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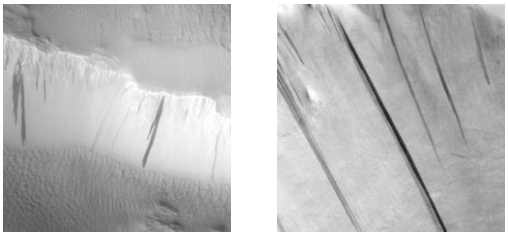
Introduction: Slope streaks are narrow, fan-shaped dark features which are seen on downslope regions of Mars, as steep reliefs and crater slopes [1]. Studies of slope streaks are important because its may provide a clue for understanding the basic properties of the martian surface layer, dust and water cycles and most recent climate changes [2]. Since the first slopes streaks found in images taken by the Viking Orbiters in 1977 to date, over 200 new slope streaks have been detected and documented [3]. Newly formed streaks are dark, and darker than other streaks in the same region, which indicates gradual fading [2]. This phenomenon is among the few known examples of contemporary geologic activity on Mars [4]. To date, the nature of slope streaks remains uncertain. On the basis of observed morphologies, two types of models have been proposed [5]: (1) dry mass movement in the form of dust avalanches [1][6] and (2) wet liquid that transports, lubricates or stains the surface material [2].

Despite the considerable number of researchers studying this phenomenon, slope streaks are still detected using a manual method by experts from digital images. Currently, approaches to automated surface identification have focus on crater or valleys. For this reason, the aim of this work was identified slope streaks from digital images using techniques of digital images processing which include histogram processing and morphological operators.

Methodology: We developed a methodology that identifies slope streaks in four steps: 1-Highlight the features of interest 2 - Filtering 3- Thresholding 4 - Removing the segmentation. In which step we tested different techniques of digital imaging processing. The purpose was to determine the best sequence of operators and parameters in order to detect slope streaks.

The first step we used local histogram equalization. Despite the global equalization be suitable for image enhancement, there are cases that is necessary to highlight just details in small areas of the image [7]. Exactly what happens in one of the images used (Fig. 1. (a)). The slope streaks are seen on isolated regions of images and the pixel number of these regions may not influence on a global transformation. Thus, besides the global equalization, we tested local equalization with masks in sizes 21x21, 51x51 and 71x71.

Next, in the filtering step we used the median filter. We chose this filter in order to preserve edges and detail in images [7]. Thereby, we tested masks in sizes 3x3 e 5x5. In the thresholding step the choice of the threshold was made analyzing the histograms of images, thus, we found 40 as the best value. Finally, to removing the segmentation we used the morphological filter areaopen. This filter works as an adaptative filter, therefore, was necessary to determine an area value which was determined empirically that was 500.



(a) (b)

Fig. 1. Original images MOC M0806884 (a), R1601030 (b).

Results and discussion: The method presented was applied to 2 images showed in Fig. 1. Therefore, we used local equalization with masks on sizes 21x21, 51x51 and 71x71. The visual analysis presented that the best results apparently seems to be the results of the larger mask 71x71, on both images used. As expected for this type of operation, the resultant images showed noise, as seen in Fig. 2. Next, median filters on sizes 3x3 and 5x5 were applied to each image of the previous results step, followed by tresholding and segmentation.

Analyzing the results of whole process, we observed for image (a) the best routine was performed by 71x71mask of local equalization and 3x3 mask of median filter. The criteria used to select this routine consisted in visual analysis. This result (Fig. 3 (a)) showed that the beginning and the end of the streaks were not degraded. On the other hand, for image (b), the best result was performed by 71x71mask of local equalization and 5x5 mask of median filter. Again, the criteria used to select this routine consisted in visual analysis. The slope streaks features on this result (Fig. 3 (b)) have less connected segmentation than the result using 3x3 mask of media filter.

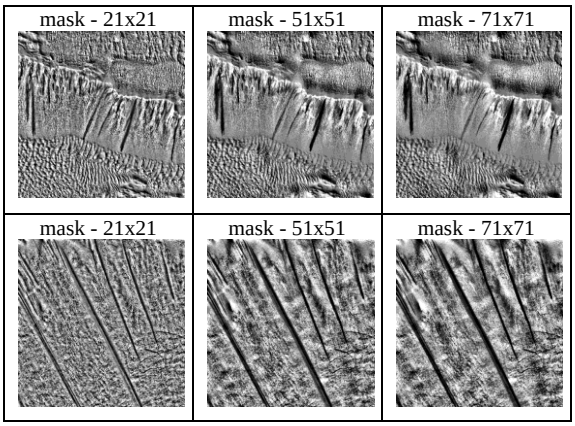


Fig. 2. Results of local equalization on MOC M0806884 (images from first line) and MOC R1601030 (images from second line).

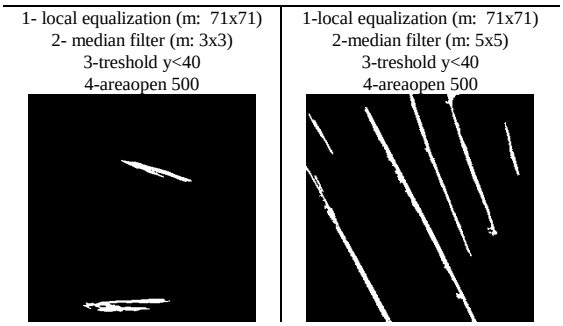


Fig. 3. Results of the best routine on MOC M0806884 (image from left) and MOC R1601030 (image from right).

Analyzing the whole process, we realized that an important factor to be considered is to determine an age range of slope streaks to be detected. The older streaks tend to be brighter than the newer ones. Thus, the routine can be developed based on an average reflectance value.

In general, this work achieved its goal that was detecting slope streaks in MOC images using image processing. However, there are lots of ways to contribute to this area of study. Beyond improve the developed routine, we intend to test other algorithms later and evaluate the results following statistical criteria.

References: [1]Sullivan R. et al. (2001) *JGR, 106*, 23607-23633. [2] Kreslavsky M. A. and Head J. W. (2009) *Icarus, 201*,517-527. [3] Schorghofer N. et al. (2007) *Icarus, 191*, 132-140. [4] Bergonio J. R. et al. (2013) *Icarus, 225* 194-199. [5] Phillips C. B et al. (2007) *GRL, 34* L21202 [6] Baratoux D. et al. (2006) *Icarus, 183* 30-45. [7] Gonzales R. C. and Woods R. E. (2010) *Digital Image Processing*.