Software

Stereo and IMU-Assisted Visual Odometry for Small Robots

This software performs two functions: (1) taking stereo image pairs as input, it computes stereo disparity maps from them by cross-correlation to achieve 3D (three-dimensional) perception; (2) taking a sequence of stereo image pairs as input, it tracks features in the image sequence to estimate the motion of the cameras between successive image pairs. A real-time stereo vision system with IMU (inertial measurement unit)-assisted visual odometry was implemented on a single 750 MHz/520 MHz OMAP3530 SoC (system on chip) from TI (Texas Instruments). Frame rates of 46 fps (frames per second) were achieved at QVGA (Quarter Video Graphics Array i.e. 320×240), or 8 fps at VGA (Video Graphics Array 640×480) resolutions, while simultaneously tracking up to 200 features, taking full advantage of the OMAP3530's integer DSP (digital signal processor) and floating point ARM processors. This is a substantial advancement over previous work as the stereo implementation produces 146 Mde/s (millions of disparities evaluated per second) in 2.5W, yielding a stereo energy efficiency of 58.8 Mde/J, which is 3.75× better than prior DSP stereo while providing more functionality.

The focus is on stereo vision and IMU-aided visual odometry for small unmanned ground vehicle applications. It is expected that elements of this implementation will carry over to small unmanned air vehicles in future work. Because the objective is to advance the state of the art in compact, low-power implementation for small robots, highly efficient algorithms that have already been field tested have been chosen. This system combines the sum of absolute differences (SAD)-based, local optimization stereo with two-frame visual odometry using FAST features (Features from Accelerated Segment Test). By exploiting the dense depth map to provide stereo correspondence for the FAST features, it achieves very respectable position errors of 0.35% of distance traveled on datasets covering 400 m of travel. The algorithms used by this system were heavily tested in previous projects, which gives a solid basis for their implementation on the OMAP3530. In the future, cost/performance trade-offs of algorithm variants may be explored.

The novelty of this system is the parallel computation of stereo vision and visual odometry on both cores of the OMAP SoC. All stereo-related computation is handled on the C64x+ side of the OMAP, while feature detection, matching/tracking, and egomotion estimation is handled on the ARM side. This is a convenient division of processing, as stereo computation is entirely an integer process, well suited to the integer only C64x+, while several parts of visual odometry involve floating point operations. The TI codec engine's IUniversal wrapper was used to integrate the ARM and DSP processes.

This work was done by Larry H. Matthies of Caltech and Steven B. Goldberg of Indelible Systems Inc. for NASA's Jet Propulsion Laboratory. **For more information, download the Technical Support Package (free white paper) at www.techbriefs.com/tsp under the Software category.**

The software used in this innovation is available for commercial licensing. Please contact Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-48103.

Global Swath and Gridded Data Tiling

This software generates cylindrically projected tiles of swath-based or gridded satellite data for the purpose of dynamically generating high-resolution global images covering various time periods, scaling ranges, and colors called "tiles." It reconstructs a global image given a set of tiles covering a particular time range, scaling values, and a color table. The program is configurable in terms of tile size, spatial resolution, format of input data, location of input data (local or distributed), number of processes run in parallel, and data conditioning.

This software can dynamically generate global images of various temporal and spatial resolutions without having to go back to the original data files, reading and conditioning, and re-projecting the source values. It can be utilized to efficiently generate global imagery of various temporal and spatial resolutions based upon cylindrically projected tiles that have been created from swath and gridded data sets.

The package supports JPL's Physical Oceanography Distributed Active Archive Center's (PO.DAAC) State of the Ocean Web page (http://podaac.jpl.nasa.gov/soto), a Google Earth-based Web interactive visualization tool.

This work was done by Charles K. Thompson of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.

This software is available for commercial licensing. Please contact Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-48113.

GOES-R: Satellite Insight

GOES-R: Satellite Insight seeks to bring awareness of the GOES-R (Geostationary Operational Environmental Satellite — R Series) satellite currently in development to an audience of all ages on the emerging medium of mobile games. The iPhone app (Satellite Insight) was created for the GOES-R Program. The app describes in simple terms the types of data products that can be produced from GOES-R measurements. The game is easy to learn, yet challenging for all audiences. It includes educational content and a path to further information about GOES-R, its technology, and the benefits of the data it collects.

The game features action-puzzle game play in which the player must prevent an overflow of data by matching falling blocks that represent different types of GOES-R data. The game adds more different types of data blocks over time, as long as the player can prevent a data overflow condition. Points are awarded for matches, and players can compete with themselves to beat their highest score.

This work was done by Austin J. Fitzpatrick, Nancy J. Leon, Alexander Novati, Laura K. Lincoln, and Diane K. Fisher of Caltech, and Daniel Karlson of NOAA for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.

This software is available for commercial licensing. Please contact Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-48264.

Aquarius iPhone Application

The Office of the CIO at JPL has developed an iPhone application for the Aquarius/SAC-D mission. The application includes specific information about

the science and purpose of the Aquarius satellite and also features daily mission news updates pulled from sources at Goddard Space Flight Center as well as Twitter. The application includes a media and data tab section. The media section displays images from the observatory, viewing construction up to the launch and also includes various videos and recorded diaries from the Aquarius Project Manager. The data tab highlights many of the factors that affect the Earth's ocean and the water cycle. The application leverages the iPhone's accelerometer to move the Aquarius Satellite over the Earth, revealing these factors. Lastly, this application features a countdown timer to the satellite's launch, which is currently counting the days since launch. This application was highly successful in promoting the Aquarius Mission and educating the public about how ocean salinity is paramount to understanding the Earth.

This is a public application available at the time of this reporting in The Apple App Store: http://itunes.apple.com/us/app/aquarius/id437313730?mt=8