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Terrestrial validation of geological analyses in PRo3D using an emulator for the ExoMars 2020 PanCam

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1. Abstract

The ExoMars 2020 Rover will use a panoramic stereo-camera system to image outcrops along its traverse, in order to characterise their geology and focus the search for ancient life. Photogrammetric reconstructions of these images are created using the Planetary Robotics Vision Processing tool (PRoViP)[1]. 3D Ordered Point Clouds (OPCs) of the reconstructed stereo images are visualized and interpreted in PRo3D [2], which has been tested using stereo-image data obtained by NASA's MER and MSL rover missions [3][4][5]. The Aberystwyth University PanCam Emulator (AUPE), an emulator for the ExoMars 2020 Rover, has been developed to collect stereo-image data of outcrops in the UK which are analogous to those expected in the candidate landing sites [6]. Stereo-image panoramas collected with AUPE are rendered in PRo3D, and full geological analyses of these outcrops are carried out. The results are compared with detailed field investigation of the same outcrops, allowing us to understand the reliability of this data when the ExoMars 2020 Rover carries out its mission.

2. Planetary Robotics 3D Viewer (PRo3D)

The interactive 3D viewing tool ***PRo3D*** [1][2][3] allows virtual exploration of reconstructed Martian terrain and geologic analysis of 3D datasets. It provides measurement and annotation tools to delineate geological boundaries, obtain dimensions of geologic features as well as the linear and projected distances between surface points and to calculate dip and strike of stratigraphic layers.

3. Aberystwyth University PanCam Emulator (AUPE)

AUPE was developed to allow the capture, processing and analysis of PanCam field data during the design, development, testing and qualification of the flight model. AUPE was constructed to match as closely as possible the specifications and capabilities of the PanCam instrument [7] using Commercial Off The Shelf components. Like PanCam, the AUPE WACs have both RGB colour and multispectral imaging capabilities although only the RGB imaging filters were used in these studies. The transmission properties of the PanCam and AUPE RGB filters are closely matched and have the same center wavelengths and bandwidths. AUPE includes a motorized Pan-Tilt Unit (PTU) to allow panoramas to be captured and ensure the precise and repeatable pointing of the cameras during image capture.

4. Validation methodology

The primary concerns of this validation are the accuracy of measurements carried out in PRo3D and the geometry of the processed OPC surfaces, adherence to true geometry at an optimum imaging distance, and how this geometry varies with distance and distance:baseline ratio. We are particularly interested in how any changes in geometry will affect key measurements, particularly vertical and lateral dimensions and layer dip and strike. Field validation also lets us gain a greater understanding as to what details we are likely to miss when just interpreting geology from panoramas and DOMs.

5. Validation at Brimham Rocks, Yorkshire, UK.

The first stages of the validation process took place at Brimham Rocks, Yorkshire, UK, in July and August 2017. Three outcrops of spectacular fluvial cross-bedded sandstones were imaged extensively using AUPE. Reference measurements were collected after imaging, for comparison to those taken from the processed OPCs in PRo3D. These included field outcrop interpretations, imaging distance measurements, general scale, bedset thicknesses, layer thicknesses, grain size and variation, as well as the dip and strike of foresets, set boundaries and cross beds. Geo-referencing of these datasets has been carried out, using a handheld GPS and compass to place the OPCs into their true positions. Initial analysis of range maps derived from the OPCs show that the surfaces are consistent with field measured imaging distances. Set thickness measurements in PRo3D also show a good agreement with the field measured values. Statistical analyses of the dip and strike measurements are ongoing.

6. Resolution of sedimentary structures at Pembrokeshire, Wales, UK.

A major issue in interpreting image data returned by the ExoMars rover mission will be the resolution of the images taken. We have imaged a series of Silurian-Ordovician outcrops of fluvial flood-plain mudstones and channel sandstones, which typically consists of thick sequences of mudstones, and fine-medium grained cross-laminated sandstones. Imaging took place at incremental distances of 2, 4, 8, 16 and in some cases 32 m from the outcrop. Automated processing using PRoViP is underway with this data, to create panoramic images and 3D OPCs. Interpretation of mosaics and OPCs taken at the different distances will be carried out to determine the level of image and OPC detail required to robustly identify and analyse key sedimentary structures which can be used for palaeoenvironmental reconstruction. Collection of this data will also help us to understand the reliability of stereo-reconstruction with an increasing distance:baseline ratio. This will provide a valuable basis for interpretation and reconstruction of the ancient environments along the ExoMars traverse, therefore providing context for the instrument science which will take place.

7. Summary and Conclusions

We show the first validation for photogrammetrically produced 3D digital outcrop models which are representative of those which will be collected by the 2020 ExoMars Rover PanCam. 3D visualization and analysis of photogrammetrically reconstructed stereo-image data enables geoscientists to extract large amounts of quantitative information from the images, so an understanding of the validity of those 3D digital outcrop models and the measurement tools used to analyse them is essential.

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