image 2 of any point on the plane in image 1. Any feature pair that is inconsistent with the homography is thrown out. The output of the process is a set of feature pairs, and the homography.

The algorithms in this innovation are well known, but the new implementation improves the process in several ways. It runs in real-time at 2 Hz on 64-megapixel imagery. The new Shi-Tomasi corner detector tries to produce the requested number of features by automatically adjusting the minimum distance between found features. The homography-finding code now uses an implementation of the RANSAC algorithm that adjusts the number of iterations automatically to achieve a pre-set probability of missing a set of inliers. The new interface allows the caller to pass in a set of predetermined points in one of the images. This allows the ability to track the same set of points through multipleframes.

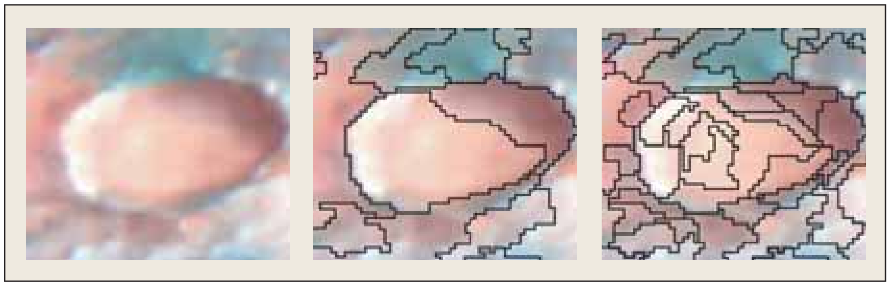
This work was done by Daniel S. Clouse, Yang Cheng, Adnan I. Ansar, David C. Trotz, and Curtis W. Padgett of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

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-46916.

Sparse Superpixel Unmixing for Hyperspectral Image Analysis

NASA's Jet Propulsion Laboratory, Pasadena, California

Software was developed that automatically detects minerals that are present in each pixel of a hyperspectral image. An algorithm based on sparse spectral unmixing with Bayesian Positive Source Separation is used to produce mineral abundance maps from hyperspectral images. A "superpixel" segmentation strategy enables efficient unmixing in an interactive session.



Here a **Subwindow of Observation** demonstrates superpixel segmentation. Left: original subimage. Center: coarse segmentation, minimum region size 100. Right: fine segmentation, minimum region size 20.

The algorithm computes statistically likely combinations of constituents based on a set of possible constituent minerals whose abundances are uncertain. A library of source spectra from laboratory experiments or previous remote observations is used. A superpixel segmentation strategy improves analysis time by orders of magnitude, permitting incorporation into an interactive user session (see figure).

Mineralogical search strategies can be categorized as "supervised" or "unsupervised." Supervised methods use a detection function, developed on previous data by hand or statistical techniques, to identify one or more specific target signals. Purely unsupervised results are not always physically meaningful, and may ignore subtle or localized mineralogy since they aim to minimize reconstruction error over the entire image. This algorithm offers advantages of both methods, providing meaningful physical interpretations and sensitivity to subtle or unexpected minerals.

This work was done by Rebecca Castano and David R. Thompson of Caltech and Martha Gilmore of Wesleyan University for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.

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-47038.

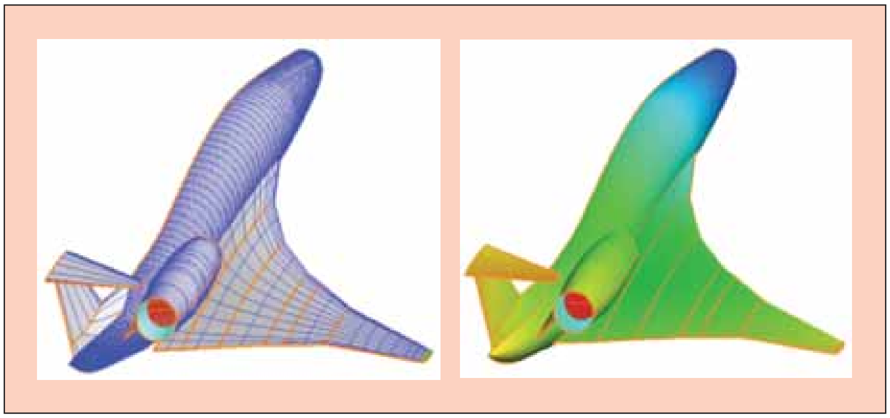
Intelligent Patching of Conceptual Geometry for CFD Analysis

Langley Research Center, Hampton, Virginia

The iPatch computer code for intelligently patching surface grids was developed to convert conceptual geometry to computational fluid dynamics (CFD) geometry (see figure). It automatically uses bicubic B-splines to extrapolate (if necessary) each surface in a conceptual geometry so that all the independently defined geometric components (such as wing and fuselage) can be intersected to form a watertight CFD geometry. The software also computes the intersection curves of surface patches at any resolution (up to 10^{-4} accuracy) specified by the user, and it writes the B-spline surface patches, and the corresponding boundary points, for the watertight CFD geometry in the format that can be directly used by the grid generation tool VGRID.

iPatch requires that input geometry be in PLOT3D format where each component surface is defined by a rectangular grid $\{(x(i,j), y(i,j), z(i,j)): 1 \leq i \leq m, 1 \leq j \leq n\}$ that represents a smooth B-spline surface. All surfaces in the PLOT3D file conceptually represent a watertight geometry of components of an aircraft on the half-space $y \geq 0$. Overlapping surfaces are not allowed, but could be fixed by a utility code "fixp3d". The fixp3d utility code first finds the two grid lines on the two surface grids that are closest to each other in Hausdorff distance (a metric to measure the discrepancies of two sets); then uses one of the grid lines as the transition line, extending grid lines on one grid to the other grid to form a merged grid.

Any two connecting surfaces shall have a "visually" common boundary curve, or can be described by an inter-



The **iPatch Computer Code** converts conceptual geometry (left) to coresponding CFD geometry (right).

section relationship defined in a geometry specification file. The intersection of two surfaces can be at a "conceptual" level. However, the intersection is directional (along either i or j index direction), and each intersecting grid line (or its spine extrapolation) on the first surface should intersect the second surface. No two intersection relationships will result in a common intersection point of three surfaces.

The output files of iPatch are IGES, d3m, and mapbc files that define the CFD geometry in VGRID format. The IGES file gives the NURBS definition of the outer mold line in the geometry. The d3m file defines how the outer mold line is broken into surface patches whose boundary curves are defined by points. The mapbc file specifies what the boundary condition is on each patch and the corresponding NURBS surface definition of each non-planar patch in the IGES file.

This work was done by Wu Li of Langley Research Center. Further information is contained in a TSP (see page 1). LAR-17685-1

Stereo Imaging Tactical Helper

NASA's Jet Propulsion Laboratory, Pasadena, California

The Stereo Imaging Tactical Helper (SITH) program displays left and right images in stereo using the display technology made available by the JADIS framework, which was described in "JAVA Stereo Display Toolkit," *NASA Tech Briefs*, Vol. 32, No. 4 (April 2008), page 63. An overlay of the surface described by the disparity map (generated from the left and right images) allows the map to be compared to the actual images. In addition, an interactive cursor, whose visual depth is controlled by the disparity map, is used to ensure the correlated surface matches the real surface. This enhances the ability of operations personnel to provide quality control for correlation results, as well as to greatly assist developers working on correlation improvements. While its primary purpose is as a quality control tool for inspecting correlation results, SITH is also straightforward for use as a basic stereo image viewer.

There are two modes for the image display: stereo (left/right) through hardware or anaglyph, and adjacent, where the right image pane is placed to the right or bottom of the left image pane. The mode is switchable at runtime. The application displays with left and right images with an overlaid cursor per image. The positions of the image pane cursors will be related such that, given the coordinates of the cursor center on the left image, the position of the right pane cursor will be the mapped coordinates found in the disparity file. In stereo mode, this constitutes a stereo cursor.

In grid mapping, a flat grid is painted over the left image, and on the right, points from the left grid are mapped to the corresponding point on the right grid. This usually results in warping that indicates a higher-level view of the correlation result. As left and right images may not be adequately aligned such that they can be viewed comfortably, manual disparity controls exist to allow the right image to be shifted along the horizontal and vertical axes to produce stereo results that are easier for the user to view.

This work was done by Nicholas T. Toole 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-46669.

Planning and Execution for an Autonomous Aerobot

NASA's Jet Propulsion Laboratory, Pasadena, California

The Aerial Onboard Autonomous Science Investigation System (AerOASIS) system provides autonomous planning and execution capabilities for aerial vehicles (see figure). The system is capable of generating high-quality operations plans that integrate observation requests from ground planning teams, as well as opportunistic science events detected onboard the vehicle while respecting mission and resource constraints.

AerOASIS allows an airborne planetary exploration vehicle to summarize and prioritize the most scientifically relevant data; identify and select high-value science sites for additional investigation; and dynamically plan, schedule, and monitor the various science activities being performed, even during extended communications blackout periods with Earth.