to remain valid. Molecular methods are better suited to model this region of the flow. Finally, granular and multiphase flow models must be employed to describe the dust and debris that are displaced from the surface, as well as how a crater is formed in the regolith. At present, standard commercial CFD (computational fluid dynamics) software is not capable of coupling each of these flow regimes to provide an accurate representation of this flow process, necessitating the development of custom software.

This software solves the fluid-flow-governing equations in an Eulerian framework, coupled with the particle transport equations that are solved in a Lagrangian framework. It uses a fourth-order explicit Runge-Kutta scheme for temporal integration, an eighth-order central finite differencing scheme for spatial discretization. The non-linear terms in the governing equations are recast in cubic skew symmetric form to reduce aliasing error. The second derivative viscous terms are computed using eighth-order narrow stencils that provide better diffusion for the highest resolved wave numbers. A fourth-order Lagrange interpolation procedure is used to obtain gas-phase variable values at the particle locations.

This work was done by Josette Bellan and Senthilkumaran Radhakrishnan of Caltech 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-47694.

Projection of Stabilized Aerial Imagery Onto Digital Elevation Maps for Geo-Rectified and Jitter-Free Viewing

Projection code is faster, cleaner, and easier to integrate.

NASA's Jet Propulsion Laboratory, Pasadena, California

As imagery is collected from an airborne platform, an individual viewing the images wants to know from where on the Earth the images were collected. To do this, some information about the camera needs to be known, such as its position and orientation relative to the Earth. This can be provided by common inertial navigation systems (INS). Once the location of the camera is known, it is useful to project an image onto some representation of the Earth. Due to the non-smooth terrain of the Earth (mountains, valleys, etc.), this projection is highly non-linear. Thus, to ensure accurate projection, one needs to project onto a digital elevation map (DEM). This allows one to view the images overlaid onto a representation of the Earth.

A code has been developed that takes an image, a model of the camera used to acquire that image, the pose of the camera during acquisition (as provided by an INS), and a DEM, and outputs an image that has been geo-rectified. The world coordinate of the bounds of the image are provided for viewing purposes. The code finds a mapping from points on the ground (DEM) to pixels in the image. By performing this process for all points on the ground, one can "paint" the ground with the image, effectively performing a projection of the image onto the ground. In order to make this process efficient, a method was developed for finding a region of interest (ROI) on the ground to where the image will project.

This code is useful in any scenario involving an aerial imaging platform that moves and rotates over time. Many other applications are possible in processing aerial and satellite imagery.

This work was done by Adnan I. Ansar, Shane Brennan, Daniel S. Clouse, Yang Cheng, Curtis W. Padgett, and David C. Trotz 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-46920.

Iterative Transform Phase Diversity: An Image-Based Object and Wavefront Recovery

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The Iterative Transform Phase Diversity algorithm is designed to solve the problem of recovering the wavefront in the exit pupil of an optical system and the object being imaged. This algorithm builds upon the robust convergence capability of Variable Sampling Mapping (VSM), in combination with the known success of various deconvolution algorithms. VSM is an alternative method for enforcing the amplitude constraints of a Misell-Gerchberg-Saxton (MGS) algorithm. When provided the object and additional optical parameters, VSM can accurately recover the exit pupil wavefront. By combining VSM and deconvolution, one is able to simultaneously recover the wavefront and the object.

To recover the exit pupil wavefront, and the unknown object, first one must collect image plane data of the optical system under test. To increase convergence robustness, diversity images are collected. Next, a guess of the wavefront is made. This can be based on a prior estimate, or a simpler random solution of small values. This guess of the exit pupil and the image data will provide a starting point for VSM phase retrieval.

After several iterations of VSM phase retrieval, the algorithm will estimate the point spread function (PSF) based on