



In this Example Showing Features Used in Visual Odometry, black lines superimposed on the image represent vectors proportional to displacement of features between sequential images.

4. A roof-line-detection algorithm identifies, as candidate roof lines, line segments (a) that exceed a threshold length and (b) above which there are no other such lines.
5. The 3D positions of line segments detected in the preceding steps are computed from either (a) ordinary stereoscopic imagery acquired simultaneously by the two cameras or (b) wide-baseline stereoscopic imagery synthesized from imagery acquired in two successive frames, using relative camera positions determined by visual odometry. The choice between (a) and (b) is made on the basis of which, given certain

parameters of the viewing geometry, is expected to enable a more accurate triangulation.

6. A heuristic pruning algorithm filters the remaining line segments: All lines that are not approximately vertical or horizontal are discarded, horizontal lines longer than 2 m are selected, vertical lines that extend above 2 m are selected, and sets of parallel lines are selected.

- *Particle-Filter-Based Localization*

The outputs of the visual-odometry and urban-feature-detection-and-ranging components are fed to this component, which implements a particle-filter-based localization algorithm. In

the theory of particle-filter-based robot localization, the key notion is that a particle filter produces an approximate probability density function for the position and heading of a robot by use of Monte Carlo techniques. This theory makes it possible to incorporate knowledge of measurement uncertainty in a rigorous manner. Because the open source particle-filter-based localization software (developed by Prof. Sebastian Thrun of Stanford University) used in a prototype of the system is based on a planar model, the input data fed to this component are preprocessed into simulated single-axis range data (in effect, simulated LIDAR range data) by projecting all 3D features onto a horizontal plane and sampling the field of view at small angular intervals ( $1^\circ$ ).

Notwithstanding the oversimplification inherent in this approach, success in localization has been achieved in initial experiments.

*This work was done by Michael McHenry, Yang Cheng, and Larry Matthies of Caltech for NASA's Jet Propulsion Laboratory.*

*In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:*

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## Programs for Testing an SSME-Monitoring System

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A suite of computer programs has been developed for special test equipment (STE) that is used in verification testing of the Health Management Computer Integrated Rack Assembly (HMC-IRA), a ground-based system of analog and digital electronic hardware and software for "flight-like" testing for development of components of an advanced health-management system for the space shuttle main engine (SSME). HMC-IRA units are designed to be integrated into a test facility wherein they enable additional engine monitoring during SSME

hot-fire tests. Running on a control processor that is part of the STE, the STE software enables the STE to simulate the SSME Controller, the SSME itself, and interfaces between the SSME and the HMC-IRA.

The STE software enables the STE to simulate the analog input and the data flow of an SSME test firing from start to finish. The STE software also provides user interfaces, error injection, data storage, and board-level test routines. Accompanying the STE software is a suite of post-processing programs that

convert stored data from the HMC-IRA and STE to readable textual and graphical formats, extract timing and statistical data, and provide for calibration of analog circuit cards.

*These programs were written by Andre Lang, Jimmie Cecil, Ralph Heusinger, Kathleen Freestone, Lisa Blue, DeLisa Wilkerson, Leigh Anne McMahon, Richard B. Hall, Kosta Varnavas, Keary Smith, and Donna Kaukler of Marshall Space Flight Center and James Hall of Sverdrup Technology, Inc. Further information is contained in a TSP (see page 1).  
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