Content Based Image Matching for Planetary Science

Abstract submitted to AGU Fall Meeting 2006

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Abstract

Planetary missions generate large volumes of data. With the MER rovers still functioning on Mars, PDS contains over 7200 released images from the Microscopic Imagers alone. These data products are only searchable by keys such as the Sol, spacecraft clock, or rover motion counter index, with little connection to the semantic content of the images.

We have developed a method for matching images based on the visual textures in images. For every image in a database, a series of filters compute the image response to localized frequencies and orientations. Filter responses are turned into a low dimensional descriptor vector, generating a 37 dimensional fingerprint. For images such as the MER MI, this represents a compression ratio of 99.9965% (the fingerprint is approximately 0.0035% the size of the original image). At query time, fingerprints are quickly matched to find images with similar appearance. Image databases containing several thousand images are preprocessed offline in a matter of hours. Image matches from the database are found in a matter of seconds.

We have demonstrated this image matching technique using three sources of data. The first database consists of 7200 images from the MER Microscopic Imager. The second database consists of 3500 images from the Narrow Angle Mars Orbital Camera (MOC-NA), which were cropped into 1024x1024 sub-images for consistency. The third database consists of 7500 scanned archival photos from the Apollo Metric Camera. Example query results from all three data sources are shown.

We have also carried out user tests to evaluate matching performance by hand labeling results. User tests verify approximately 20\% false positive rate for the top 14 results for MOC NA and MER MI data. This means typically 10 to 12 results out of 14 match the query image sufficiently. This represents a powerful search tool for databases of thousands of images where the a priori match probability for an image might be less than 1%. Qualitatively, correct matches can also be confirmed by verifying MI images taken in the same z-stack, or MOC image tiles taken from the same image strip. False negatives are difficult to quantify as it would mean finding matches in the database of thousands of images that the algorithm did not detect.