Tracking Positions and Attitudes of Mars Rovers

NASA's Jet Propulsion Laboratory, Pasadena, California

The Surface Attitude Position and Pointing (SAPP) software, which runs on computers aboard the Mars Exploration Rovers, tracks the positions and attitudes of the rovers on the surface of Mars. Each rover acquires data on attitude from a combination of accelerometer readings and images of the Sun acquired autonomously, using a pointable camera to search the sky for the Sun. Depending on the nature of movement commanded remotely by operators on Earth, the software propagates attitude and position by use of either (1) accelerometer and gyroscope readings or (2) gyroscope readings and wheel odometry. Where necessary, visual odometry is performed on images to fine-tune the position updates, particularly on high-wheel-slip terrain. The attitude data are used by other software and ground-based personnel for pointing a high-gain antenna, planning and execution of driving, and positioning and aiming scientific instruments.

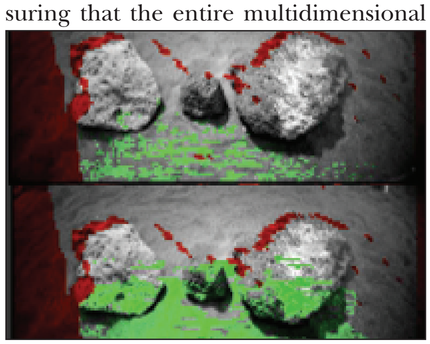
This work was done by Khaled Ali, Charles Vanelli, Jeffrey Biesiadecki, Alejandro San Martin, Mark Maimone, Yang Cheng, and James Alexander of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

This software is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-41876.

Stochastic Evolutionary Algorithms for Planning Robot Paths

NASA's Jet Propulsion Laboratory, Pasadena, California

A computer program implements stochastic evolutionary algorithms for planning and optimizing collision-free paths for robots and their jointed limbs. Stochastic evolutionary algorithms can be made to produce acceptably close approximations to exact, optimal solutions for path-planning problems while often demanding much less computation than do exhaustive-search and deterministic inverse-kinematics algorithms that have been used previously for this purpose. Hence, the present software is better suited for application aboard robots having limited computing capabilities (see figure). The stochastic aspect lies in the use of simulated annealing to (1) prevent trapping of an optimization algorithm in local minima of an energy-like error measure by which the fitness of a trial solution is evaluated while (2) ensuring that the entire multidimensional configuration and parameter space of the path-planning problem is sampled efficiently with respect to both robot joint angles and computation time. Simulated annealing is an established technique for avoiding local minima in multidimensional optimization problems, but has not, until now, been applied to planning collision-free robot paths by use of low-power computers.



A comparison of **Digital Terrain Maps** shows reachability of targets with the FIDO robotic arm. Green (light) areas are reachable, with arm path solutions. Grey areas are not reachable and red (dark) areas indicate no data available for a solution. (Note: FIDO is Field Integrated Design and Operations.)

This program was written by Wolfgang Fink, Hrand Aghazarian, Terrance Huntsberger, and Richard Terrile 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 (626) 395-2322. Refer to NPO-42206.

Compressible Flow Toolbox

John H. Glenn Research Center, Cleveland, Ohio

The Compressible Flow Toolbox is primarily a MATLAB-language implementation of a set of algorithms that solve approximately 280 linear and nonlinear classical equations for compressible flow. The toolbox is useful for analysis of one-dimensional steady flow with either constant entropy, friction, heat transfer, or Mach number >1. The toolbox also contains algorithms for comparing and validating the equation-solving algorithms against solutions previously published in open literature. The classical equations solved by the Compressible Flow Toolbox are as follows:

- The isentropic-flow equations,
- The Fanno flow equations (pertaining to flow of an ideal gas in a pipe with friction),
- The Rayleigh flow equations (pertaining to frictionless flow of an ideal gas, with heat transfer, in a pipe of constant cross section),
- The normal-shock equations,
- The oblique-shock equations, and
- The expansion equations.

This program was written by Kevin J. Melcher of **Glenn Research Center**. *Further information is contained in a TSP (see page 1).*

Inquiries concerning rights for the commercial use of this invention should be addressed to:

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