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Automated dynamic feature tracking of RSLs on the Martian surface through HiRISE super-resolution restoration and 3D reconstruction techniques

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Abstract

In this paper, we demonstrate novel Super-resolution restoration and 3D reconstruction tools developed within the EU FP7 projects and their applications to advanced dynamic feature tracking through HiRISE repeat stereo.

1. Introduction

Almost fifty years have elapsed since the NASA Mariner 4 spacecraft first took the pictures of the Martian surface. Over that time period, the resolution and quality of these images has improved from tens of kilometres up to 25 cm. Over the intervening ≈50 years, many areas on Mars have been imaged repeatedly more than 5 times for scientific studies.

Within the recently completed EU FP-7 iMars (http://www.i-mars.eu) project, a fully automated multi-resolution DTM processing chain was developed by UCL for NASA CTX and HiRISE stereo-pairs, called the Co-registration ASP-Gotcha Optimised (CASP-GO), based on the open source NASA Ames Stereo Pipeline (ASP) [1], tie-point based multi-resolution image co-registration [2], and the Gotcha [3] sub-pixel refinement method.

The implemented system guarantees global geo-referencing compliance with respect to High Resolution Stereo Colour imaging (HRSC), and hence to the Mars Orbiter Laser Altimeter (MOLA), providing refined stereo matching completeness and accuracy from the ASP normalised cross-correlation.

In Parallel, a novel Super-resolution restoration (SRR) technique using Gotcha sub-pixel matching, orthorectification, segmentation, and 4th order PDE-TV, called GPT-SRR was developed [4]. SRR is able to restore 5cm-12.5cm near rover scale images (Navcam at a range of ≥5m) from multi-angle repeat-pass 25cm resolution MRO HiRISE images [5].

2. Method

Recently, we explored the possibility to apply GPT-SRR on areas with known dynamic changes, including Recurring Slope Lineae (RSL), Gullies, and Polar Dune Flows. The idea came about when observing individual input scenes for the 3 rovers and noting that the appearance of the rovers were different in each image but the final SRR image no longer included the rovers. Due to the ability of the SRR technique to extract super-resolution for static features, , we are able to restore matched (unchanged) features and meanwhile automatically track the unmatched (dynamic) pixels to characterise and measure the "change".

On the other hand, by adding 3D information from repeat DTMs produced from multiple overlapping stereo-pairs, we are able to restore the unchanged surface also in 3D as SRR requires multiple angle views as inputs. This allows us to overlay tracked dynamic features onto the reconstructed "original" surface, providing a much more comprehensive interpretation of the surface formation processes in 3D.

3. Results

In iMars, ~5,300 CTX DTMs using the developed CASP-GO system. Around 400 HiRISE stereo pairs have 5 or more repeat views and these are being processed using the Amazon® AWS cloud computing resources that are all co-registered to a global reference system derived from MOLA.

In parallel, a recent study on one of the RSL sites (centre coordinates: 41.6°S, 202.3°E) in the Palikir Crater [6] took 8 repeat-pass 25cm HiRISE images from which a 5cm SRR image using GPT-SRR [Figure 1] was produced using SRR which is shown here in comparison with one of the original HiRISE images that have large RSL features [Figure 2]. The SRR image shows the restored static surface without any dynamic features. By tracking the unmatched features from the original HiRISE images, we are able to mask out the dynamic features (e.g. RSLs) on the static surface shown in [3].

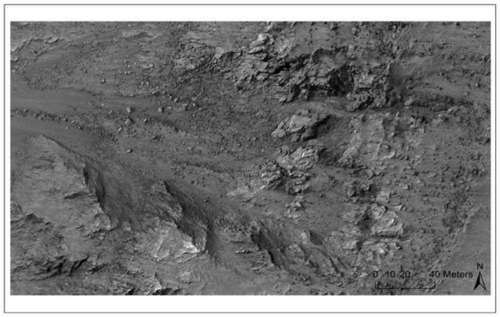

Figure 1 Example of 5cm GPT-SRR image at Palikir Crater (centre coordinates: 41.6°S, 202.3°E) processed using 8 repeat-pass 25cm HiRISE images.

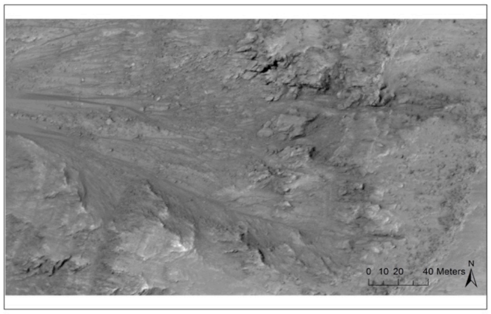

Figure 2 Example of original 25cm HiRISE image (ESP_031102_1380) at Palikir Crater (centre coordinates: 41.6°S, 202.3°E) showing several (faint) RSL features.

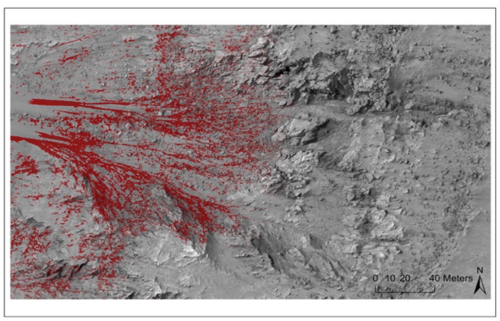

Figure 3 Example of 5cm GPT-SRR image at Palikir Crater (centre coordinates: 41.6°S, 202.3°E) showing automatically tracked dynamic features (masked in red colour) from one of the original HiRISE scene (ESP_031102_1380).

4. Summary and Future work

This initial result shows only the total area that changed in 2D. It is planned to extend this to provide an index of individual features in HiRISE, image by image, and their associated velocities in 3D. This will enable better characterisation and modelling of dynamic features by analysing the "change-statistics", including the total affected areas, shapes and propagation directions in 3D of the masked pixels. In addition, from the greater detail in the RSL-free image and DTM we are also able to observe fine-scale detail of the surface and detect if any small targets have moved as well as analyze their motion.

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References

[1] Moratto, Z. M., M. J. Broxton, R. A. Beyer, M. Lundy, and K. Husmann, 2010. Ames Stereo Pipeline, NASA's Open Source Automated Stereogrammetry Software. Lunar and Planetary Science Conference 41, abstract #2364.

[2] Y. Tao, J.-P. Muller, W. Poole (2016) Automated localisation of Mars rovers using co-registered HiRISE-CTX-HRSC orthorectified images and wide baseline Navcam orthorectified mosaics, ICARUS, Vol 280, p139-157.

[3] Shin, D. and J.-P. Muller, Progressively weighted af-fine adaptive correlation matching for quasi-dense 3D reconstruction. Pattern Recognition, 2012. 45(10): p. 3795 -3809.

[4] Y. Tao and J.-P. Muller (2015) A novel method for surface exploration: super-resolution restoration of Mars repeat-pass orbital imagery, Planetary and Space Science, http://www.sciencedirect.com/science/article/pii/S0032063315003591.

[5] Y. Tao and J.-P. Muller (2016), Quantitative assessment of a novel super-resolution restoration technique using HiRISE with Navcam images: how much resolution enhancement is possible from repeat-pass observations, ISPRS 2016 Commission IV, WG IV/8.

[6] Massé, M., S. J. Conway, J. Gargani, and M. R. Patel (2016) "Transport processes induced by metastable boiling water under Martian surface conditions," Nature, vol. 9, pp. 425–428, DOI: 10.1038/NGEO2706.