PATTERN RECOGNITION ALGORITHMS FOR AN AUTOMATED SEARCH FOR MARTIAN DUST DEVILS.

C. Stanzel, M. Pätzold *and* **A. Wennmacher**, *Institute of Geophysics and Meteorology, University of Cologne, Germany (stanzel@geo.uni-koeln.de).*

Introduction:

Dust devils are temporal and spatial variable surface features. They are recognised as bright spots accompanied by a dark shadow in Martian images (Figure 1). Image data from the various Mars missions are getting more and more voluminous. A Pattern Recognition algorithm is going to be developed which will help to scan and search the images for dust devils. Several questions can then be answered:

How often do these phenomenons occur? In which areas can you detect them? How fast are they? What is their height? How long do they last?

Pattern Recognition Techniques:

The principle of Pattern Recognition is shown in Figure 2. After image processing, dust devil parameters are extracted by the software and put into a n-dimensional vector. The classifier analyses the vector and puts the detected objects in classes. The classes represent a probability from 0 to 100 percent that a detected object is a dust devil.

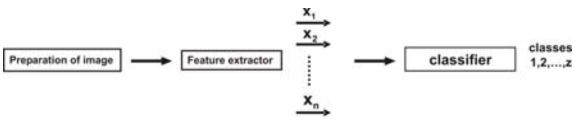

Fig. 2: The schematic principle of pattern recognition.

Relative brightness maxima were selected from the images with a simple criterion: the images are divided in sectors which are searched for pixels with an intensity $I > n*\sigma + I_{mean}$ where I is the intensity, I_{mean} the mean intensity of one square, n is a factor between 3 and 4, σ is the standard deviation. In order to get all pixels with high intensity and to avoid problems at the boundaries of the scan sectors, the sectors are slightly shifted and searched again. The selected pixels have been marked black, all others are rendered white (Figure 3). A value of $n = 3.8$ was found appropriate after quite a number of test iamges. If the search was not successful (e.g. resulting in an almost white image), the factor n may be changed and the search is repeated. Detected black pixels represent quite well the bright spots of dust devils. Random noise may be spread over the resulting image or other parts of surface features like crater rims.

The Hoshen-Kopelman algorithm (Hoshen and Kopelman, 1976; Hoshen et al., 1997; Hoshen-Kopelman-Algorithm) is used to identify each cluster of black pixels with a number. This is a very quick and efficient algorithm. The first run assigns every new black pixel which is not connected to a former cluster a new number. The difficulty is to adjust the numbers if it occurs that a cluster was first given two numbers because of its shape. In the second loop wrong numbers will be corrected and every cluster will end up by one number. The coordinates of the pixels which belong to a cluster are known in order to determine the size and the shape of each cluster. The size is determined by the number of pixels in each cluster. A best-fit ellipse (Figure 4) is adjusted to describe the shape of the cluster by using the minimum and maximum moments of inertia (Habili et al., 2001; Haddadnia et al., 2003; Lau et al., 2002).

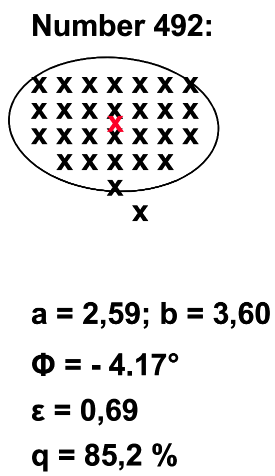

Fig. 4: A detected cluster with given number and the derived parameters: a = semi-minor axis, b = semi-major axis, Φ = angle between horizontal x-axis and b, ε = eccentricity, q = quality parameter (ratio of the area of filled positions to the area of the ellipse). The red x represents the centre of mass.

Several images have been analysed to constrain the values of eccentricity and quality parameter for possible dust devils. Dust devil clusters have been compared to craters and other features. The eccentricity of dust devil pixel clusters ranges at high values of up to 0.7 or 0.8. Most values of the quality parameter lie between 70 to 90 %.

The same method is applied to detect the shadow of the dust devils by searching for minima of brightness. The shadows are identified quite well. In some cases also the shape was clearly represented in the tested examples. The retrieved shadow parameters have to be checked carefully. The shadows represent the vertical structure of a dust devil and no clear line can be expected.

Quick-look plots (Figure 5) are generated to check visually if the identified object is really a dust devil and if the calculated clusters fit the bright spot and the dark shadow.

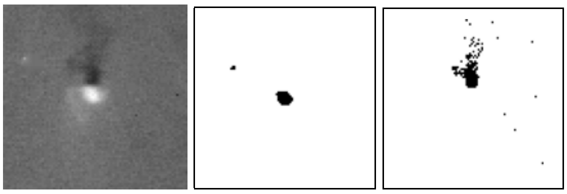

Fig. 5: Original grey-scale image section with a dust devil and corresponding black and white images with detected bright spot and shadow.

References:

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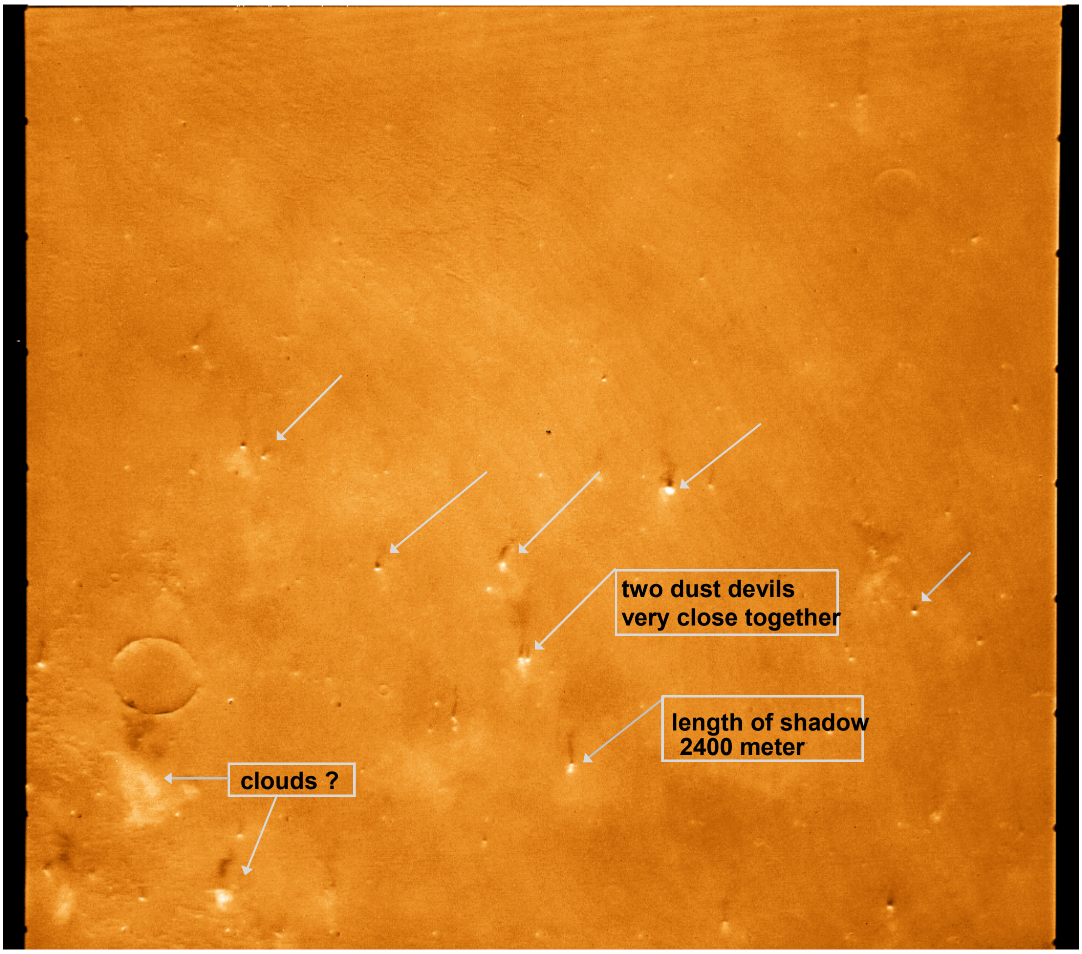

Fig. 1: Dust devils seen in a Viking image with false colors. The dust devils are well identifiable as bright spots with long dark shadows.

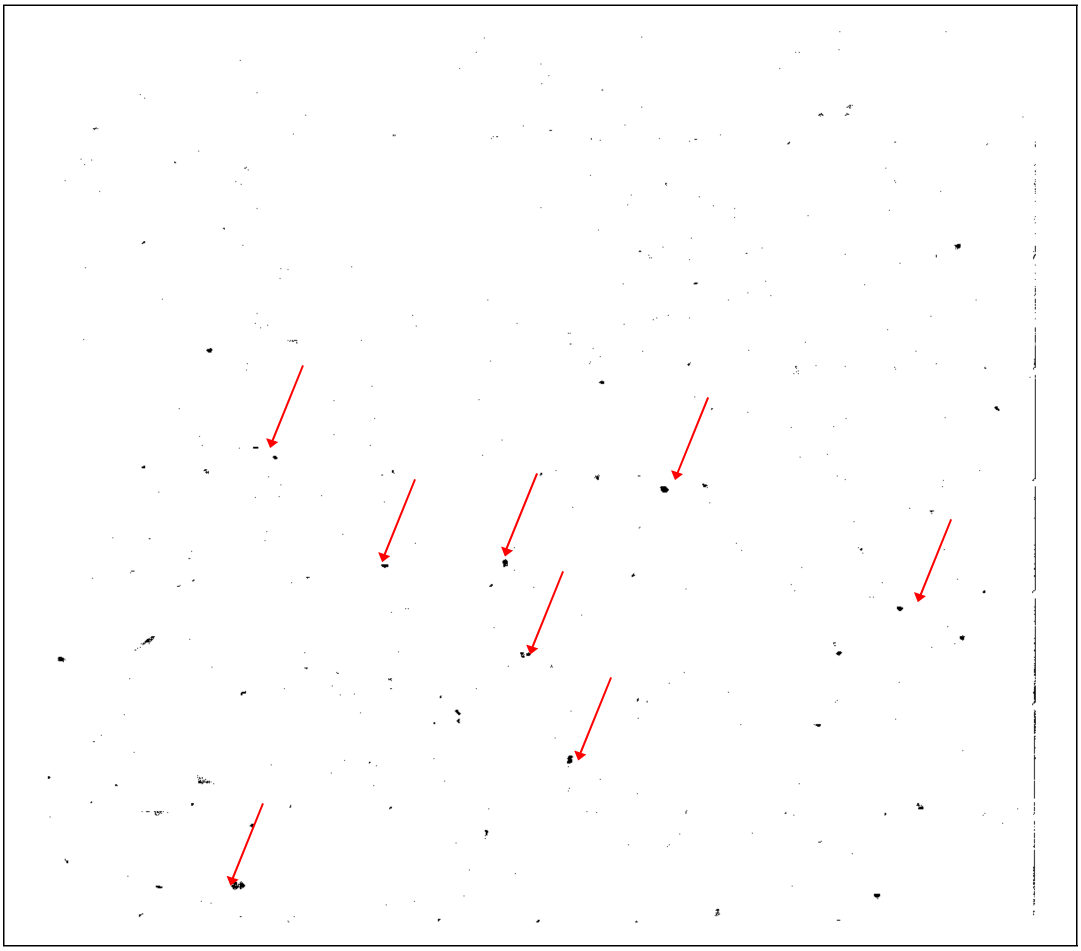

Fig. 3: Black and white image corresponding to Fig. 2. Possible dust devils are identified as black clusters.