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3DPD application to the first CaSSIS DTMs

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Abstract

The main objective of the ExoMars Trace Gas Orbiter (TGO) is the search for traces of atmospheric gases that could be the signature of biological activity on Mars. Among different onboard instruments, the spacecraft includes an imaging and photogrammetric camera called Colour and Stereo Surface Imaging System (CaSSIS, [1]) that is a narrow angle telescope dedicated to i) imaging with four filters (centered at 0.499 μm, 0.675 μm, 0.836 μm and 0.937 μm) and a spatial scale < 5m and ii) to 3D reconstruct specific targets of interest through stereo capabilities. INAF-OAPD institute (The Astronomical Observatory of Padova), as part of the CaSSIS team, leads the Digital Terrain Models (DTMs) generation in association with other team members. In addition, INAF-OAPD is responsible for DTMs archiving [2]. Here, a preliminary DTM is shown, as example.

1. Introduction

The stereo satellite photogrammetry is generally based on push-broom acquisition systems. Different push-broom instruments have provided DTMs from Mars planetary images even without an actual stereo configuration, like NASA's CTX [3] and HiRISE [4] cameras.

Nowadays, the push frame approach is replacing the push broom in missions oriented to photogrammetry. The use of 2D images, buffered while the spacecraft moves, increase the geometry information avoiding registration problems. This is the case of CaSSIS: a common telescope configuration (oriented 10° with respect to the nadir pointing) taking advantage of a rotational unit to perform imaging in different directions.

To obtain a stereo couple, CaSSIS firstly acquires a set of "framelets" while looking forward along the orbit. Consequently the telescope rotates 180° degrees and, looking backward along the orbit, it acquires a second set of "framelets" covering the same area imaged by the first set. This approach guarantees a sufficient baseline to reach a vertical precision equal to the pixel on-ground.

Since its arrival around Mars in October 2016, CaSSIS already demonstrated its stereo performance despite a non-nominal orbit. Indeed, the first CaSSIS DTM of a Deep Seated Gravitational Slope Deformation (DSGSD) was reconstructed [5] and analysed [6]. At the end of April 2018, TGO started its commissioning phase and it is now ready for its nominal science mission phase.

2. 3DPD

INAF-OAPD developed a stereo pipeline for the 3D reconstruction of planetary surfaces, rooting its know-how from the design of the stereo camera STC [7] on board the BepiColombo mission. Despite STC and CaSSIS instruments are different in terms of optical design and stereo strategy, they both share the push-frame approach. Therefore, these contexts brought to the development of a ad-hoc DTM generation software, called 3DPD (three-Dimensional reconstruction of Planetary Data), which can be used for both the instruments.

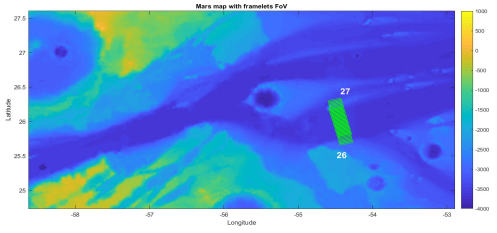

Figure 1: Screenshot of the 3DPD user interface showing the two CaSSIS frames' FoVs projected on the Mars surface that are used for the DTM generation.

The software includes a user interface for CaSSIS acquisition visualisation, as shown in Figure 1.

The full pipeline of the software [8] includes i) the geometrical distortion calibration [9], ii) the mosaicking of the images on the MOLA quote, iii) the definition of SURF tie-points and iv) a sequential use of both pyramidal NCC(Normalize Cross Correlation) and ALSM(Adaptive Least Square Matching) algorithms for the definition of disparity maps. The final steps leading to the resulting DTM production include v) the outliers detection and filling holes based on dephormable models [10] and vi) the triangulation phase. Tests will be also conducted to improve the level of details in the DEMs by photoclinometry [10].

3. CaSSIS first Stereo Images

During the first commissioning orbits (STP003 phase) CaSSIS acquired more than 800 panchromatic framelets, returning a total of 30 frames. Among them, eight frames are stereo couples.

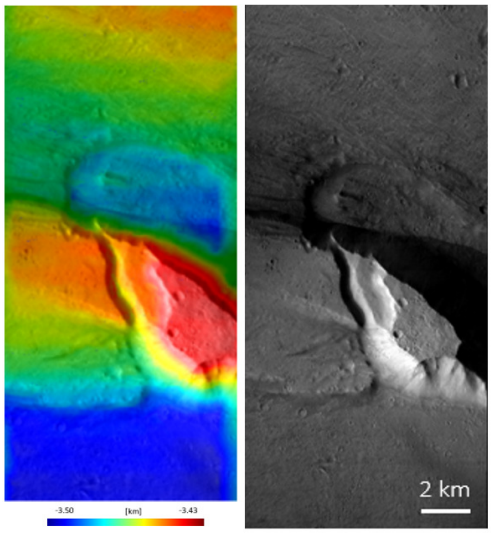

Figure 2: Preliminary height map reconstruction (texturized) of the structure (left hand side) and one of the two stereo images obtained after mosaicking process (right-hand side). The quotes are referred to mean MOLA radius.

On May, 7, 2018, at 14:09:08 UT, the CaSSIS camera acquired the frames no. 26-27 covering a section of the Kasei Vallis canyon (the southernmost channel of the Kasei Valles) located at 26° N, -54.3°. Fig. 1 shows the FoV positions of the two CaSSIS frames, while the colorbar represents the MOLA elevation in metres. The stereo couple covers part of the outflow channels' outlet towards the Chryse Planitia, south-east of one of the largest teardrop shaped islands located in the area. Such location lies right at the boundary between the Noachian highland unit (Nhu) and the Amazonian and Hesperian impact unit (AHi) of the Mars global geology of [10]. The preliminary DTM result is presented in Fig. 2 and covers an incised dome/structure that is 4.4 km long, 1.9 km wide and 60 meters taller than the local plane. The CaSSIS DTMs will be integrated with multi-band orthorectified images provided by the color filters adding valuable compositional information to the reconstructed topography.

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References

[1] Thomas, N., et al. 2014, 8th International Conference on Mars. 2014.
[2] Cremonese G. et al 2018, EPSC
[3] Bell III, J. F., et al., 2013, International Journal of Mars Science and Exploration 8: 1-14
[4] McEwen, Alfred S., et al. 2007, Journal of Geophysical Research: Planets 112.E5.
[5] Cremonese, G., et al.2017. LPSC. Vol. 48.
[6] Massironi, M., et al., 2017, EPSC2017-618-1
[7] G. Cremonese, et al, 2006, Mem. S.A.It. Suppl. 9, pp. 173-175 . ISSN: 1824-0178.
[8] Simioni, E., et al.,2017, ISPRS 42: 133-139.
[9] Tulyakov, Stepan, et al.2018, Advances in space research 61.1: 487-496.
[10] Simioni, E, et al. 2011, PE&RS 77.5: 495-507.
[11] Douté, S., et al. 2018 EPSC 2018.
[12] Tanaka et al., 2014.. Planet. Space Sci. 95, 11-24.