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Identificação e caracterização de terrenos poligonais na superfície de Marte

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**Dissertação para obtenção do Grau de Mestre em
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ABSTRACT

Different studies have been carried through, on the basis of images of Mars surface, to prove the water presence in the subsoil of this planet. These studies are based on the relation between the existence of certain typical type of polygonal terrains, analogous to the terrestrial forms that generally are associated to water presence and to climatic phenomena of extreme variation. The identification and characterization of this type of lands have been done through a somewhat subjective form, with manual analyses and measurements for restricted regions with few polygons. In a way to be able to analyze these polygon nets in all its extension of a quantitative form, it's presented in this thesis a method of and polygonal terrain identification and characterization in images of remote detention of the Mars surface, becoming this task in a reproductively and faster process. This methodology allows getting more information of the nets making possible a detailed analysis of what have been done yet. The measured parameters are geometric and topological. The verification of two classic laws (Lewis and Aboav-Weaire) that establish relations between geometric parameters and topological was verified for the set of 35 studied nets. The analysis of the gotten characteristics, although didn't detect clearly the existence of groups that allow the classification in types, but it supplies some tracks and important contributes to a posterior multidimensional analysis that allows an unequivocal classification of these patterns. It can be affirmed that the presented methodology was validated, having been gotten results satisfactorily positives.

KEYWORDS: Mars, polygonal terrains, image analysis, automatic recognition.

IX REFERÊNCIAS BIBLIOGRÁFICAS

- Aboav, D.A. (1970) - The arrangement of grains in a polycrystal, *Metallography*, 3 (4), 383 - 390
- Aboav, D.A. (1980) - Arrangement of cells in a net, *Metallography*, 13 (1), 43 - 58
- Bandeira, L., Pina, P., Saraiva, J., (2008) - A new approach to analyse neighborhood relations in 2D polygonal networks, *CIARP2008, In press*
- Bleau, A., Leon, L.J. (2000) - Watershed-based segmentation and region merging, *Computer Vision and Image Understanding*, 77, 317 - 370
- Hiesinger, N.M., Head, J.W. (2000) - Characteristics and origin of polygonal terrain in southern Utopia Planitia, *Mars Geophysics Research* 105, E5, 11999 - 12022
- Kargel, J.S., (2004) - *Mars: A warmer, wetter planet*. Springer Berlin
- Kossacki, K.J., Markiewicz, W.J. (2002) - Martian seasonal CO₂ ice in polygonal troughs in southern polar region: Role of the distribution of surface H₂O ice, *Icarus*, 160, 73 - 85
- Kubat, M., Holte, R.C., Matwin, S. (1998) - Machine Learning for the Detection of Oil Spills in Satellite Radar Images, *Machine Learning* 30, 195 - 215
- Kuzmin, R., Zabalueva, R. (2003) - Polygonal Terrains on Mars: Preliminary Results of Global Mapping of Their Spatial Distribution, *XXXIV Lunar and Planetary Science*, Abstract 1912
- Kuzmin, R.O., Ershow, E.D., Komarow, I.A., Kozlov, A.H., Isaev, V.S. (2002) - The comparative morphometric analysis of polygonal terrain on Mars and the Earth high latitude areas, *XXXIII Lunar and Planetary Science*, abstract 2030
- Langsdorf, E.L., Britt, D.T. (2005) - Classification and distribution of patterned ground in the southern hemisphere of Mars, *XXXVI Lunar and Planetary Science*, Abstract 2140
- Lewis, F.T. (1928) - The correlations between cell divisions and the shape and size of prismatic cells in the epidermis of Cucumis, *The Anatomical Records*, 38 (3), 341 - 376
- Lewis, F.T. (1931) - A comparison between the mosaic of polygons in a film of artificial emulsion and the pattern of simple epithelium in surface view (cucumber epidermis and human amnion), *The Anatomical Records*, 50 (3), 235 - 265
- Malin, M.C., Edgett, K.S. (2000) - Evidence for recent groundwater seepage and surface run-off on Mars, *Science*, 288, 2330 - 2335
- Malin, M.C., Edgett, K.S. (2001) - Mars Global Surveyor Mars Observer Camera: interplanetary cruise through primary mission, *Journal of Geophysical Research*, 106 (E10), 23429 - 23570
- Mangold N. (2005) - High latitude patterned grounds on Mars: Classification, distribution and climatic control, *Icarus* 174, 336 - 359
- Mangold, N., Forget, F., Costard, F., Peulvast, J.P. (2002) - High latitude patterned grounds on Mars: evidence for recent melting of near-surface ground ice, *XXXIII Lunar and Planetary Science*, Abstract 1912

- Mangold, N., Maurice, S., Feldman, W.C., Costard, F., Forget, F. (2004) - Spatial relationships between small patterned ground and ground ice detected by the Neutron Spectrometer on Mars, *Journal of Geophysical Research*, 109 - E08001, doi: 10.1029/2004JE002235
- Moreels, P., Smrekar, S.E. (2003) - Watershed identification of polygonal patterns in noisy SAR images, *IEEE Transaction on Image Processing* 12, 740 - 750
- Najman, L., Schmitt, M. (1996) - Geodesic saliency of watershed contours and hierarchical segmentation, *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 18 (12): 1163-1173
- Pechmann, J.C. (1980) - The origin of polygonal troughs on the Martian northern plains, *Icarus* 42, 185 - 210
- Pina, P., Barata, T., Saraiva, J., Bandeira, L. (2007) - Automatic identification of polygonal patterns on Mars, *XXXVIII Lunar and Planetary Science*, abstract 1315
- Pina, P., Saraiva, J.; Bandeira, L., Barata, T. (2006) - Identification of Martian polygonal Patterns using the Dynamics of Watershed Contours, *ICIAR, LNCS 4142*, pp. 619 - 699
- Pina, P., Saraiva, J., Antunes, J., Bandeira, L. (2008) -Automatic recognition of diverse types of polygons on Mars, *XXXIX Lunar and Planetary Science*, abstract 2091
- Pina, P., Saraiva, J., Bandeira, L., Barata, T. (2006) - Identification of Martian Polygonal Patterns Using the Dynamics of Watershed Contours, *Lecture Notes in Computer Science*, abstract 4142, 691 - 699
- Saraiva, J., Bandeira, L., Antunes, J., Pina, P., Barata, T. - Polygonal Terrains on Mars, artigo submetido à revista *Finisterra*
- Seibert, N.M., Kargel, J.S. (2001) - Small-scale Martian polygonal terrain: Implications for liquid surface water, *Geophysics research Letter* 28, 899 - 902
- Smrekar, S.E., Moreels, P., Franklin, B.J. (2002) - Characterization and formation of polygonal fractures on Venus, *Journal of Geophysics research* 107, E11, doi: 10.1029/2001JE001808
- Soille, P. (2003) - Morphological images analysis. Principles and applications, Springer, Berlin
- van Gasselt, S., reiss, D., Thorpe, A.K., Neukum, G. (2005) - Seasonal variations of polygonal thermal contraction crack patterns in a south polar trough Mars, *Journal of geophysical research*, 110 - E08002, doi: 10.1029/2004JE002385
- Vincent, L., Soille, P., (1991) - Watersheds in digital spaces: an efficient algorithm based on immersion simulations, *IEEE Transactions on Pattern Analysis and Machine Intelligence*, IEEE, 13(6), 583 - 598
- Weaire, D., (1974) - Some remarks on the arrangement of grains in a polycrystal, *Metallography*, 7 (2), 157 - 160
- Williams, D. R., (2006) - Viking Mission to Mars, acedido em: 17, Abril, 2008 em: <http://nssdc.gsfc.nasa.gov/planetary/viking.html>
- Yoshikawa, K. (2000) -Contraction cracking and ice wedge polygons in Mars, *II Conference Mars Polar Science*, abstract 4045