ANALYZING THE LARGE EXTENSION OF POLYGONAL TERRAIN IN THE NORTHERN PLAINS OF MARS. P. Pina, J. Antunes, L. Bandeira, and J. Saraiva, CERENA, Instituto Superior Técnico, Av. Rovisco Pais, 1049-001 Lisboa, Portugal (ppina@ist.utl.pt).

Introduction: The northern region of Mars where Phoenix landed in 2008 is constituted by extensive plains largely occupied by small-scale polygonal terrains, which were difficult to perceive in previous imagery but are now being unveiled by the higher spatial resolution of the HiRISE camera onboard Mars Reconnaissance Orbiter [1]. According to recent measurements [2], these polygons fall into two populations with average axes in the ranges 3-6 m and 20-25 m. Those measures were performed by manually sampling some polygons on a limited number of images, without being exhaustive. We believe that it is possible to achieve a finer characterization of this type of terrain by means of an automated approach [3] that is able to extensively exploit its geometric and topological features [4] [5]. Since the amount of information acquired by HiRISE in a single image is huge, its processing and analysis demands a different approach than the usual manual analysis of sections of images by human or automated means.

HiRISE image datasets: We conducted a survey of HiRISE images currently available whose center falls within a region between 67.5º and 69º N in latitude and 233.5º and 235º E in longitude. Up to the moment of writing, 39 images with centimetric spatial resolution are available; their footprints are plotted over corresponding MOLA data on Figure 1.

Strategy: The regions covered by HiRISE images have variable dimensions, but a typical figure is an area of about 10x5 km, which normally results in a digital image containing more than 2 Gpixels (for instance, 100,000 x 20,000 pixels). This huge amount of information is quite difficult to process all at once. But, given that the spatial detail provided by the images and their complete analysis can reveal important characteristics of the polygonal networks, that could not be perceived by a procedure based on sampling of selected regions, we devised a strategy to extract that information. Thus, it was decided to divide the images into squared regions of 600x600 m^2 (in map-projected images with 0.25 m/pixel, this corresponds to 2,400x2,400 pixels). When preparing these images, the polygons that intercept the border are cut and must be suppressed, as they cannot be correctly analysed. Later, when applying the neighbourhood analysis procedure, only polygons with complete neighbours will be considered, so additional layers of polygons will be also filtered out. Thus, in order to get information on a maximum number of polygons we cut the images with a degree of overlapping between adjacent images (the value chosen for the cases presented is 100 m). Some polygons will be counted twice, but their number is very small (see scheme in Figure 2).

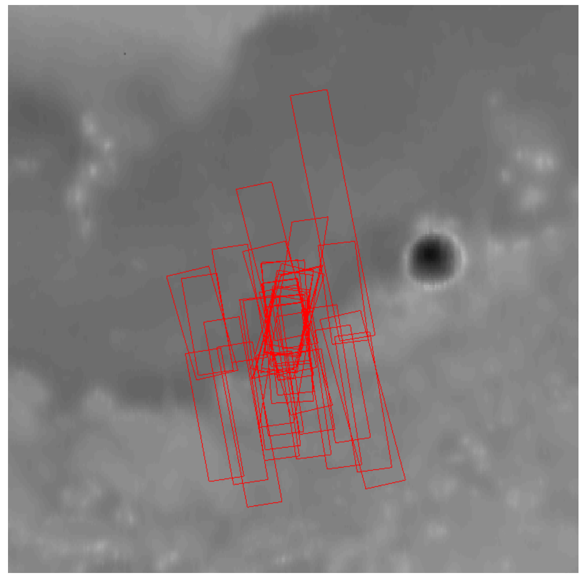

Figure 1. Footprints of HiRISE images currently available within the region between 67.5 and 69ºN in latitude and 233.5 and 235ºE in longitude (background image is a MOLA topographic relief at 128 pixels/degree).

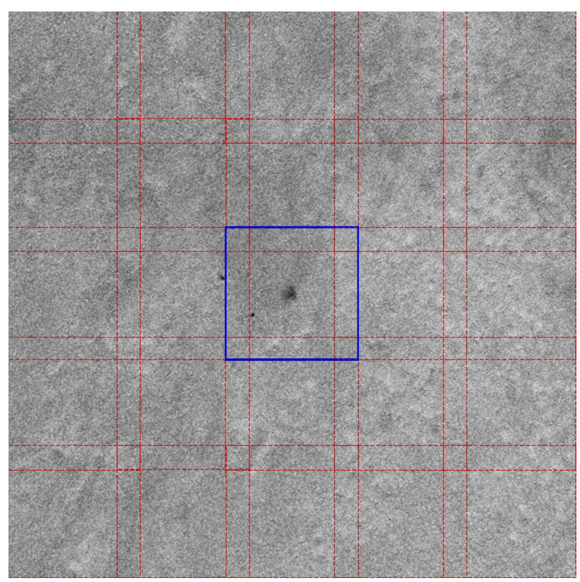

Figure 2. Example of grid of analysis superposed on the HiRISE image PSP_008591_2485 around Phoenix landing site (centre). Each square measures 600 m (example in blue) and overlapping between adjacent squares is 100 m.

Automatic identification robustness: The identification of the small-scale polygons is not always trivial, even by an expert visually analyzing the images, and depends on several conditions related to the geometry of image acquisiton. The edges of the polygons may be difficult to infer from orbital images also because of their intrinsic characteristics: the edges may be incomplete or somewhat disguised. But if there is nothing that can be done about the intrinsic characteristics of the polygons in order to enhance the visibility of their edges, in what concerns the images we can enhance them and test to see if an automatic procedure can be applied correctly to every location, independently of the conditions of acquisition. Thus, in order to evaluate our algorithm [3] we tested it on HiRISE images of the same region, acquired in different orbits of MRO. A 600x600 m^2 region, judged to be approximately the same (there may be some deviation, since some discrepancies affect the georeferencing and may result in shifts in the order of meters, which is not relevant for our case), was cut from images PSP_08585_2985 and PSP_08591_2485 and was processed using the same parameters. The polygons were identified and characterized. Visually, the automatic procedure produces a similar network (Figure 3); the major differences relate to the local behaviour of the edges of the polygons and also to the merging and splitting of a few polygons.

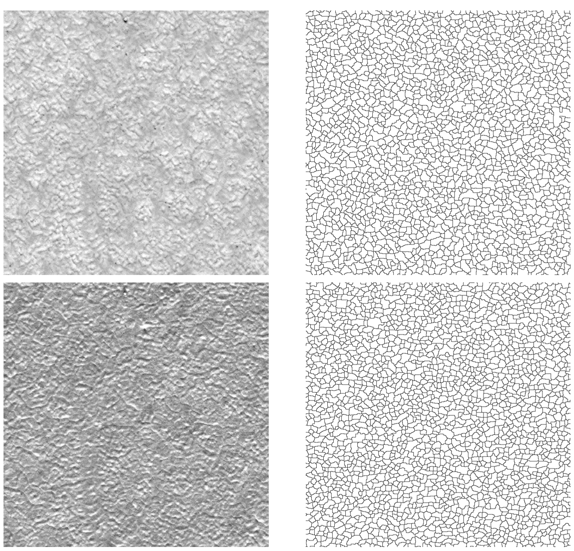

Figure 3. Details of the same approximate region in two different images (side of squares is 187.5 m): (left) PSP_08585_2985 and PSP_08591_2485 images (right) correspondent segmented networks.

The global results obtained for some geometric and topological parameters are presented in Table I. The major conclusion is that they are very much the same. The major difference lies in the number of polygons detected on each image; we think this is mainly due to the fact that the regions are not exactly the same. Since the other parameters show almost insignificant differences, we believe that the discrepancy on the number of objects analysed is of small importance.

Due to the small dimensions of the polygons that we are searching for and since the main operator behind our segmentation approach (the watershed transform) may be sensitive to the order by which the pixels are analysed, we have performed another robustness test, by rotating one image and computing the same parameters. The results obtained were practically the same: no differences were detected when compared to the initial image.

Table I. Comparison of measures

Image reference	**08585**	**08591**
# of polygons	19112	17001
Range of average axis (m)	3.60-5.45	3.80-5.76
Average # of neighbors	5.98	5.97
Range of # of neighbors	3-13	3-14
Variance of # of neighbors	1.91	2.08
Lewis parameter	0.43	0.39
Aboav-Weaire parameter	1.13	1.05

Based on the high similarity between the results obtained, we conclude that our algorithm can be used with confidence in the automatic detection of small-scale polygons

Future work: We are applying this strategy to all available HiRISE images of the plains around the Phoenix landing site [6]. The images are being analysed in detail, with the goal of achieving the automatic identification of the polygons and the full geometric and topological characterization of the networks. The quantified information that is currently being collected will be mapped, so that the behaviour of parameters can be analysed in detail to look for differences at the local and regional scales.

Acknowledgements: Work developed within project TERPOLI (PTDC/CTE-SPA/65092/2006), funded by FCT, Portugal. JS (SFRH/BD/37735/2007) and LB (SFRH/BD/40395/2007) acknowledge financial support by FCT, Portugal.

References: [1] Levy et al. (2008) *GRL*, 35(4):L04202. [2] Mellon et al. (2008) *JGR-Planets*, 113:E00A23. [3] Pina et al. (2006) *LNCS*, 4142:691-699. [4] Pina et al. (2008) *PSS*, 56(15):1919-1924. [5] Saraiva et al. (in press) *Phil. Mag. Lett*. [6] Saraiva et al. (2009) *LPS XL* (submitted).