ISPRS Working Group IV/8 Planetary Mapping and Spatial Databases Meeting
24 – 25 September 2015, Berlin, Germany

ON DETECTING THE PATTERNS IN LOW-QUALITY VIKING ORBITER IMAGES

Panagiotis Sidiropoulos[1], James Cleves and Jan-Peter Muller

Imaging Group, Mullard Space Science Laboratory, University College London, Holmbury St Mary, Surrey, RH56NT, UK p.sidiropoulos@ucl.ac.uk james.cleves.14@ucl.ac.uk j.muller@ucl.ac.uk

ABSTRACT:

The Viking Orbiter missions were the first to perform systematic high-resolution orbital mapping of the Martian surface. Both of the spacecraft reached Mars in 1976 (Soffen, 1976) and performed global mapping through their Visual Image Subsystem (VIS) during Martian Years 12-14, i.e. between 1976 and 1980. More specifically, Viking Orbiter 1 acquired approximately 32,000 images until 7 August 1980, while Viking Orbiter 2 lasted until 25 July 1978 returning almost 15,000 images. It should be noted that the spatial resolution of each image varied significantly; it could be as coarse as 1.8 kilometres per pixel or as fine as 8 metres per pixel. During the 4 years that the Viking Orbiter missions acquired image data, they achieved a complete global coverage of Mars with resolution finer than 1 km per pixel and a coverage of 22.7% of the surface with high-resolution images (i.e. with resolution finer than 100m per pixel).

Viking Orbiter VIS products suffered from a number of shortcomings in imaging prior to the era of fully digital charge coupled device camera systems, especially the size of CCD cameras. The VIS cameras consisted of twin high-resolution, slow-scan television framing vidicon cameras mounted on the scan platform of each orbiter with the optical axes offset by 1.38 deg. Each had mechanical shutters; a 475-mm focal length telescope; a 37-mm diameter vidicon, the central section of which was scanned in a raster (i.e. image) format of 1056 lines by 1182 samples. The footprint of each image covered roughly 40 x 44 km, acquired from an altitude of 1500 km. Each pixel was digitized as a 7-bit number (0 to 127) stored on the on-board tape-recorder, and later transmitted to Earth and converted to an 8-bit number by multiplying by 2.

Due to the early technology employed in Viking Orbiter VIS, the acquired image products presented several types of data degradation. The list of internally-triggered low-quality images is augmented by images that are of low-quality due to external causes, such as dust and clouds, thus leading to 9 classes of low-quality images. These classes are listed on Table 1.

Error Id	Degradation	Group
1	Burst Noise	Internal
2	DN Quantisation	Internal
3	Horizontal Stripes	Internal
4	Vertical Stripes	Internal
5	Salt & Pepper Noise	Internal
6	Low Contrast	Internal
7	Dust	External
8	Clouds	External
9	Near Terminator Image	External

Table 1. Types of Viking Orbiter VIS low visual quality data.

The volume of the Viking Orbiter VIS dataset is too large to allow the manual inspection of each and every image to identify all types of visual content degradation. Therefore, we have developed a novel automatic image quality assessment technique focusing on planetary images. (No-Reference) image quality assessment (NR-IQA) is a relatively new image processing domain, which deals with the assessment of the image quality without any a priori information about the content that is depicted on the image. For a thorough presentation of automatic image quality assessment domain, the reader is referred to (Chandler, 2013).

[1] Corresponding Author

Image quality assessment techniques that focus on planetary images should take into account the characteristics of these type of images, especially the multitude of causes that can trigger content degradation. Actually, the automatic image quality assessment that we have developed combines 6 quality assessment measures, 3 selected from the (generic) image quality assessment literature and 3 novel ones, tailored to the planetary image requirements. More specifically, the literature measures included image anisotropy (Gabarda and Cristobal, 2007), which is a generic image quality measure based on the assumption that high-quality images have richer information content than low-quality images, power spectrum slope (Liu et al., 2008), which gauge image blur at the local level, and edge profile kurtosis (Caviedes and Gurbuz, 2002), which is a computationally efficient measure of global image blur based on image edge appearance. In addition, we have developed three more image quality measures, a novel self-similarity measure to gauge distortion types that create symmetrical image patches, such as gravity waves, a measure that aims to detect images suffering from low contrast and, finally, an impulse noise measure.

The above 6 features comprise the image quality vector of a planetary image. The image quality assessment is performed using a Support Vector Machine (SVM) classifier (Hearst et al., 1998). The SVM classifier includes a training step, which is conducted through the extraction of the image quality vectors from a set of manually annotated (regarding their quality) planetary images, and the estimation of the hyperplane that best separates the two classes of image quality vectors (i.e. vectors extracted from low-quality images and vectors extracted from high-quality images) by a SVM. After estimating the class boundary, for each input planetary image it's quality vector is extracted and the sub-space that it belongs to determines the quality label that is assigned, i.e. high-quality or low-quality image. Finally, a group of (trained in a similar way) SVM classifiers is used to identify different types of planetary image degradations.

We are using this software to assess the image quality of all Viking Orbiter VIS images, in order to detect all different types of degradations. Subsequently, we are going to conduct a spatio-temporal analysis of certain low-quality types (such as "dust" and "cloud") in order to extract information about the martian features related to these visual degradations. Results and statistics will be presented during ISPRS.

Acknowledgements: The research leading to these results has received funding from the STFC "MSSL Consolidated Grant" ST/K000977/1 and partial support from the European Union's Seventh Framework Programme (FP7/2007-2013) under iMars grant agreement n˚ 607379

References:

Caviedes, J. and Gurbuz, S.: No-reference sharpness metric based on local edge kurtosis, IEEE International Conference on Image Processing (ICIP), Vol. 3, pp. 53-56, 2002.

Chandler, D. M.: Seven Challenges in Image Quality Assessment: Past, Present, and Future Research, ISRN Signal Processing, Vol. 2013, pp. 1-53, 2013.

Gabarda S. and Cristobal, G.: Blind image quality assessment through anisotropy, Journal of the Optical Society of America A, Vol. 24, No. 12, pp. B42-B51, 2007.

Hearst, M.A., Dumais, S.T., Osman, E., Platt, J., and Scholkopf, B.: Support vector machines, IEEE Intelligent Systems and their Applications, Vol. 13, No. 4, pp. 18-28, 1998.

Liu, R., Li, Z., and Jia, J.: Image Partial Blur Detection and Classification, IEEE Conference on Computer Vision and Pattern Recognition (CVPR), pp. 1-8, 2008.

Soffen, G.A., 1976. Scientific results of the Viking mission. Science 194(4271), 1274-1276.