THE CAMEL PROJECT - CHARACTERIZATION AND CLASSIFICATION OF DUNE FIELDS ON MARS BASED ON EARTH. T. Barata1, P.Pina2, J. Saraiva2, E. I. Alves1, A. Machado1, D. A. Vaz1, L. Bandeira2 ,G. G. Ori3
[1]CGUC, Coimbra, Portugal (mtbarata@gmail.com), [2]CERENA/IST, Lisboa, Portugal, [3]IRSPS, Pescara, Italy.

Introduction: Dunes are common features on planetary surfaces where unconsolidated material is present in abundance and responds to an atmosphere capable of producing significant winds. Wind is the most important erosive agent on present-day Mars, and the availability of large amounts of loose sand and dust provides conditions for the existence of dune fields all over the planet. They are the most frequent aeolian features on the Martian surface and they constitute a unique record of the interactions between the atmosphere and the planetary surface, so their study may contribute to understand the way the climate has evolved along the history of Mars [1].

Identification and characterization of dune fields on Mars started in the 1970s, on a global scale. Visual data from the Viking mission orbiters consisted mostly of images whose spatial resolution did not allow for detailed studies of the identified fields, which were seen to cover large (kilometric) areas of the surface. The instruments currently orbiting Mars, however, acquire digital images with much better spatial resolution. New imagery from Mars, with higher spatial resolution (up to 25 cm/pixel for the HiRISE camera) and better temporal coverage, can lead to more detailed studies of dune fields, including the study of their evolution through time, which should be more evident for small-scale structures [2].

The Mars Dune Consortium is a group of planetary scientists whose stated intention is to create a catalogue containing all dune fields identifiable on the surface of Mars. According to them, a huge effort and cooperation among planetary scientists is necessary to enlarge the database, deepen the knowledge on these features and improve our understanding of the fundamental processes underlying their formation [3].

The Mars Digital Dune Database (MDDD) was initiated [4], mainly using THEMIS IR images (100 m/pixel) and including dune fields of medium to large dimensions. When images with better quality (THEMIS VIS and MOC NA) covering dune fields already identified are available, the members of MDDD perform a classification based on the classic terrestrial scheme [5] and calculate some characterizing parameters. Thus, the MDDD offers the opportunity to study the global distribution of aeolian dune fields on Mars, both in regional and global contexts, permitting the establishment of correlations between climate, sedimentary and aeolian processes and evaluating the wind directions predicted by the GCM [6]. As of 2011, this database contains information for the whole planet, where dunes cover an area of approximately 985,000 km^2, mainly in the Northern polar area (845,000 km^2). These numbers only include medium to large size dune fields, except for 15,000 km^2 of smaller dune fields located in the South polar area [7, 8]. However, the procedure for the identification and delineation of the dune fields continues to be based on the manual coarse drawing of their contours, with no emphasis put on the detailed determination of the shape of individual dunes [9].

Two Portuguese research groups (CGUC and CERENA/IST) together with one Italian group (IRSPS), organized around a research project, named CAMEL, funded by the Portuguese Science Foundation (FCT), will try in the period 2012-2014 to give a major contribution to the understanding of dune fields on Mars through the development of a methodology to automatically delineate dune fields in remotely sensed images of the Martian surface. The methodology also intends to extract dimensional and morphological features that will permit the characterization and classification of dunes fields, with little or no human intervention after input of the original gray-level image.

Plans and Methods: Methods for the identification of dunes on Mars have been recently developed by a team involving some members of this project, with very promising results [10, 11], that point to a definite direction for this research. Moreover, members of this team have also been involved in the automated detection of dune migrations on Mars [2].

We plan to further develop an approach for the automated detection of dune fields on remotely sensed images of the surface of Mars that we have already started to implement, and that we succinctly describe below.

An image is divided into square cells from which gradient-based features are extracted. To increase the invariance to factors such as illumination/shadowing, an aggregation of the local features is performed within larger regions, blocks constituted by 3×3 cells; the cell which will be classified into dune or not-dune occupies the centre of the block. Blocks are moved along the whole grid, in order to cover all the cells. The classification itself is performed by machine-learning methods (Boosting and Support Vector Machines), after a training phase during which dune and not-dune examples

are provided to the classifier. This method has achieved high performances (above 95% of correct detection) on the already cited preliminary studies of images of dunes on the surface, and thus seems suited for further development and application in the framework of this project.

For each identified dune field we plan to extract a series of parameters related to dimension, morphology, geologic and geographic setting, and wind regime. Attention shall be given to dune fields located in the interior of craters, in an attempt to establish possible relations with the characteristics and degradation of impact structures; dimension and location of the dune field inside the crater (central or marginal) are factors to be considered. The application of this automated approach will lead to a much faster enlargement of dune field databases.

It is reasonable to think that similar geomorphological features on different planets will have a similar nature and formation and evolution processes. Thus it is important to compare those Martian structures with terrestrial analogues, that is, to compare the characteristics of aeolian dunes on both planets. Using remotely sensed Landsat images and aerial photos, a first attempt at a global inventory of dune fields in desert environments on Earth was made [12]. Cataloguing of terrestrial dune fields permitted to establish five basic types of dunes [13]; the most common are the barchan and transverse types. The shapes of dunes are directly controlled by aerodynamic processes [14], and their morphological parameters can be used to establish relations with the aeolian regimes and material supplies [15]. Remotely sensed images of dunes on Earth have been used for an objective characterization that can serve as an initial guide for similar studies of the dunes seen on images of Mars.

Thus, the activities to develop will be organized into the following main tasks:

1. Data acquisition – Compilation of existing data on terrestrial and Martian dune fields.

2. Methodology development – development of an automated methodology to delineate, characterize and classify dune fields on Mars using optical images.

3. Analysis of dunes fields of Earth and Mars - the establishment of analogies, in an objective and quantitative manner, between the dune fields of Mars and Earth.

4. Mapping of Martian Dunes Fields – contribution to the expansion of the Mars Digital Dune Database.

Expected results: : It is expected that the full development of the CAMEL project will lead to:

1. The completion of a robust methodology for the automatic identification of dunes fields on Mars.

2. Significant advances in our understanding of this type of features on Mars, their relation with current and past environmental conditions.

3. Establishment a collaborative effort with the researchers presently involved in the Mars Digital Dune Database, so that the methodology and the information collected can be integrated into the MDDD and used by the community at large to achieve a substantive improvement in our knowledge of dune fields on Mars.

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