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In situ granulometry of Martian soils through image analysis

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Introduction

The physical properties of Martian soils have been the subject of many studies based on data acquired by surface probes [1] [2] [3]. The granulometry of the particles is an important factor influencing those properties, and can play a major role when trying to plan the best route for a rover traversing an extension of sandy surface, as seen in the current missions of the MERs Spirit and Opportunity. Given the absence of dedicated instruments on board surface probes, however, this type of analysis has been conducted through the careful manual examination of images. We propose an alternative way of achieving the same results, consisting in an automated methodology (based on mathematical morphology) that can measure the area occupied by the different dimensional fractions of particles on a digital image [4].

Methodology

With a view to developing this procedure, we collected a number of MI (Microscopic Imager) high resolution images, acquired by the Mars rovers along their traverses on the Martian surface; each image covers an area of 3.2 x 3.2 cm^2, and the particles present have dimensions generally in the order of the millimetres, though embedded in a finer matrix.

The volumetric granulometry of an image can be determined by the application of successive morphological openings (erosion followed by dilation) of increasing size. The structuring element employed is a disk, in order to try to reproduce the most common shape shown by the particles. As this structuring element grows, the smaller granulometric fractions progressively disappear. A curve, somewhat similar to a continuous spectrum, can thus be constructed, where the peaks correspond to the most frequented particle dimensions. The interpretation of this curve must take into account not only the dimensions of the smaller particles but also the internal irregularities of the largest among them.

Results

We built cumulative size distribution curves for seven samples (all from the Opportunity landing site). When plotted together, the granulometric differences between them are evident (Figure 1).

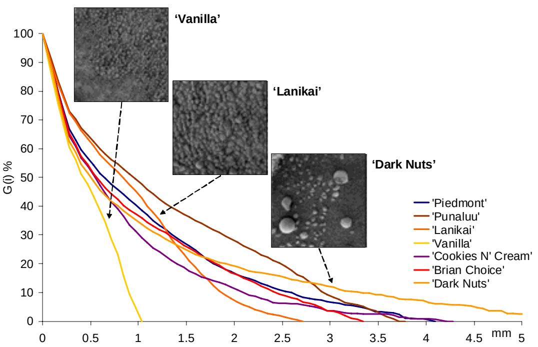

Figure 1: Cumulative size distribution curves for the seven sample of martian soil

Image "Vanilla" presents well-calibrated fine grains, resulting in a curve with a rapid decrease. "Lanikai" seems the best sorted of the seven samples, with a small amount of fine matrix visible between the larger grains; thus, the shape of the curve is similar to that of "Vanilla", but to the right and with a tail. "Dark Nuts", by contrast, shows a small number of particles in a field dominated by a fine matrix; the grains are clearly separated in size, and include the largest visible in all of the seven samples investigated; accordingly, the curve decreases slowly and to the left of that of "Lanikai", but extends much further to the right than any of the others.

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Future work

This methodology is still undergoing development and testing. There are a number of ideas to be implemented that can lead to improved results, making the interpretation of the curves much easier. These revolve mainly around the application of adequate filters to eliminate background effects, and to achieve an identification of individual particles, thus allowing for the collection of some quantitative measurements about their shape.

Furthermore, the method can only benefit from calibration using natural and prepared samples, a step that is currently in the planning stage.

References

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Acknowledgments

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