiRISE mosaic from the above using ASP.

The HiRISE-CTX-HRSC DTM was then combined with the ORI for 3D visualization using the NASA DERT platform [7]. The Yellowknife Bay HiRISE mosaic was separately combined with a 6.5-cm super-resolution restored (SRR) orthoimage [8] and the 25-cm HiRISE ORI of the rover traverse for visualization of this local region. Perspective, "rover eye" view images were simulated from both scenes with the "camera" feature in DERT, using the approximate FOV and height of the MSL Navcam as described using the techniques in [9].

Midnight Planets and the Mars Analyst's Notebook were used to select along-traverse sites and visualize the rover data, and results were compared with Navcam panoramas in Midnight Planets [10].

3. Results

The resulting "rover eye" views of Gale Crater show comparable detail at-distance with MSL Navcam images. Figure 1 shows an example simulated Navcam view, with the linear features on the northern central mound clear in the CTX DTM, along with ridges and rocks along the slope and in the foreground.

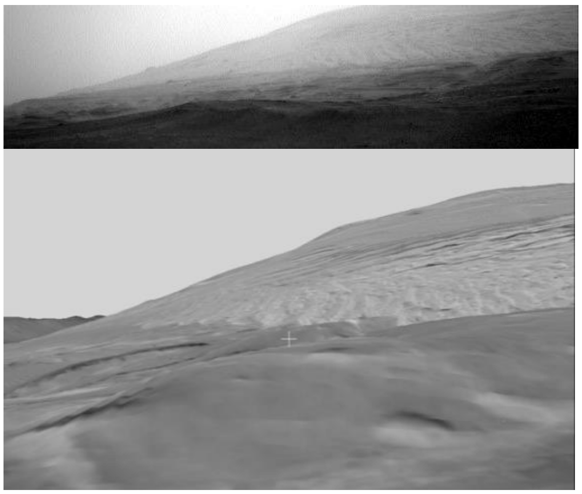

Figure 1. MSL Navcam, sol 2312 (top) and DERT view (bottom). This image features only the CTX DTM.

"Combined" views include greater close-range detail, especially for Yellowknife Bay, which includes the SRR orthoimage, as well as smooth transitions between products when visualized in 3D.

Summary and Conclusions

These results demonstrate successful fusion of a co-registered HiRISE-CTX-HRSC DTM, and the utility of visualizing this product in 3D for contextualizing close-range geological features with longer-range morphology, with possibilities for rover science mission targeting and analyses.

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