Quickly Approximating the Distance Between Two Objects

Lyndon B. Johnson Space Center, Houston, Texas

A method of quickly approximating the distance between two objects (one smaller, regarded as a point; the other larger and complexly shaped) has been devised for use in computationally simulating motions of the objects for the purpose of planning the motions to prevent collisions. The method is needed because computer-based-graphics techniques that have been used heretofore to make such estimates entail amounts of computation that are excessively large for purposes of the simulations.

The method, denoted tree-based model learning, is an integral combination of (1) decision-tree techniques upon which several machine learning techniques have been based and (2) a relatively accurate function-approximation technique. Each node of a decision tree corresponds to a partition of the problem domain — in this case, starting with one node representing a large cubic volume centered on the large object and dividing and subdividing it, at symmetry planes, into successively smaller cubes. Each branch of the tree represents a rule-based decision selecting one of the child nodes of a parent node. The smallest subdivisions (leaf nodes) contain coefficients of a quadric equation that estimates the distance between the objects.

This work was done by David Hammen of LinCom Corp. for Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809. MSC-23264-1

Processing Images of Craters for Spacecraft Navigation

NASA's Jet Propulsion Laboratory, Pasadena, California

A crater-detection algorithm has been conceived to enable automation of what, heretofore, have been manual processes for utilizing images of craters on a celestial body as landmarks for navigating a spacecraft flying near or landing on that body. The images are acquired by an electronic camera aboard the spacecraft, then digitized, then processed by the algorithm, which consists mainly of the following steps:

1. Edges in an image detected and placed in a database.
2. Crater rim edges are selected from the edge database.
3. Edges that belong to the same crater are grouped together.
4. An ellipse is fitted to each group of crater edges.
5. Ellipses are refined directly in the image domain to reduce errors introduced in the detection of edges and fitting of ellipses.
6. The quality of each detected crater is evaluated.

It is planned to utilize this algorithm as the basis of a computer program for automated, real-time, onboard processing of crater-image data. Experimental studies have led to the conclusion that this algorithm is capable of a detection rate >93 percent, a false-alarm rate <5 percent, a geometric error <0.5 pixel, and a position error <0.3 pixel.

This work was done by Yang Cheng, Andrew E. Johnson, and Larry H. Matthies of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-40122

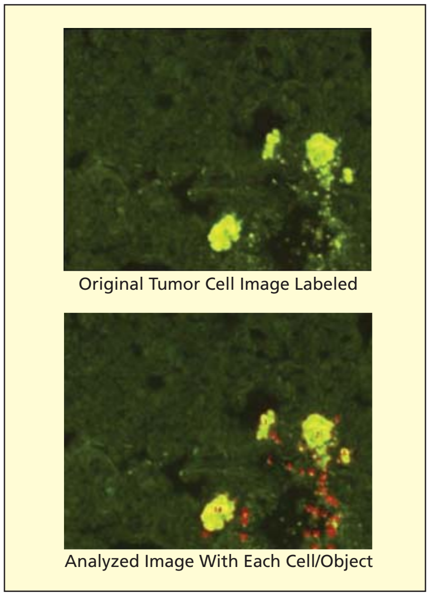
Adaptive Morphological Feature-Based Object Classifier for a Color Imaging System

This technique has potential use in the fields of disease state identification, cancer screening and detection, and wound healing.

John H. Glenn Research Center, Cleveland, Ohio

Utilizing a Compact Color Microscope Imaging System (CCMIS), a unique algorithm has been developed that combines human intelligence along with machine vision techniques to produce an autonomous microscope tool for biomedical, industrial, and space applications. This technique is based on an adaptive, morphological, feature-based mapping function comprising 24 mutually inclusive feature metrics that are used to determine the metrics for complex cell/objects derived from color image analysis. Some of the features include:

- Area (total numbers of non-background pixels inside and including the perimeter),
- Bounding Box (smallest rectangle that bounds and object),
- centerX (*x*-coordinate of intensity-weighted, center-of-mass of an entire object or multi-object blob),
- centerY (*y*-coordinate of intensity-weighted, center-of-mass, of an entire object or multi-object blob),
- Circumference (a measure of circumfer-



CCMIS Automatically Identifies Tumor Morphology of florescence stained images. The key with this application is that the second set of tumor images above could not be identified by human experts. However, CCMIS was able to identify the tumor cells in seconds.

ence that takes into account whether neighboring pixels are diagonal, which is a longer distance than horizontally or vertically joined pixels),

- Elongation (measure of particle elongation given as a number between 0 and 1. If equal to 1, the particle bounding box is square. As the elongation decreases from 1, the particle becomes more elongated),
- Ext_vector (extremal vector),
- Major Axis (the length of a major axis of a smallest ellipse encompassing an object),
- Minor Axis (the length of a minor axis of a smallest ellipse encompassing an object),
- Partial (indicates if the particle extends beyond the field of view),
- Perimeter Points (points that make up a particle perimeter),
- Roundness [$(4\pi \times \text{area})/\text{perimeter}^2$) the result is a measure of object roundness, or compactness, given as a value between 0 and 1. The greater the ratio, the rounder the object.],
- Thin in center (determines if an object becomes thin in the center, (figure-eight-shaped),
- Theta (orientation of the major axis),
- Smoothness and color metrics for each component (red, green, blue) the minimum, maximum, average, and standard deviation within the particle are tracked.

These metrics can be used for autonomous analysis of color images from a microscope, video camera, or digital, still image. It can also automatically identify tumor morphology of stained images and has been used to detect stained cell phenomena (see figure).

This work was done by Mark McDowell of Glenn Research Center and Elizabeth Gray of Scientific Consulting, Inc. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18291-1.

Rover Slip Validation and Prediction Algorithm

NASA's Jet Propulsion Laboratory, Pasadena, California

A physical-based simulation has been developed for the Mars Exploration Rover (MER) mission that applies a slope-induced wheel-slippage to the rover location estimator. Using the digital elevation map from the stereo images, the computational method resolves the quasi-dynamic equations of motion that incorporate the actual wheel-terrain speed to estimate the gross velocity of the vehicle.

Based on the empirical slippage measured by the Visual Odometry software of the rover, this algorithm computes two factors for the slip model by minimizing the distance of the predicted and actual vehicle location, and then uses the model to predict the next drives. This technique, which has been deployed to operate the MER rovers in the extended mission periods, can accurately predict the rover position and attitude, mitigating the risk and uncertainties in the path planning on high-slope areas.

This work was done by Jeng Yen of Caltech for NASA's Jet Propulsion Laboratory.

The software used in this innovation is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-45240.

Safety and Quality Training Simulator

Lyndon B. Johnson Space Center, Houston, Texas

A portable system of electromechanical and electronic hardware and documentation has been developed as an automated means of instructing technicians in matters of safety and quality. The system enables elimination of most of the administrative tasks associated with traditional training. Customized, performance-based, hands-on training with integral testing is substituted for the traditional instructional approach of passive attendance in class followed by written examination.

The system includes four workstations, accommodating up to eight students. The system simulates hazardous conditions (without exposing students to real hazards) and quality or safety discrepancies that students are required to recognize and for which the students are required to perform corrective actions. The system enables students to demonstrate knowledge gained from previous training and work experience. The system provides remedial training for each student who does not perform satisfactorily in a simulation.

This work was done by Pete T. Scobby of United Space Alliance for Johnson Space Center. Further information is contained in a TSP (see page 1). MSC-23232-1