

A quantitative assessment of rock size distributions from original and super-resolution HiRISE images against rover image-derived measurements

Y. Tao and J.-P. Muller

Imaging group, Mullard Space Science Laboratory, University College London, UK (yu.tao@ucl.ac.uk; j.muller@ucl.ac.uk)

Abstract

We show results from a quantitative study on automatically detected rock features from NASA MRO HiRISE orthorectified image at 25cm compared against these detected from a 5cm super-resolution resolved HiRISE image validated by these same features determined by analysis of MER-A Navcam orthorectified images to demonstrate one of the advantages of using our novel Gotcha-PDE-TV (GPT) super-resolution restoration (SRR) technique to better understand Martian surface processes.

1. Introduction

Higher spatial resolution imaging data is always desirable to the international community of planetary scientists interested in improving understanding of surface formation processes. For example, studying an area on Mars using 12m panchromatic HRSC allows you to be able to visualise the “big picture” of the Martian landscape whilst 6m CTX images allows you to see important mineralogical and geomorphological information which you can't identify in HRSC and finally for a tiny percentage of the Martian surface ($\approx 1\%$), 25cm HiRISE allows you to see details of surface features such as fine-scale layering. However, 25cm is not high enough resolution to be able to view individual rock features with diameters less than 0.75m or observe and measure the types of sedimentary features that MSL Curiosity has found in rover-based imagery. We have developed a novel SRR algorithm/pipeline, called GPT SRR, which is able to restore rover scale images (at ranges of $\geq 5\text{m}$) from multiple lower resolution orbital images [1] to support better surface analysis beyond the limited spatial coverage of rover imagery. This technique has been successfully applied to resolve 5cm-12.5cm super-resolution HiRISE images for the areas around the traverses for MER-A, MER-B and MSL missions in the EU-FP7 Planetary Robotic Vision Data Exploitation (PRoViDE) project (<http://provide-space.eu>).

In this paper, we look into measurements of rock size distributions for several critical sites in comparison between the original HiRISE image, corresponding SRR image, and rover Navcam orthorectified image mosaics. Furthermore, an assessment of the potential utility of SRR products will be shown for features such as RSL formation and gully movements in comparison to using HiRISE by the time of the conference.

2. Method

We use our in-house toolkit to automatically detect rocks [2] from HiRISE, SRR, and Navcam orthorectified images that cover the same area. Rock sizes and distribution are calculated from the three datasets and the differences between them are analyzed.

3. Results

In this experiment, rocks have been automatically detected from the original 25cm HiRISE and 5cm SRR image for the same area around an impact crater near the MER-A traverse acquired on Sol 150 and 151. Figure (1) and Figure (2) show that in 25cm HiRISE images, rocks less than 150cm diameter are not visible and are hard to detect, whereas in 5cm SRR, rocks larger than 30cm diameter are resolved.

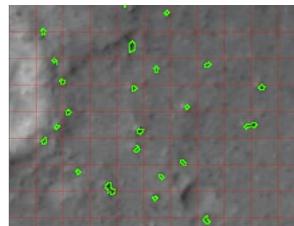


Figure 1 Automatically detected rocks (labelled green) of 25cm HiRISE image (PSP_001513_1655) (top) with 20pixel grid (5m) around an impact

crater close to MER-A traverse at $\sim (175.511^\circ, -14.585^\circ)$

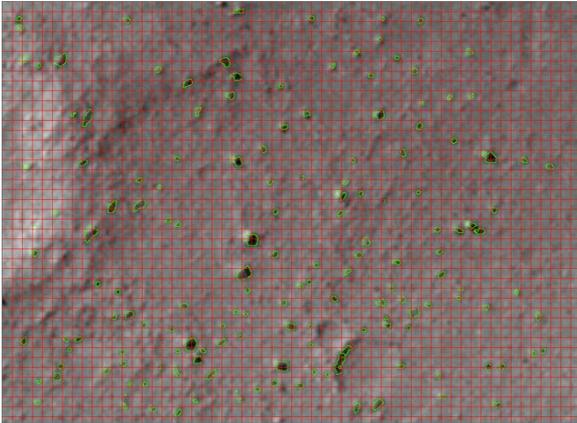


Figure 2 Automatically detected rocks (labelled green) of 5cm SRR image with 20pixel grids (1m) around the same impact crater close to MER-A traverse at $\sim (175.511^\circ, -14.585^\circ)$.

Rock diameter (D)	Accumulated number of rocks in HiRISE	Accumulated number of rocks in SRR image
$D \geq 150\text{cm}$	22	33
$D \geq 50\text{cm}$	23	144
$D \geq 30\text{cm}$	23	153

Table 1 Accumulated number of rocks in HiRISE and SRR image.

As shown in Table (1), for rocks with diameters larger than 150cm, there are 22 detected from the original HiRISE image and only 1 rock detected in the range $50\text{cm} < \text{diameter} < 150\text{cm}$. On the other hand, in the SRR image, there were 33 rocks with diameter larger than 150cm, 111 rocks with $50\text{cm} < \text{diameter} < 150\text{cm}$, and 9 rocks with $30\text{cm} < \text{diameter} < 50\text{cm}$. This experiment has demonstrated that there are a large number of rocks, which are not clear enough for either automated detection/classification or manual measurement in the original HiRISE image. However, with SRR, a much greater number of rocks can be detected and therefore provide stronger evidence to support an application such as the selection of a future landing site. Examples will be shown of how these rock size distributions compare against those derived from Navcam images.

6. Summary and Conclusions

We have performed a quantitative analysis on one key geomorphological feature, rocks, using HiRISE,

SRR and Navcam orthorectified image mosaics and compared the results to demonstrate the additional information content of using our unique SRR technique for improving understanding of Martian surface compared with using original HiRISE image. An initial comparison on rock size distribution based on HiRISE and SRR image is given in this paper.

We aim to process all available image datasets in future where we have repeat multi-view imagery starting with HiRISE first and then apply these techniques to HRSC, CTX, THEMIS, MOC and Viking Orbiter into geo-referenced SRR mapped datasets after porting the software onto a GPU. We also plan to apply such techniques to the retrieval of 3D heights where we have multiple stereo-pairs available. The geo-referenced SRR datasets should greatly support the geological and morphological analysis and monitoring of Martian surface processes especially change detection features in future planetary research. They can also be applied to landing site selection, in order to avoid terrains, which are unsuitable for any future rover as well as define future rover paths.

Acknowledgements

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement No. 312377 PProViDE.

References

- [1] Y. Tao and J.-P. Muller (Submitted, 4/2015) A novel method for surface exploration: super-resolution restoration of Mars repeat-pass orbital imagery.
- [2] Y. Tao and J.-P. Muller (2013). Automated science target selection for future Mars rovers: A machine vision approach for the future ESA ExoMars 2018 rover mission. EGU2013-12407. Vol. 15.