Proton Upset Monte Carlo Simulation

Lyndon B. Johnson Space Center, Houston, Texas

The Proton Upset Monte Carlo Simulation (PROPSET) program calculates the frequency of on-orbit upsets in computer chips (for given orbits such as Low Earth Orbit, Lunar Orbit, and the like) from proton bombardment based on the results of heavy ion testing alone. The software simulates the bombardment of modern microelectronic components (computer chips) with high-energy (≈200 MeV) protons. The nuclear interaction of the proton with the silicon of the chip is modeled and nuclear fragments from this interaction are tracked using Monte Carlo techniques to produce statistically accurate predictions.

Following the bombardment with high-energy heavy ions (such as carbon, gold, and the like), the upset rate dependency on each of the ion species is known. This precisely defines the amount of energy an ion must deposit within the "sensitive volume" of the chip in order to cause an upset. These data are put through PROPSET, which repeatedly models the proton/silicon collision process and tracks each of these fragments from each collision and the energy that each imparts into the "sensitive volume" of the chip. PROPSET then counts the number of upsets produced by a given number of incident protons.

This innovation allows for the code to be easily modified so that the effect of input parameters, such as the thickness and shape of a computer chip's sensitive volume, can be assessed. Heavy ion data are easily entered in terms of only four Weibull parameters rather than a data file of 50 to 100 data pairs. In order to determine how to track ions through a chip's sensitive volume while accounting for the variability of that sensitivity, a grid is defined and works outward where each shell has a different sensitivity. PROPSET executes rapidly on a personal computer.

This program was written by Patrick M. O'Neill and Coy K. Kouba of Johnson Space Center and Charles C. Foster of Foster Consulting Services. Further information is contained in a TSP (see page 1). MSC-24274-1

FPGA Boot Loader and Scrubber

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A computer program loads configuration code into a Xilinx field-programmable gate array (FPGA), reads back and verifies that code, reloads the code if an error is detected, and monitors the performance of the FPGA for errors in the presence of radiation. The program consists mainly of a set of VHDL files (wherein "VHDL" signifies "VHSIC Hardware Description Language" and "VHSIC" signifies "very-high-speed integrated circuit").

The first of three parts of the program loads the configuration code from a flash memory device by means of an industry-standard interface. The second part continuously reads back the configuration data stream through the interface, calculates a cyclic redundancy code (CRC) on the data, and compares the calculated CRC values with values stored in the flash memory device. If the calculated CRC values do not match the stored values, the configuration data memory is cleared and the configuration data are reloaded. The third part of the program implements a watchdog register, to which the FPGA is required to write at regular intervals. If the FPGA fails to write to the register within a required time, the configuration memory is cleared and the configuration data are reloaded.

This program was written by Randall S. Wade of Johnson Space Center and Bailey Jones of Jacobs Sverdrup. Further information is contained in a TSP (see page 1). MSC-24124-1

Using Thermal Radiation in Detection of Negative Obstacles
At night, negative obstacles usually appear bright in infrared images.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method of automated detection of negative obstacles (potholes, ditches, and the like) ahead of ground vehicles at night involves processing of imagery from thermal-infrared cameras aimed at the terrain ahead of the vehicles. The method is being developed as part of an overall obstacle-avoidance scheme for autonomous and semi-autonomous off-road robotic vehicles. The method could also be applied to help human drivers of cars and trucks avoid negative obstacles — a development that may entail only modest additional cost inasmuch as some commercially available passenger cars are already equipped with infrared cameras as aids for nighttime operation.

The need for this or an alternative method arises because the geometric nature of negative obstacles makes it difficult to detect them by processing of geometric information extracted from ordinary images: As drivers of ground vehicles know from common experience, it is difficult to visually detect negative obstacles in sufficient time to avoid them, making it necessary to drive slowly enough to be able to stop or swerve within the limited safe look-ahead/stopping distance. In robotic vehicles equipped with stereoscopic machine vision or lidar systems that yield range and elevation data, obstacles are detected through analysis of those data, and essentially the same difficulty arises. The source of the difficulty is the fact that whereas the angle subtended by a positive obstacle is approximately inversely proportional to the horizontal distance, the angle subtended by a negative obstacle is ap-
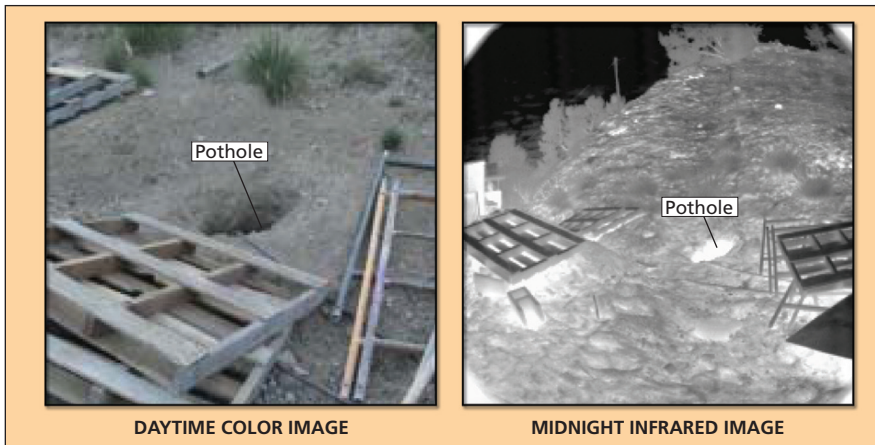
A **Pothole Dug at a Construction Site** looks dark in a daytime image in visible light but looks bright in an infrared image acquired at midnight.

proximately inversely proportional to the square of the horizontal distance.

The method involves exploitation of the fact that throughout the night, negative obstacles are usually warmer than the surrounding terrain. Therefore, in infrared terrain images acquired at night, negative obstacles usually appear brighter than the surrounding terrain (see figure). (During the day, the negative obstacles can be warmer or cooler than their surroundings, depending on sky conditions and the apparent position of the Sun.) At the present state of development, the method is embodied in a rudimentary algorithm that processes a combination of infrared imagery and range-versus-elevation data. The algorithm identifies candidate negative obstacles in the form of infrared bright spots on the terrain, then performs simple geometric tests to confirm or reject the candidate negative obstacles. The algorithm has been shown to be sufficient for initial proof-of-concept demonstrations. Further development of this or an improved algorithm will be necessary to enable reliable detection of negative obstacles under a variety of conditions.

This work was done by Arturo L. Rankin and Larry H. Matthies 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-40368.

Planning Flight Paths of Autonomous Aerobots
Trajectories are planned to satisfy survey coverage requirements without violating dynamical constraints.

NASA's Jet Propulsion Laboratory, Pasadena, California

Algorithms for planning flight paths of autonomous aerobots (robotic blimps) to be deployed in scientific exploration of remote planets are undergoing development. These algorithms are also adaptable to terrestrial applications involving robotic submarines as well as aerobots and other autonomous aircraft used to acquire scientific data or to perform surveying or monitoring functions.

These algorithms are built on a number of previously developed algorithms for planning optimal trajectories in two- and three-dimensional spaces. As used here, "optimal" could have any of a variety of different meanings. For example, "optimal" could be used to characterize a trajectory that passes through a set of waypoints specified by a user and that satisfies a minimum-length or a minimum-time criterion while also remaining within limits posed by dynamical and resource constraints. The present algorithms can also satisfy a requirement that the trajectory suffice to enable the field of view of camera aboard an aerobot to sweep all of a specified ground area to be surveyed (see figure).
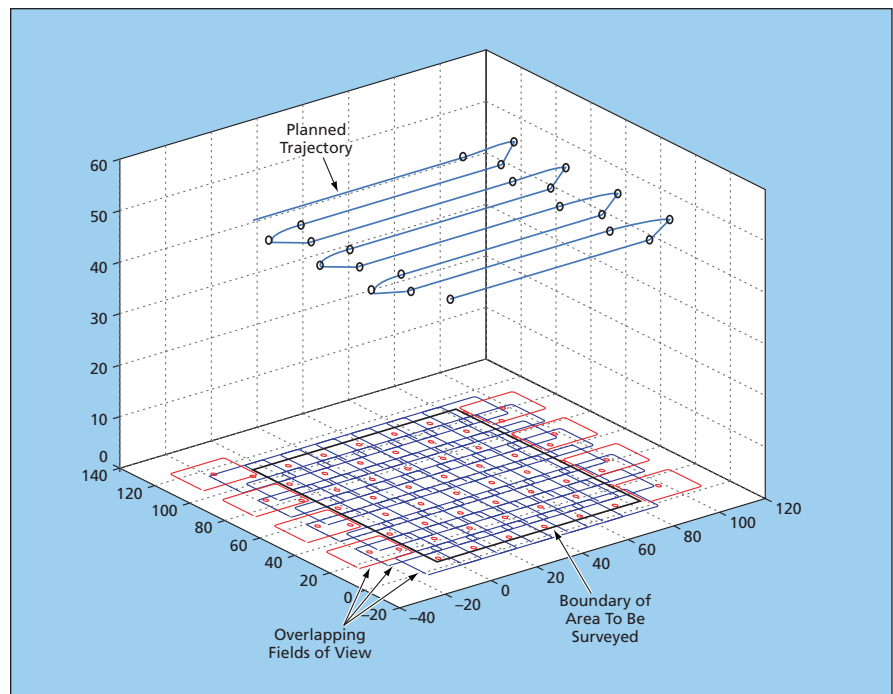
This **Raster-Scan Trajectory** was calculated to enable surveying, from a fixed altitude, of a defined rectangular area by use of a camera having a rectangular field of view. First, the survey area was mapped using successive fields of view that were required to overlap by 35 percent in length and/or width. Then the centers of the successive fields of view were designated as waypoints. Finally, the waypoints were used to generate the trajectory.