AUTOMATIC DELIMITATION OF REGIONS WITH AEOLIAN FEATURES ON MARS. L. Bandeira[1] , J.S. Marques[2], P. Pina[1], [1]CERENA, Instituto Superior Técnico, Av. Rovisco Pais, 1049-001 Lisboa, Portugal (lpcbandeira@ist.utl.pt), [2]ISR, Instituto Superior Técnico, Av. Rovisco Pais, 1049-001 Lisboa, Portugal.

Introduction: The number of currently available images of the surface of Mars is in the order of the hundreds of thousands. These have been captured over the years by many different instruments on board automatic probes. They have diverse spectral characteristics, varying spatial resolutions and cover areas of different dimensions, providing global, regional and sometimes local views. To manually browse all these images in search of a specific structure of interest is a hard and time consuming process. Thus, our objective is to create a tool that can learn the characteristics of a certain structure in an image and be able to automatically search for it over a huge quantity of data. Currently, we are interested on dune fields, being our approach developed, tested and calibrated for searching those aeolian features on Mars.

Dunes fields serve as unique indicators of the interaction between the atmosphere and surface, being among the most widespread aeolian features present on Mars. The study of dune processes contributes to both atmospheric and sedimentary science. Previous works that characterized aeolian features in regional terms conducted manual surveys on image datasets in order to find dune fields [1]. Also, the well established Mars Digital Dune Database [2] was constructed and updated without the use of automated procedures.

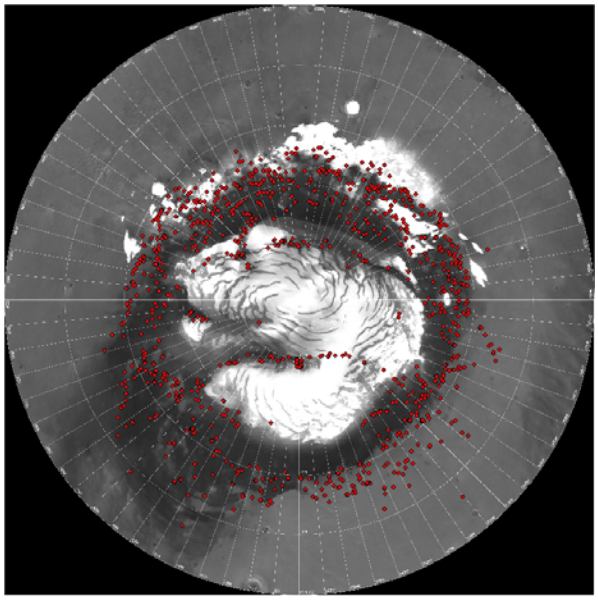

Figure 1. Results of the survey performed, showing in red dune field distribution on the Martian northern hemisphere [NASA/JPL/MSSS].

A preliminary survey was performed by ourselves using narrow-angle MOC images acquired between 1998 and 2006, and interesting dune field images were selected according to a number of conditions, namely latitude of the centre of the image (higher than 45ºN) and spatial resolution (better than 6 meters per pixel). All 4301 images that respected both of these criteria were visually inspected and we found that in 1002 of them adequate extensions of dune fields were present (their locations are shown in Figure 1).

Automatic dune identification: The methodology is constituted by two main phases and it is intended to be applied in the search for morphological structures in planetary images, namely dunes fields, independently of its type and also the type of terrain where they may occur. The first phase consists of the extraction of features from their histogram of oriented gradients (R-HOG) [3]. This method is based on evaluating well-normalized local histograms of image gradient orientations in a dense rectangular grid. To obtain these results we used 18 orientation bins over 3x3 block cells and 168x168 pixels cells, strongly normalized (using Lowe's L2-norm followed by hysteresis thresholding [4]) and with 2/3 overlapping descriptor blocks. In the second phase, the image blocks previously delimited are classified employing the widely used linear Support Vector Machines (SVMs) trained with the freely distributed package SVMLight [5] to determine if in fact dunes are present or not in a block image. The parameters used in our case were gamma equal to 2 and C equal to 8.

Results: The method is illustrated by its application to a narrow-angle MOC image (E01-01256) that we selected for this purpose. This is a high latitude image (77.54º N) with spatial resolution of 3.24 meters per pixel.

The image was visually analyzed and the dune fields manually contoured, constructing in this way our ground-truth. Each block was evaluated by intersecting it with the ground-truth (previously constructed by an expert) and those that had a degree of overlay higher than 0.5 were identified to have dune fields. This formed the basis to train and evaluate the performance of our methodology in quantitative terms. In order to classify the entire image, a 4-fold cross validation was performed.

The results obtained showed that the methodology presented is clearly capable of distinguish dune fields from background: out of the 104 blocks classified, 95

were correctly identified (64 blocks recognized as dunes, true positives, and 31 as background, true negatives) and only 9 were falsely identified (1 false positive and 8 false negatives) resulting in an overall accuracy of 91 % (Figure 2).

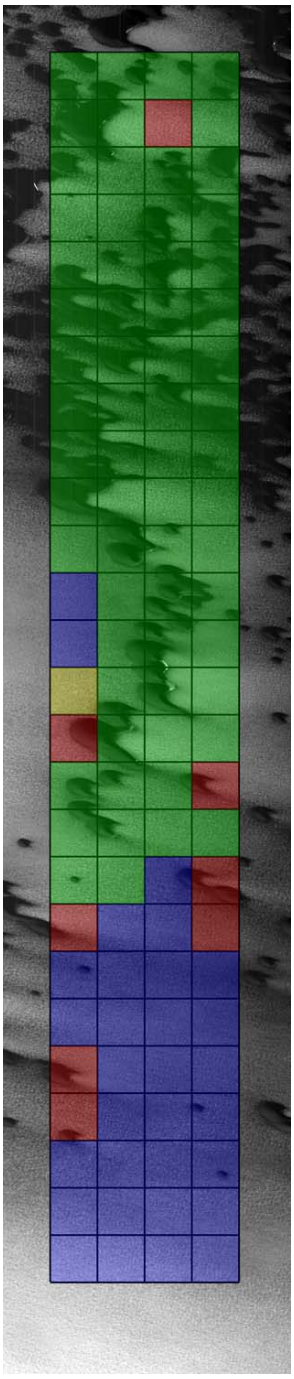

Figure 2. Classification results for narrow-angle MOC image E01-01256: true positives in green; true negatives in blue; false negatives in red and a false positive in yellow [NASA/JPL/MSSS].

On-going work: Although the results we have obtained so far are very promising, the final objective is to train the SVM classifier with ~~a~~ the greatest variety of images from our database and look for for every type of dune field on images that the algorithm has not yet analysed, in order to make it a valuable tool in an automatic and intensive search procedure. Due to the adaptive nature of this method we will also employ it to search for other types of structures.

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