



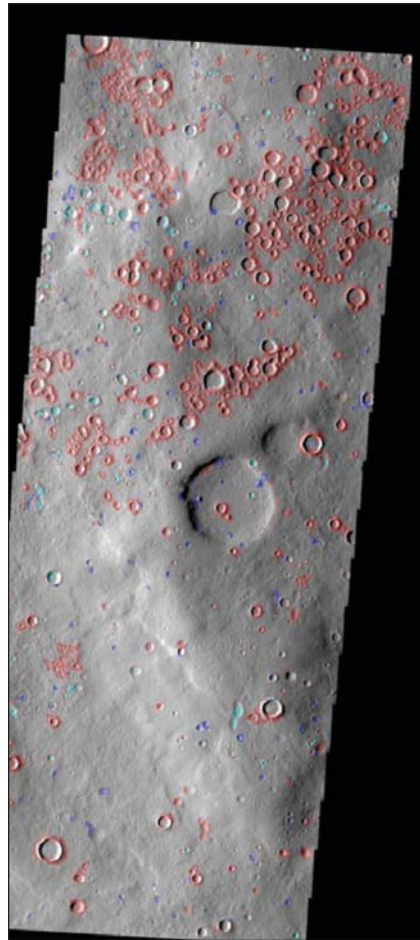
Landmark Detection in Orbital Images Using Saliency Histograms

This technique enables automated identification of objects and regions in airborne or orbital images.

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NASA's planetary missions have collected, and continue to collect, massive volumes of orbital imagery. The volume is such that it is difficult to manually review all of the data and determine its significance. As a result, images are indexed and searchable by location and date but generally not by their content. A new automated method analyzes images and identifies "landmarks," or visually salient features such as gullies, craters, dust devil tracks, and the like. This technique uses a statistical measure of saliency derived from information theory, so it is not associated with any specific landmark type. It identifies regions that are unusual or that stand out from their surroundings, so the resulting landmarks are context-sensitive areas that can be used to recognize the same area when it is encountered again.

A machine learning classifier is used to identify the type of each discovered landmark. This classifier can also indicate when a previously unknown type of landmark is encountered, enabling the discovery of new and unusual physical phenomena. Using a specified window size, an intensity histogram is computed for each such window within the larger image (sliding the window across the image). Next, a saliency map is computed that specifies, for each pixel, the saliency of the window centered at that pixel. The saliency map is thresholded to identify landmark contours (polygons) using the upper quartile of



Landmarks Are Automatically Identified in THEMIS image V19619013 of Terra Sabaea (Mars). Craters are marked in red, streaks in blue, and unrecognized landmarks in cyan.

saliency values. Descriptive attributes are extracted for each landmark polygon: size, perimeter, mean intensity, standard deviation of intensity, and shape features derived from an ellipse fit. Each landmark is classified as one of a set of known types, or marked as "unknown" using a classifier previously trained on hundreds of manually annotated landmarks. Each image is annotated with its contents (list of landmarks with their locations, types, and attributes).

This method enables fast, automated identification of landmarks to augment or replace manual analysis; fast, automated classification of landmarks to provide semantic annotations; and content-based searches over image archives.

Automated landmark detection in images permits the creation of a summary catalog of all such features in an image database, such as the Planetary Data System (PDS). It could enable entirely new searches for PDS images, based on the desired content (landmark types). In the near future, landmark identification methods using Gabor filters (texture) or covariance descriptors will also be investigated for this application.

This work was done by Kiri L. Wagstaff and Julian Panetta of Caltech; Norbert Schorghofer of the University of Hawaii; and Ronald Greeley, Mary Pendleton Hoffer, and Melissa Bunte of Arizona State University for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-46674

Efficient Bit-to-Symbol Likelihood Mappings

A new algorithm that increases decoder speed contributes to the development of high-speed optical communications links.

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This innovation is an efficient algorithm designed to perform bit-to-symbol and symbol-to-bit likelihood mappings that represent a significant portion of the complexity of an error-correction

code decoder for high-order constellations. Recent implementation of the algorithm in hardware has yielded an 8-percent reduction in overall area relative to the prior design. This gain re-

sulted from changing just two operations in a complex decoder. Larger gains are possible for larger constellations that are of interest for deep-space optical communications. The algorithm struc-