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3DPD - CaSSIS Digital Terrain Models status

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Abstract

1. Introduction

We designed a photogrammetric pipeline at the National Institute for Astrophysics – Astronomical Observatory of Padova to process the recent stereo images obtained with the CaSSIS instrument [1]. Taking into account the actual state of art of the DTM generation using the CaSSIS images, the 3DPD software developed in Padova is the first tool that has made the stereo products accessible to the scientific the community through the public web repository (www.cassis.oapd.inaf.it/archive/).
At the moment, almost 70 DTM and related ancillary products, such as orthophoto, height maps, quality maps and other auxiliary files are collected in the CaSSIS team repository with the main aim to foster scientific investigations.

2. The stereo camera CaSSIS

The CaSSIS (Colour and Stereo System) [1] is a push broom imaging system on board the Trace Gas Orbiter and it is equipped with a suite of four different filters: a panchromatic filter and three broad band filters glued on a hybrid CMOS. The telescope has a focal length of 869 mm. A rotation system and an emission angle of 10° with respect the nadiral direction make CaSSIS a stereo photogrammetric instrument able to reconstruct the Martian surface with a vertical precision of 4.6 m.
The panchromatic filter has a dimension of 280x2048 pixels. The instrument provides images with a dynamical range of 14 bit and allows to take advantage of binning or compression to manage the data volume. Multiple images are acquired in the along track direction with low repetition time providing sequences of overlapped images on the surface.
The operational orbit of the TGO is defined at 400 km of altitude. The data for orbit, pointing and clock timing are generated in NASA's NAIF/Spice format. All the acquisition sessions are divided in the so called MTPs (Medium Term Period).

1.1 Stereo pairs distribution

Until MTP11, CaSSIS has acquired 1492 stereo pairs with different acquisition strategie, and with different filters modes. Figure 1 shows the distribution of stereo acquisitions divided by Mars quadrangles.

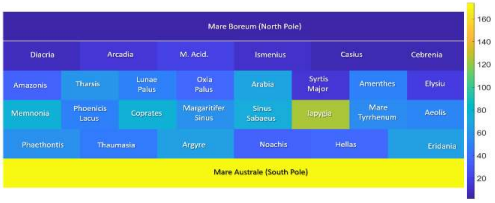

Figure 1: Distribution of the stereo acquisition of CaSSIS for each Mars quadrangles.

3. OAPD activities

The OAPD team is leading the management of the DTMs requests for science analysis as well as producing them for the scientific community.
The request management process is performed thanks to a Web Dynamical page system structured as a web Repository [2,3] which allows the booking of the DTMs and the quality check of the CaSSIS acquisitions. An example of data visualization of the

website is shown in Figure 2, representing the stereo couple used for the DTM generated as presented in Figure 3. This is produced thanks to the subsequent process performed through a Matlab/C# multiprocessor software called 3DPD [4,5].

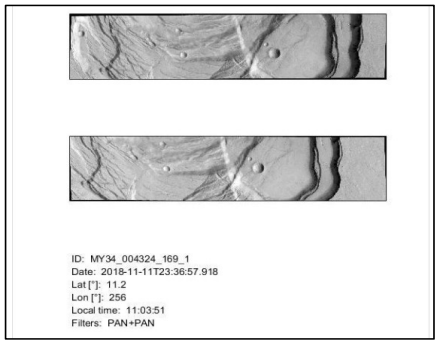

Figure 2: Extract of the stereo pair visualization from the Repository web page

3.1 Stereo Data process

The image processing consists of two main steps.

First, a systematic processing of the raw data is performed considering the radiometric and stray light correction of the images and then, the photogrammetric process for the derivation of mosaicked and orthorectified images. The first step is automatically performed by the team at Bern University [6]. The latter is systematically performed by CASSIS_Reader every time an MTP is concluded.

The process includes the removal of the distortion of the instrument and the generation of ortho-rectified images. This consists of ray tracing process on a define surface. Different surfaces are then taken in account: the mean plane on the MOLA surface [7], the Mars spheroid defined in Spice Kernels or the Mola (463 m/px) body shape are considered as possible choices.

The mosaicking process is used as the base for computing a geometrically consistent solution: the process takes advantage of both the image content and the features. The images allow to minimize photo plane errors by fixing the geometry of the acquisitions. The features, on the other side, define the stereo block geometry. Their scope is to reach an auto consistent collinearity solution thanks to a non linear bundle adjustment process.
First comparisons with HiRiSE DTMs have demonstrated a relative vertical precision of the pipeline of ~5 m [8].

3.2 Tharsis Mons Case

The mosaicked images shown in Figure 2 were acquired by CaSSIS at 2018-11-11 at coordinate 11.203° -104.71° The resulting DTM is shown in Figure 3 as height maps.

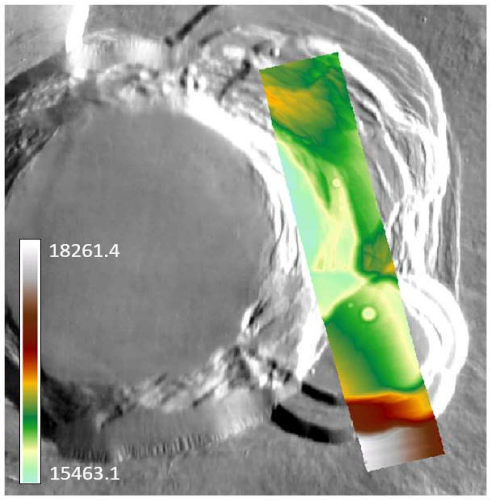

Figure 3: Example of colorized height map om Tharsis Mons Acquisition. Height are reported in metres respect to Mars aroid.

The data covers the eastern side of the Caldera of the Ascraeus Mons, a 480 km wide shield volcano belonging to the Tharsis Montes. With an elevation of 18.1 km, Tharsis Montes is the second highest peak on Mars. Such volcano was built by several thousand basaltic lava flows. With the exception of it huge size, it is similar to terrestrial shield volcanoes like those forming the Hawaiian island.

Acknowledgements

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