IMPACT CRATER DETECTION ON MARS FROM DIGITAL IMAGE. M. M. Pedrosa[1], E. A. Silva[2] and J. R. Nogueira[3], [1]Programa de Pós-graduação em Ciências Cartográficas, Universidade Estadual Paulista – FCT/UNESP, R. Roberto Simonsen, 305, Presidente Prudente, SP, Brazil, (miriammmp@hotmail.com), [2]Depto de Cartografia, Universidade Estadual Paulista – FCT/UNESP, Presidente Prudente, SP, Brazil, (silva.erivaldo@gmail.com), [3]Depto de Matemática, Universidade Estadual Paulista – FCT/UNESP, Presidente Prudente, SP, Brazil (jrnog@fct.unesp.br).

Introduction: Currently, the study of Martian's surface have been interesting to many space exploration program, this justifies the relevant number of probes launched to this planet. Consequently, there's a huge orbital image file from Martian surface. With sensors whose spatial resolution is more and more better, the amount of information contained on these images grows on a rate higher than the capability of human being on extracting relevant data from these images.

Among the present targets on planetary and lunar surface, impact craters stand out, not only on the surface of Mars, but on most of them. Identifying and counting these craters have a crucial significance on the study of this planet due the great amount of information available on a detailed analysis of them. They represent the only available tool for measures remotely the relative age from geological formations on planets [1]. Besides, they are important to space exploration since man has been prepared to send a future manned space mission to Mars.

Methodology: We developed a methodology which includes techniques of digital image processing and pattern recognition, aiming to detect impact craters on the surface of Mars. This methodology was based on work [2]. The methodology we present in this proceeds was divided into three main steps, which are described below.

The methodology was applied to a set of three images from an image mosaic acquired by the THEMIS camera – Thermal Emission Imaging System, aboard the Mars Odyssey probe, from the region Utopia. Due to the low efficiency of Matlab to process images with large dimensions, it was necessary to cut these images in 48 sub-images. The figure 1 shows one sub-image used.

The first step is the selection of candidates. In this phase the objective is to identify regions that correspond to crater rims. In order to that, it was used Mathematical Morphology [3, 4]. The operators used were pre-processing, binarization, filtering and segmentation. For this purpose we used following operators: mmvmax and mmvmin which aims to remove peaks and basins with higher and lower contrast, respectively. The gradient operator was applied aiming increasing the different tones of gray at the edges of the craters and the background of the scene image. After the image was binarized then applied the closing operator using the disk structuring element with radius 2 pixels, with the aim of recovering the craters that were degraded in the pre-processing. To eliminate noise in the image, we applied the opening operator with the same struct element, and the watershed operators in a attempt to separate targets that it was detected as two, but correspond to only one.

The second step aim to compute the similary between the scene image and a given template.

At this phase, the candidate areas craters (images obtained in the first stage), were subjected to comparison with the templates. These templates are binary models containing the target qualities sought, namely, crowns with different sizes of white lightning. The figure 2 displays four examples de templates used.

These templates were overlapped on the images obtained in the first phase and a measure of similarity between the pair was calculated. The Fast Fourier Transform [5], a proven method applied in the frequency domain, was used for the computation of the correlation between the scene image and the series of templates with different sizes. The result can be seen in the figure 4 (a) which the highest probability values correspond to bright areas of the image. This values are normalized and collected into a probability volume, figure 4 (b), a stack of r planes (r being the range of values used for template radius) each containing u x v pixels.

The third and final step was carried out identifying the craters. This was achieved by analyzing the volume of probability. This task was, first, locating local maxima (by morphology operators), in accordance with a given probability, comparing them in a neighborhood of twenty-six elements, and lastly calculated the circularity of the targets.

Results: The images used as test areas are panchromatic images with 256 gray levels and spatial resolution is 100 m/pixel.

Figure 3 shows the result obtained by applying the morphological operators, which served as input for the next phase of the methodology.

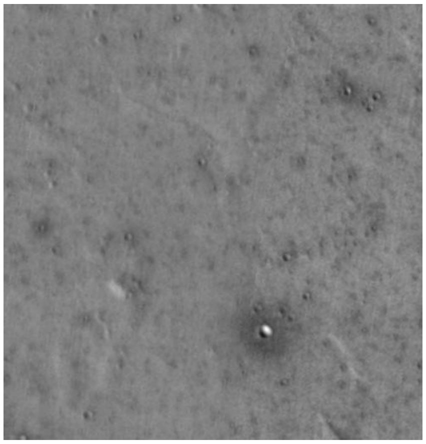
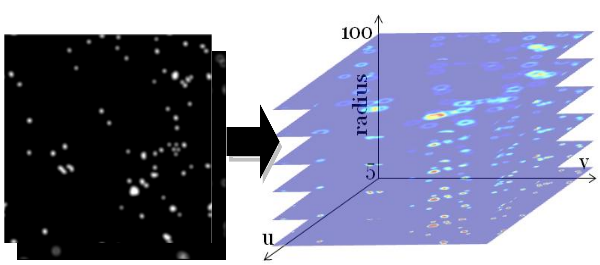


Figura 1: Original image.

(a) (b) (c) (d)

Figure 2: Examples of the templates with radius: (a) 10, (b) 15, (c) 20 and (d) 35 pixels.

Figure 3: Result obtained by mathematical morphology.



(a) (b)

Figure 4: (a) FFT result for a given template. (b) Probability volume.

The evaluation of the results was done by comparing the ground truth with the result obtained by methodology developed.

The methodology developed achieved the rate of approximately 92% of true detections and 23% of false detection. On average, 92% of the 292 craters with diameter between 1 and 20 km that we identified on all images were correctly detected. On figure 5 can be seen the result containing the craters detected correctly (green), targets detected by the methodology, but that does not correspond to craters (red) and craters that were not detected by the methodology (blue).

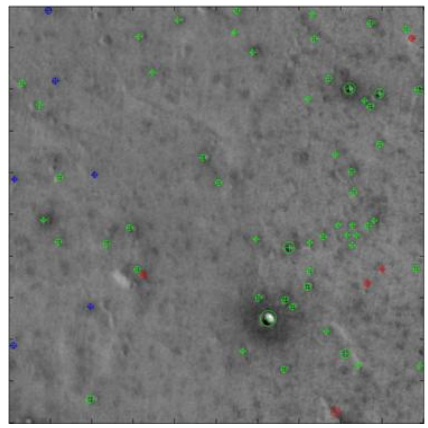


Figure 5: Result obtained by methodology developed.

To conclude, the methodology presented relevant result, but to test the efficient we intend to test it in different regions of the planet's surface and in images of different spatial resolutions.

References: [1] Urbach, E. R. and Stepinski, T. F. (2009) Planetary and Space Science, 57, p. 880–887. [2] Bandeira, L. et al (2007) IEEE Transactions on Geoscience and Remote Sensing, 12, p. 4008 – 4015. [3] Lotufo, R. A. and Dougherty, E. R. (2003) SPIE Press,. Bellingham, Washington. [4] Soille, P. (2003) Berlin. Springer - Verlag, second edition. [5] Cooley J. W. and Tukey J. W. (1965) Math. Comput., vol. 19, no. 90, pp. 297–301.