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Global Hybrid HRSC+OMEGA Image Mosaics of Mars

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1. Introduction

The High Resolution Stereo Camera (HRSC) on the Mars Express (MEx) orbiter has acquired 3640 images (with 'preliminary level 4' processing as described in [1]) of the Martian surface since arriving in orbit in 2003, covering over 90% of the planet [2]. At resolutions that can reach 10 meters/pixel, these MEx/HRSC images [3-4] are constructed in a push-broom manner from 9 different CCD line sensors, including a panchromatic nadir-looking (Pan) channel, 4 color channels (R, G, B, IR), and 4 other panchromatic channels for stereo imaging or photometric imaging.

In [5], we discussed our approach towards automatically mosaicking hundreds of the MEx/HRSC Pan or RGB images together. Herein, we present our latest results using this approach (Fig. 1; PDF is zoomable). Currently, our best results consist of adding a high-pass-filtered version of the HRSC mosaic to a low-pass-filtered version of the MEx/OMEGA [6] global mosaic.

2. Methodology

The images were acquired under different atmospheric conditions over the entire mission and under different observation/illumination geometries. Therefore, the main challenge that we have addressed is the color (or gray-scale) matching of these images, which have varying colors (or gray scales) due to the different observing conditions. We use a simple photometric correction (Lambertian, by dividing by the cosine of the incidence angle), which is (for example) currently used in the global mosaicking and map-tile creation of MRO/CRISM multispectral data [7-9]. The main portion of the photometric-correction effort involves the determination of the illumination and observation angles with respect to the digital elevation model [10-12]. The color-matching techniques that we have investigated include: 'dodging and burning' and 'histogram matching'. Dodging and burning is a local contrast-enhancement technique similar to high-pass filtering. One digital implementation of dodging and burning is Local Range Modification (LRM) [13-14], though we currently use the dodging option in the mosaicking tool of ArcGIS. This dodged, high-pass-filtered (HP) mosaic is then added to a low-pass-filtered (LP) version of either the entire photometrically-corrected HRSC mosaic or the OMEGA [6] 1.08-μm albedo mosaic, to create a HP+LP version of the mosaic (similar to processing that was done for the Viking MDIM [15]), which retains both the high-spatial frequency detail as well as the low-spatial frequency albedo variations.

Thus far, we have constructed a panchromatic (nadir) mosaic with over 2200 images that covers about 65% of Mars (at the low-to-mid latitudes) at a resolution of 475 meters/pixel (Fig. 1), with the intent of producing mosaics at 50 m/pixel. This subset of over 2200 images had already been 'cleaned': images of sub-standard data quality or with atmospheric issues were eliminated prior to the mosaicking.

We are in the process of repeating this construction for two new semi-global mosaics: one for the RGB HRSC images and one for the Pan HRSC images. The first would use LP-filtered OMEGA R, G, B mosaics, integrated over the wavelengths for these three HRSC color channels; and the second would employ a LP-filtered OMEGA Pan mosaic, summed over the wavelengths of the HRSC Pan channel.

3. Discussion

The photometrically-corrected and cleaned version of the semi-global HRSC (visible) panchromatic/nadir mosaic shows similar global trends in albedo to those observed in the global OMEGA 1.08-μm albedo mosaic [6]. However, there

are a number of HRSC-images that have slightly-different albedos than the neighboring HRSC images. This is the cause of 'cloudiness' or strip-to-strip variations observed in the HRSC LP mosaic and in the final HRSC HP+LP mosaic.

By using a LP-filtered version of the MEx/OMEGA 1.08-µm albedo mosaic, and combining it with the HP dodged HRSC Pan mosaic, we can construct a semi-global hybrid HP(HRSC)+LP(OMEGA) mosaic that does not have the 'cloudiness' or strip-to-strip-variations that are present in the HRSC-only HP+LP product.

One advantage of using the hybrid HP(HRSC)+LP(OMEGA) mosaic over the OMEGA-only 1.08-µm albedo mosaic is that the former can be much higher spatial resolution than the latter; the HRSC images used here were map-projected at 12.5 m/pixel, whereas this OMEGA mosaic is 1500 m/pixel. The mosaics presented here are 475 m/pixel.

4. Future

Using these techniques, we intend to make preliminary, non-archival, spatially-complete 'semi-global' mosaics (global mosaics, but excluding the polar regions, due to several factors, including the difficulty imposed by the changing polar atmosphere) available to the community in the next months (i.e., by a mapserver website; see [16]), at a resolution of 50 m/pixel. We plan to develop our own code for dodging and burning, in order to gain more control over the process, as compared to the ArcGIS function. We also intend to create mosaics with more advanced techniques:

i. Strip-to-Strip balancing prior to LP filtering;
ii. Color Grading [17];
iii. Color Histogram Warping [18];
iv. Pan-sharpening;
v. other photometric-correction techniques (Minnaert [10-12] and lunar-Lambert [19]);
vi. with atmospheric correction;
vii. for the polar regions.

Upcoming discussions are required to define science-data products to be potentially archived at PDS or PSA or which are going to be distributed via dedicated dissemination platforms. The work presented here may not be the final mosaic that is archived.

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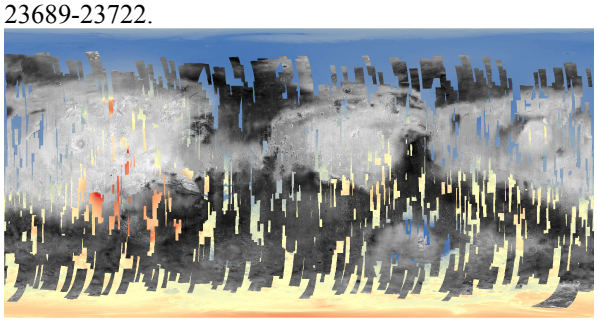

Figure 1: HP(HRSC)+LP(OMEGA) Pan mosaic [5]. Images selected for the mosaic have |LAT| < 60°. Colorized MOLA [20] elevation basemap.