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3D DIGITAL OUTCROP MODELLING IN UTOPIA PLANITIA (MARS) USING PHOTOGRAMMETRY ON ZHURONG'S NATECAM IMAGES. G. Caravaca^{1,*}, Z. Chen^{1,3}, S. Le Mouélic², X. Ren³, S. Maurice¹,
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Introduction: The Chinese robotic probe *Zhurong* of the Tianwen-1 mission landed in May 2021 on Mars to become the sixth rover at the surface of the red planet. *Zhurong* landed in southern Utopia Planitia, an immense smooth area of lowland from the northern hemisphere thought to have possibly hosted marine to oceanic basins during the Hesperian to Noachian epochs [e.g., 1]. *In-situ* investigation conducted by the *Zhurong* rover during its ~1 year of activity allowed to gather new data on the sedimentary rocks composing the basement and aeolian features of this area (Fig. 1; [e.g., 2, 3]). In this work, we use Structure-from-Motion photogrammetry to produce 3D Digital Outcrop Models (DOM) of workspaces explored by the rover using images gathered by *Zhurong*, to assess their potential for use in future geological studies.

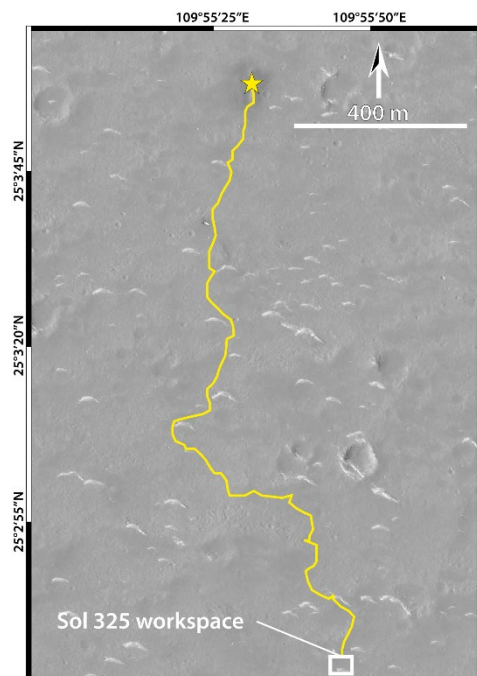


Fig. 1 Orbital view of the area of operation of the *Zhurong* rover of the Tianwen-1 mission (HiRISE basemap). Yellow star indicates the landing site in southern Utopia Planitia, and the yellow line indicates the traverse of the *Zhurong* rover (after [2]), with the position of the Sol 325 workspace replicated in 3D in this work.

Context: *Zhurong* landed in southern Utopia Planitia on May 14th, 2021 (UTC; May 15th CST), with the goal to characterize the geology of the area, thought to have hosted possibly marine to oceanic basins [1]. The rover explored flat-lying, smooth terrains covered with pebbles and laden with cemented dunes [e.g., 2; 3]

as it traversed ~2 km southward from its landing site (Fig. 1) during ~1 Earth year of activity. One of the latest workspaces before entering hibernation was explored from Sol 325 (Fig. 1). This workspace was selected in this work to be reconstructed as a DOM, both for ease of localization (at the end of the traverse), and because it contains features (dune, block, cf. Fig. 2) large enough to be observed in orbital HiRISE image for accuracy control.

Digital Outcrop Modeling: *Zhurong* is equipped with a pair of two mast-mounted, panoramic color imagers, the Navigation and Terrain Cameras (NaTeCam [4]). NaTeCam provide 2048 x 2048 px color images of the immediate surroundings of the rover, and were useful to both characterize the terrain and point targets for the different payloads onboard the rover.

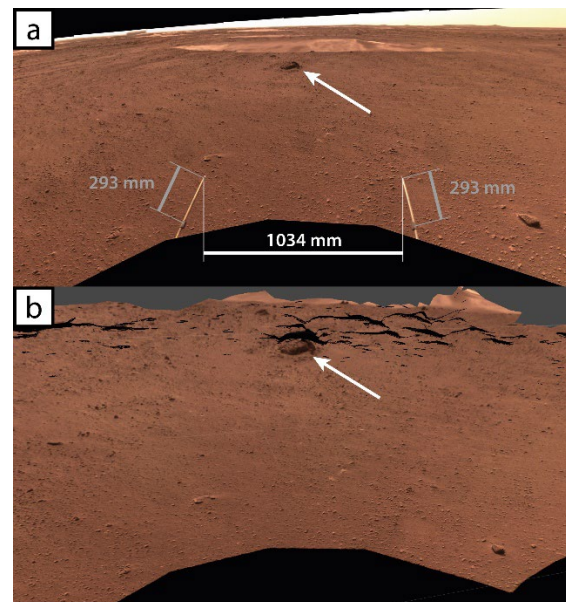


Fig. 2 Sol 325 workspace. White arrow indicates the featured large block. a) 2D Panorama of the workspace, as seen by *Zhurong*. The two front-facing CH1 antennas of the onboard georadar are visible and serves to provide scaling control on the images. b) 3D DOM of the workspace. DOM visible on Sketchfab at: <https://skfb.ly/oOpnZ>.

To recreate the DOM of the Sol 325 workspace, we are using 8 images (4 stereo pairs) covering about 120° of field of view (Fig. 2a). We are using the method set in [5] based on images from the Mars Science Laboratory rover *Curiosity*, and using the Structure-from-Motion Agisoft Metashape professional software (v.2.0.3, 2023). Compared to *Curiosity* or even

Perseverance data, that are operating in craters and therefore areas with some relief, *Zhurong* has traversed a mostly flat-lying, smooth and featureless region, making the photogrammetric alignment process more difficult, due to the lack of specific landscape elements to tie on. Nevertheless, the NaTeCam color images were sufficiently resolved to allow the alignment to occur in Metashape. This resulted in a high-resolution model of the workspace, as illustrated in Figure 2b (also visible on Sketchfab platform at: <https://skfb.ly/oOpnZ>). This models spans over ~ 324 m², with a maximum radius from the rover of ~ 12 meters.

Scaling and accuracy control: Contrary to *Curiosity* or *Perseverance* rovers that routinely take 360° panorama of their stops, most NaTeCam image sets only show the workspace in front of *Zhurong*. Therefore, it is difficult to see the wheel tracks of the rover, that are usually used as a scaling tool to control the size of the 3D DOMs [5]. To provide scaling, we therefore rely on pieces of hardware that are systematically imaged by the NaTeCam: the front-facing CH1 antennas of the embarked georadar. Both antennas are situated 1034 mm apart from each other [6], providing us with a readily usable fixed scale on each image set. Additional measures, such as the 293 mm-long part between the tip and the hinge of each antenna (as used in [2]) give us additional constrains to scale our model.

To ensure the scaling was accurate enough to use for scientific purposes (e.g., measurements, spatial distribution of clasts, etc.), we proceeded to an accuracy control using the orbital HiRISE orthoimage of the area (Fig. 1; cf. [5]). Figure 3 illustrates that control made by cross-measuring the block situated in the background of the workspace (Fig. 2) on both the orthoimage and on

the 3D model. We measure the block at 79.6 cm on the orthoimage (Fig. 3a) and at 79.5 cm in the DOM (Fig. 3 cm), confirming the very high accuracy of the scaling of the DOM. This accuracy is valid up to ~ 8.5 m from the rover, distance to where is situated the measured block from the rover.

Summary: Here, we used Structure-from-Motion photogrammetry on NaTeCam stereo images acquired by the *Zhurong* rover, to compute a 3D mesh of its Sol 325 workspace. We demonstrate that this method provides a high-resolution, accurately scaled 3D replica of the studied workspace. Using it, we produce accurate, calibrated meshes of the workspaces explored by *Zhurong*, allowing for a variety of measurements and characterization to be made for further investigations. At the time of writing, we are also considering implementing the DOM into a Virtual Reality environment to allow true-scale exploration of *Zhurong*'s premises [e.g., 5; 7].

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References: [1] Liu *et al.* (2021) *Nature Astro.* **6**(1), 65-71. [2] Xiao *et al.* (2023) *NSR* **10**(9), nwad137. [3] Chen *et al.* (2024) *LPSC LV* (this conf.). [4] Liang *et al.* (2021) *Space Sci Rev* **217**(37). [5] Caravaca *et al.* (2020) *PSS* **182**, 104808. [6] Zhou *et al.* (2020) *EPP* **4**, 345-354. [7] Le Mouélic *et al.* (2023) *PSS*, 105813

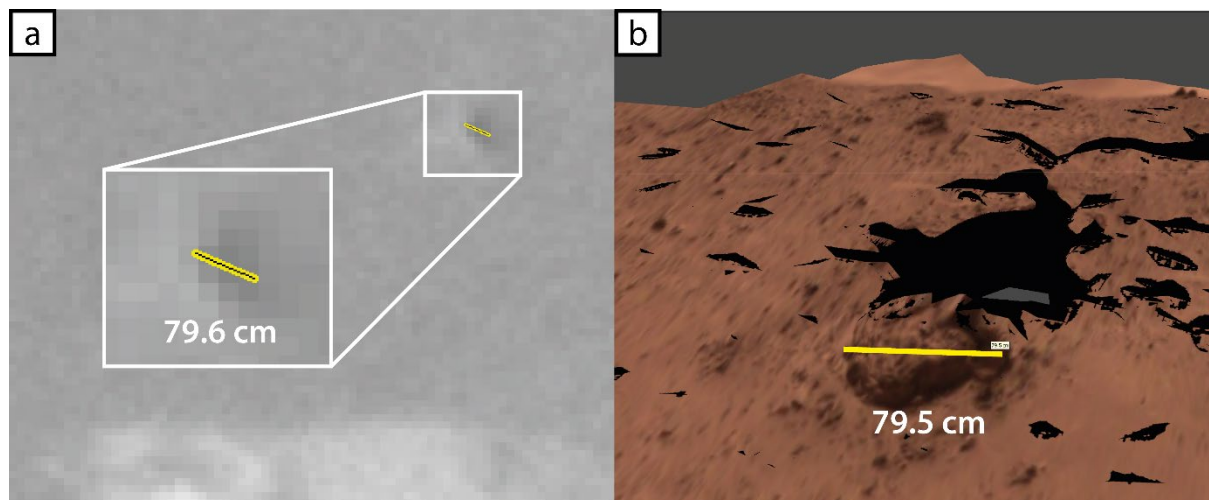


Fig. 3: Accuracy control of the scaling by cross-measurement of a block in the workspace on the orbital HiRISE image (a) and on the 3D DOM (b), allowing to measure a size of ~ 80 cm for the block observed ~ 8.5 m away from the rover (see Fig. 2).