Software

Autonomous Navigation by a Mobile Robot

ROAMAN is a computer program for autonomous navigation of a mobile robot on a long (as much as hundreds of meters) traversal of terrain. Developed for use aboard a robotic vehicle (rover) exploring the surface of a remote planet, ROAMAN could also be adapted to similar use on terrestrial mobile robots. ROAMAN implements a combination of algorithms for (1) long-range path planning based on images acquired by mast-mounted, wide-baseline stereoscopic cameras, and (2) local path planning based on images acquired by body-mounted, narrow-baseline stereoscopic cameras. The long-range path-planning algorithm autonomously generates a series of waypoints that are passed to the local path-planning algorithm, which plans obstacle-avoiding legs between the waypoints. Both the long- and short-range algorithms use an occupancy-grid representation in computations to detect obstacles and plan paths. Maps that are maintained by the long- and short-range portions of the software are not shared because substantial localization errors can accumulate during any long traverse. ROAMAN is not guaranteed to generate an optimal shortest path, but does maintain the safety of the rover.

This program was written by Terrance Huntsberger and Hrand Aghazarian of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

This software is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (818) 393-2827. Refer to NPO-30532.

Software Would Largely Automate Design of Kalman Filter

Embedded Navigation Filter Automatic Designer (ENFAD) is a computer program being developed to automate the most difficult tasks in designing embedded software to implement a Kalman filter in a navigation system. The most difficult tasks are selection of error states of the filter and tuning of filter parameters, which are time-consuming trial-and-error tasks that require expertise and rarely yield optimum results. An optimum selection of error states and filter parameters depends on navigation-sensor and vehicle characteris-

tics, and on filter processing time. ENFAD would include a simulation module that would incorporate all possible error states with respect to a given set of vehicle and sensor characteristics. The first of two iterative optimization loops would vary the selection of error states until the best filter performance was achieved in Monte Carlo simulations. For a fixed selection of error states, the second loop would vary the filter parameter values until an optimal performance value was obtained. Design constraints would be satisfied in the optimization loops. Users would supply vehicle and sensor test data that would be used to refine digital models in ENFAD. Filter processing time and filter accuracy would be computed by ENFAD.

This program was written by Jason C. H. Chuang of **Marshall Space Flight Center** *and William J. Negast, formerly of Gray Research, Inc. Further information is contained in a TSP (see page 1). MFS-31967-1*

Predicting Flows of Rarefied Gases

DSMC Analysis Code (DAC) is a flexible, highly automated, easy-to-use computer program for predicting flows of rarefied gases — especially flows of upper-atmospheric, propulsion, and vented gases impinging on spacecraft surfaces. DAC implements the direct simulation Monte Carlo (DSMC) method, which is widely recognized as standard for simulating flows at densities so low that the continuum-based equations of computational fluid dynamics are invalid. DAC enables users to model complex surface shapes and boundary conditions quickly and easily. The discretization of a flow field into computational grids is automated, thereby relieving the user of a traditionally time-consuming task while ensuring (1) appropriate refinement of grids throughout the computational domain, (2) determination of optimal settings for temporal discretization and other simulation parameters, and (3) satisfaction of the fundamental constraints of the method. In so doing, DAC ensures an accurate and efficient simulation. In addition, DAC can utilize parallel processing to reduce computation time. The domain decomposition needed for parallel processing is completely automated, and the software employs a dynamic load-balancing mechanism to ensure optimal parallel efficiency throughout the simulation.

This work was done by Gerald J. LeBeau of **Johnson Space Center** *and Richard G. Wilmoth of Langley Research Center. For further information, contact the Johnson Innovative Partnerships Office at (281) 483-3809. MSC-23445*

Centralized Planning for Multiple Exploratory Robots

A computer program automatically generates plans for a group of robotic vehicles (rovers) engaged in geological exploration of terrain. The program rapidly generates multiple command sequences that can be executed simultaneously by the rovers. Starting from a set of high-level goals, the program creates a sequence of commands for each rover while respecting hardware constraints and limitations on resources of each rover and of hardware (e.g., a radio communication terminal) shared by all the rovers. First, a separate model of each rover is loaded into a centralized planning subprogram. The centralized planning software uses the models of the rovers plus an iterative repair algorithm to resolve conflicts posed by demands for resources and by constraints associated with the all the rovers and the shared hardware. During repair, heuristics are used to make planning decisions that will result in solutions that will be better and will be found faster than would otherwise be possible. In particular, techniques from prior solutions of the multiple-traveling-salesmen problem are used as heuristics to generate plans in which the paths taken by the rovers to assigned scientific targets are shorter than they would otherwise be.

This program was written by Tara Estlin, Gregg Rabideau, Steve Chien, and Anthony Barrett of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

This software is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (818) 393-2827. Refer to NPO-35192.

Electronic Router

Electronic Router (E-Router) is an application program for routing documents among the cognizant individuals in a government agency or other organization. E-Router supplants a prior