EPSC Abstracts
Vol. 10, EPSC2015-582, 2015
European Planetary Science Congress 2015

Identifying dynamic features on Mars through multi-instrument co-registration of orbital images

P. Sidiropoulos and J.-P. Muller
Imaging Group, Mullard Space Science Laboratory, Dept. of Space and Climate Physics, University College London,
Holmbury St. Mary, Dorking, Surrey, RH56NT, UK (p.sidiropoulos@ucl.ac.uk, j.muller@ucl.ac.uk)

Abstract

The detection and characterisation of dynamic phenomena on Mars can benefit from the systematic reconnaisance of the martian surface through high-resolution orbiter imagery. The original framework implies the straightforward detection of surface changes through the comparison of multi-temporal images acquired from a single instrument. However, up until the present-day, mainly single-instrument image pairs significantly limit the time and areal coverage range on which change detection techniques can be applied. Therefore, we have developed a pipeline that performs multi-instrument co-registration of orbital images, thus allowing the automatic detection of changes in images originating from different orbiter cameras. This work summarises the developed pipeline and shows some examples of surface changes that were detected with the help of multi-instrument co-registration.

1. Introduction

The high-resolution mapping of the Martian surface through orbital cameras started with Viking Orbiter 1 & 2 twin missions, which were launched in 1975, and was achieved between 1976 and 1980 at global medium resolution coverage of Mars, while also acquiring images with resolution as fine as 8 metres per pixel. After Viking Orbiter, four more orbiters, three from NASA and one from ESA, have been sent to Mars to image its surface with high-resolution imagery, which since 2007 reach to 25 centimetres per pixel for HiRISE images. The systematic reconnaisance of Mars with high-resolution images have allowed the identification of previously undiscovered dynamic surface phenomena and unusual surface features [1], as well as the examination of surface composition and geological history [2].

A crucial role in this analysis is played by change detection modules, in which two images acquired at different time are compared in order to try to identify surface features that have changed in the meantime, irrespective of the lighting conditions but with little or no obscuration from clouds or dust. While change detection was originally tackled in a manual and non-systematic way, the increasing imaging rate with high resolution implies the need for a fully automatic approach that would maximise the exploitation of the available data. As a result, techniques that aim at automatic surface change detection are being introduced [3], [4]. However, these few approaches tackle only the last part of a fully automatic temporal change detection pipeline, which is the change identification and classification, thus assuming the implied successfull co-registration of the input images.

Most automatic co-registration techniques are based on assumptions that limit their use in single-instrument image pairs. In order to allow the comparison of images acquired from different instruments we have developed a multi-instrument co-registration pipeline, which use HRSC orthorectified images (ORI) and digital terrain models (DTM) as a baseline so as to project all NASA images onto the same coordinate system. Subsequently, the co-registered images are examined for changes using an automatic classification scheme.

2. Method

Initially, the input images are co-registered using an HRSC ORI and DTM as a baseline. The co-registration employs SIFT points [5], which are matched through an elaborate iterative process called coupled decomposition [6], before the matched points are used to determine a camera model that projects the input image into the HRSC coordinate system.

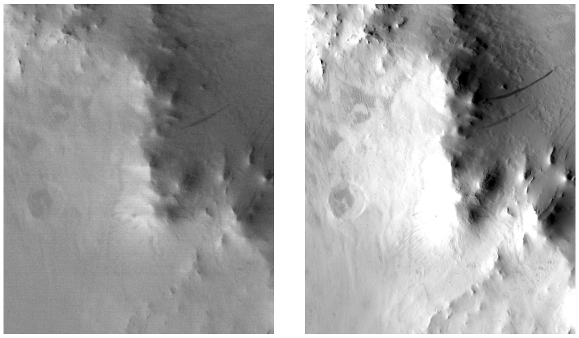
At this stage, the co-registration results may be used to indicate candidate changed regions. As a matter of fact, since the pixels of a pair of co-registered images correspond to the same location, a straightforward pixel-wise comparison (e.g. through correlation) would signify pixel-level changes. Since change detection using such correlation is rather computationally demanding when performed on the complete image strips (especially, since the latter can reach up to 10 gigapixels), we use pixel-level changes to prioritise regions-of-interest (ROIs) in the image pair. Subsequently, the change detection pipeline is executed independently in each ROI.

The latter is based on a Support Vector Machine (SVM) [7] classification scheme. More specifically, pixel features are extracted from each ROI to represent the candidate changed area. These features are the input into a SVM classifier that discriminates between actual changes and non-informative ”changes” (e.g. ”changes” triggered from different point spread functions).

3. Results

Some examples of surface changes discovered in multi-instrument high-resolution pairs are given in Figures 1 and 2. All images show an area of $9X7$ kilometres, with the North being placed at the top. The left sub-image in both examples is a HRSC orthorectified image, with resolution 12.5 metres per pixel, while the right sub-image is a CTX image (orthorectified using our co-registration pipeline), with resolution approximately 5.5 metres per pixel. Finally, the temporal distance between HRSC and CTX images is in both cases approximately 2 Martian Years. More surface changes will be shown in the EPSC presentation.

Figure 1: (a) HRSC image (b) CTX image.

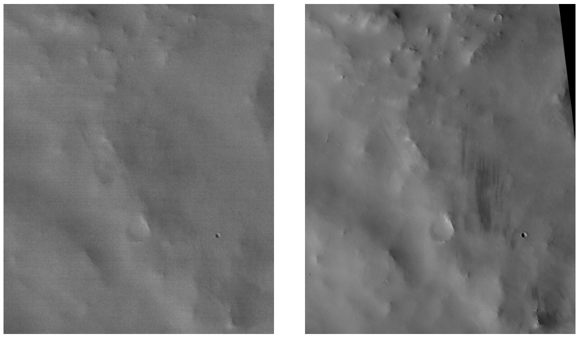


(a) (b)

Acknowledgements

The research leading to these results has received funding from the STFC “MSSL Consolidated Grant” ST/K000977/1 and partial support from the European Union’s Seventh Framework Programme (FP7/2007-2013) under iMars grant agreement n° 607379.

Figure 2: (a) HRSC image (b) CTX image.



(a) (b)

References

[1] A. McEwen et al.: Seasonal Flows on Warm Martian Slopes, Science, Vol. 333, No. 6043, pp. 740-743, 2011

[2] S. Byrne et al: Distribution of mid-latitude ground ice on Mars from new impact craters, Science, Vol. 325, No. 5948, pp. 1674-1676, 2009

[3] K. Wagstaff et al.: Dynamic Landmarking for Surface Feature Identification and Change Detection, ACM Transactions on Intelligent Systems and Technology, Vol. 3, No. 3, pp. 1-22, 2012

[4] K. Di et al.: Mars Surface Change Detection from Multi-temporal Orbital Images, 35th International Symposium on Remote Sensing of Environment, 22-26 April 2013, Beijing, Chaoyang, China

[5] Lowe, D. G.: Distinctive Image Features from Scale-Invariant Keypoints, International Journal of Computer Vision, Vol. 60, No. 2, pp. 91–110, 2004

[6] Sidiropoulos, P. and Muller, J.-P.: Matching of Large Images Through Coupled Decomposition, IEEE Transactions on Image Processing, Vol. 24, No. 7, pp. 2124-2139, 2015

[7] Hearst, M.A., Dumais, S.T., Osman, E., Platt, J., and Scholkopf, B.: Support vector machines, IEEE Intelligent Systems and their Applications, Vol. 13, No. 4, pp. 18-28, 1998.