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Morphometry and trafficability of planetary analogue terrains based on very high resolution remote sensing imagery

Angelo Pio Rossi (1), Riccardo Pozzobon (2) Erica Luzzi (1) Carlos Brandt (1) Vikram Unnithan (1), Francesco Sauro
(1) Jacobs University Bremen, Germany (an.rossi@jacobs-university.de), (2) Università di Padova, Italy, (3) Università di Bologna, Italy

Traverse design for planetary in-situ sampling and sample return are of key importance for both robotic and human-robotic exploration [1]. The geologic and morphologic documentation along traverses is based on the collection of high-resolution remotely sensed data, as well as sample selection [2]. Sample characterisation can be performed at the outcrop to hand-specimen scale in the field, and up to microscopic scale, either in the field or in the lab.

The integration of different experiments and techniques is important for [3] and the use of suitable analogues, for either scientific or operational [4].

ESA Analog-1 planetary analogue operations experiment will perform geological observations via a remotely operated rover along a traverse, including sample selection and collection.

The A1TRAP (Analog-1 TRAverse Preparation) activity was performed during the ESA Pangaea-X 2018 campaign. A1TRAP included multiple experiments such as drone and field-based photogrammetry, laser scanning, in order to define the location of traverses, based on cartographic, morphometric and geologic merit. Traverse geometry and positioning have been finalised and documented. Selected samples have been precisely located and collected [5], to be later used within remote operations.

In order to better plan the Analog-1 rover operations, a digital terrain model (DTM) and orthomosaic of the analogue site of Tinguatón were built using drone-based data collected during the ESA Pangaea-X 2018 campaign.

Data have been processed with resolution at centimetric levels, in order to flexibly adapt to the evolution of rover requirements and capabilities. The development of stay-out zones has been performed based on both slope and morphometric calculations. Specifically, the choice of the topographic position index (TPI) [6, 7, 8] has been made to characterise qualitatively and quantitatively surface morphologic properties.

Differences in elevation between several neighboring cells are performed and the resulting height and slope values are used for classifying local landforms based on their geometry and convexity. The classification can be obviouly used also in non-terrestrial settings [9] in order to characterise in detail planetary surface morphologies (Figure 1).

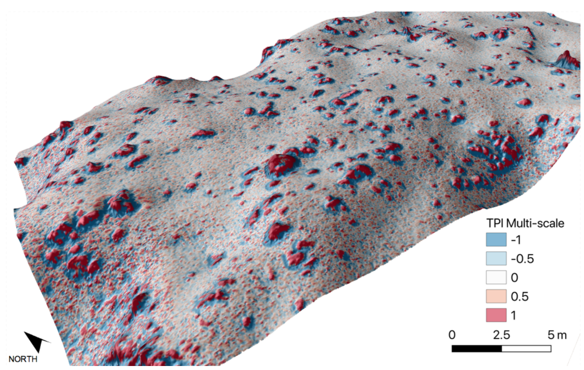

Figure 1: Perspective view of the TPI index draped onto the shaded relief of drone photogrammetry with 1.3 come resolution. The red portions are corresponding to TPI value of 1, highlighting the presence of convexities emerging from the average topographic trend. Grey, light blue, orange portions represent the roughness of the terrain, that can be still quantified by TPI and separable from boulders. Boulders up to 10-15 centimeters are visible and indexed with TPI value equal to 1. Smaller pebbles are classified in the range between -0.5 and 0.5 The TPI= -1 value (blue on the legend) corresponds to depressions and concavities, usually proximal to the largest boulders, where the topography flexes generating high-curvature concavities.

The extraction of local convexities from TPI mapping (Figure 1) can be used to extract specifically convex features such as boulders or mounds, regardless their physical nature, either loose deposits, such as pyroclastic material in the case of Tinguatón historical eruption deposits or boulders on their surface [10]. Since boulders or convex geometries larger than the engineering requirements of planetary or analogue rovers constitute hazards to the (analogue) planetary exploration, extraction of such convex geometries is of readily use for mission planning and execution.

Complementing and augmenting the raster approach to TPI, we are vectorizing and extracting attributes, such as height, height difference, local TPI class, from raster(s) and using the vector attributes (such as area, shape) in order to better discriminate and filter small-scale landforms, such as boulders. The mixed raster-vector approach, with very high-resolution photogrammetry and raster analysis allows the generation and update of trafficability maps in short time.

Planetary landing sites cannont benefit from extremely high-resolution, i.e. both imaery and topograhy at centimetric levels. Nevertheless the same approach could be adapted for eitehr from stereogrammetric, shape-from-shading [11] slightly lower resolution topography, in order to assist manual or semi-automatic approaches in landing site safety and trafficability mapping.

The combination of raster topographic analyses and vector-based attribute extraction and querying, with a certain amount of pre-processing and data preparation is valuable for the various stages of planning and operations of remotely operated rovers and their experiments.

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References

[1] Allender, E. J., et al.: Traverses for the ISECG-GER design reference mission for humans on the lunar surface, ASR. vol. 63, 1, p. 692-727, doi: 10.1016/j.asr.2018.08.032, 2019,

[2] Steenstra, E. S., et al.,: Analyses of robotic traverses and sample sites in the Schrödinger basin for the HERACLES human-assisted sample return mission concept, ASR, vol. 58, 6, p. 1050-1065, doi: 10.1016/j.asr.2016.05.041, 2016.

[3] Rossi, A. P., et al.: AGPA: Integrating field Geology and Geophysics for Planetary Analogues, European Planetary Science Congress, #EPSC2018-408, 2018.

[4] Karimova, R., et al.: Geological Characterization of AS-GUARD Rover Test Terrains and Correlation with Mobility on the Vulcano Island Planetary Analogue ROBEX Site (Italy), LPSC, vol. 48, #1699, 2017.

[5] Drozdovskiy. I., et al.: The Analytical Tools (ATLS) experiment within the ESA PANGAEA-X campaign, Geophysical Research Abstracts, #EGU2019-18250, 2019.

[6] Jenness, J.: Topographic Position Index (TPI) v. 1.2: , p. 42., 2006

[7] De Reu, J., et al.: Application of the topographic position index to heterogeneous landscapes: Geomorphology, v. 186, p. 39–49, doi: 10.1016/j.geomorph.2012.12.015, 2013.

[8] Wilson, M.F.J., et al.: Multiscale Terrain Analysis of Multibeam Bathymetry Data for Habitat Mapping on the Continental Slope: v. 30, 3–35 p., doi: 10.1080/01490410701295962, 2007.

[9] Pozzobon, R., et al.:Fluids mobilization in Arabia Terra, Mars: depth of pressurized reservoir from mounds self-similar clustering, Icarus, vol. 321, p. 938-959, doi: 10.1016/j.icarus.2018.12.023, 2019.

[10] Carracedo, J., C., et al.: The 1730–1736 eruption of Lanzarote, Canary Islands: a long, high-magnitude basaltic fissure eruption, Journal of Volcanology and Geothermal Research, vol 53, 1-4, p. 239-250, 1992

[11] O'Hara, R., and Barnes, D.: A new shape from shading technique with application to Mars Express HRSC images, Isprs Journal of Photogrammetry and Remote Sensing, 67, 27-34, doi: 10.1016/j.isprsjprs.2011.07.004, 2012.