The final module is the RTPG processor. Its role is to find the exact states of the tools given initial conditions provided by the ITPG module. The requirement that the initial conditions exist allows this module to make use of a local search (whereas the ITPG module had global scope). To perform the local search, 3D model matching is used, where a synthetic image of the object is created and compared to the sensed data. The availability of low-cost PC graphics hardware allows rapid creation of synthetic images. In this approach, a function of orientation, distance, and articulation is defined as a metric on the difference between the captured image and a synthetic image with an object in the given orientation, distance, and articulation. The synthetic image is created using a model that is looked up in an object-model database.

A composable software architecture is used for implementation. Video is first preprocessed to remove sensor anomalies (like dead pixels), and then is processed sequentially by a prioritized list of tracker-identifiers.

This work was done by James English, Chu-Yin Chang, and Neil Tardella of Energid Technologies for Johnson Space Center. Further information is contained in a TSP (see page 1).

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:

Energid Technologies
124 Mount Auburn Street
Suite 200 North
Cambridge, MA 02138
Phone No.: (617) 401-7090
Toll Free No.: (888) 547-4100

Refer to MSC-23947-1, volume and number of this NASA Tech Briefs *issue, and the page number.*

Method for Implementing Optical Phase Adjustment

Goddard Space Flight Center, Greenbelt, Maryland

A method has been developed to mechanically implement the optical phase shift by adjusting the polarization of the pump and probe beams in an NMOR (nonlinear magneto-optical rotation) magnetometer as the proper phase shift is necessary to induce self-oscillation. This innovation consists of mounting the pump beam on a ring that surrounds the atomic vapor sample. The propagation of the probe beam is perpendicular to that of the pump beam. The probe beam can be considered as defining the axis of a cylinder, while the pump beam is directed radially. The magnetic field to be measured defines a third vector, but it is also taken to lie along the cylinder axis. Both the pump and probe beams are polarized such that their electric field vectors are substantially perpendicular to the magnet field. By rotation of the ring supporting the pump beam, its direction can be varied relative to the plane defined by the probe electric field and the magnetic field to be measured.

This work was done by David C. Hovde of Southwest Sciences and Eric Corsini of the University of California, Berkeley, for Goddard Space Flight Center. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810. GSC-15608-1

Visual SLAM Using Variance Grid Maps

This algorithm is suitable for real-time navigation on irregular terrain.

NASA's Jet Propulsion Laboratory, Pasadena, California

An algorithm denoted "Gamma-SLAM" performs further processing, in real time, of preprocessed digitized images acquired by a stereoscopic pair of electronic cameras aboard an off-road robotic ground vehicle to build accurate maps of the terrain and determine the location of the vehicle with respect to the maps. Part of the name of the algorithm reflects the fact that the process of building the maps and determining the location with respect to them is denoted "simultaneous localization and mapping" (SLAM). Most prior real-time SLAM algorithms have been limited in applicability to (1) systems equipped with scanning laser range finders as the primary sensors in (2) indoor environments (or relatively simply structured outdoor environments). The few prior vision-based SLAM algorithms have been feature-based and not suitable for real-time applications and, hence, not suitable for autonomous navigation on irregularly structured terrain.

The Gamma-SLAM algorithm incorporates two key innovations:

- Visual odometry (in contradistinction to wheel odometry) is used to estimate the motion of the vehicle.
- An elevation variance map (in contradistinction to an occupancy or an elevation map) is used to represent the terrain.

The Gamma-SLAM algorithm makes use of a Rao-Blackwellized particle filter (RBPF) from Bayesian estimation theory for maintaining a distribution over poses and maps. The core idea of the RBPF approach is that the SLAM problem can be factored into two parts: (1) finding the distribution over robot trajectories, and (2) finding the map conditioned on any given trajectory. The factorization involves the use of a particle filter in which each particle encodes both a possible trajectory and a map conditioned on that trajectory. The base estimate of the trajectory is derived from visual odometry, and the map conditioned on that trajectory is a Cartesian grid of elevation variances. In comparison with traditional occupancy or elevation grid maps, the grid elevation variance maps are much better for representing the structure of vegetated or rocky terrain.

This work was done by Andrew B. Howard of Caltech and Tim K. Marks of the University of California San Diego for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-46114