TOPOGRAPHIC ANALYSIS WITH A STEREO MATCHING TOOL KIT. S. L. André[1] and M. S. Robinson[1,2], and T. C. André[3] [1]Department of Geological Sciences, Northwestern University, 1850 Campus Drive, Evanston, Illinois, 60208-2150, USA, sarah@earth.northwestern.edu, [2]Center for Planetary Sciences, Northwestern University, Evanston, Illinois 60208-2150, USA, [2]Department of Physics, University of Chicago, Chicago, Illinois 60637, USA.

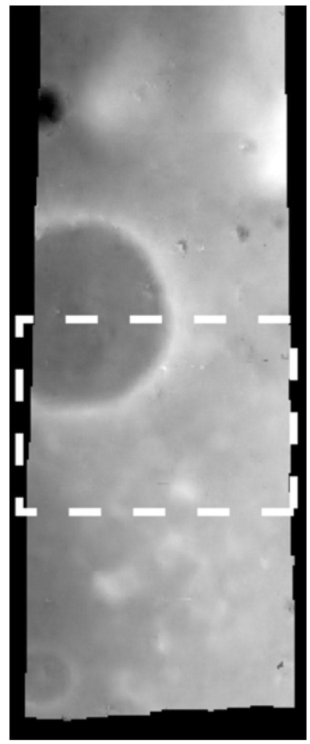
Introduction: Digital elevation models (DEMs) are invaluable products for planetary interpretation [i.e. 1,2,3]. Typically, stereo matching programs require a user-selected set of homologous points (seed points) in the left and right images to initiate automated stereo matching routines. Relying on the set of initial seed points, the program then finds matching points between the two images. User input of seed points for each stereo pair can be a tedious and time-consuming step. An automated stereo matching tool for planetary images is useful in reducing or eliminating the need for human interaction (and potential error) in choosing initial seed points. We present a set of stereo matching tools that can (1) automatically generate seed points, (2) perform the stereo matching process, (3) apply the camera intersection model, and (4) produce DEMs.

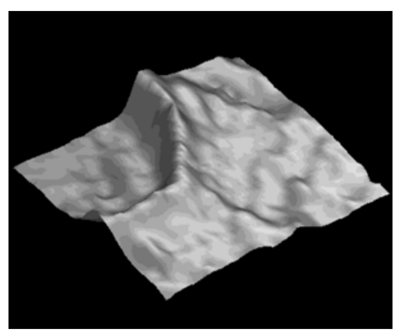
Methods: The first step of the software, Stereo Matching Tool Kit (SMTK) [4], is to determine good initial homologous points (seed points). Seed points are chosen either automatically or manually. Automatic seed points use SPICE information as the initial guess. We utilize SPICE ancillary data system [i.e. 5] implemented by the Navigation and Ancillary Information Facility (NAIF) group at JPL. Manual seed points can be input by the user if desired, and are used when SPICE information is not ideal. The quality of a seed point is determined via a least-squares algorithm (described below). The best seed points are retained as growth points for the sheet growing algorithm (also described below).

The adaptive least-squares correlation algorithm iteratively determines affine correlation parameters between a correlation box in the left image and a patch in the right image. Using the seed points and the affine transformation parameters, the program predicts nearby match points. Nearby match points are "grown" if they converge within the adaptive least-squares algorithm. Quality parameters are specified within the program to minimize the number of poor matches.

Spacecraft ephemeris (camera position and orientation data) from SPICE and ray intersection techniques are used to determine 3D coordinates (latitude, longitude, and height) for all match points. Finally, we construct a digital elevation model, which represents the results as an image of interpolated heights.

Figure 1. DEM and shaded relief plot of Clementine derived stereo images.

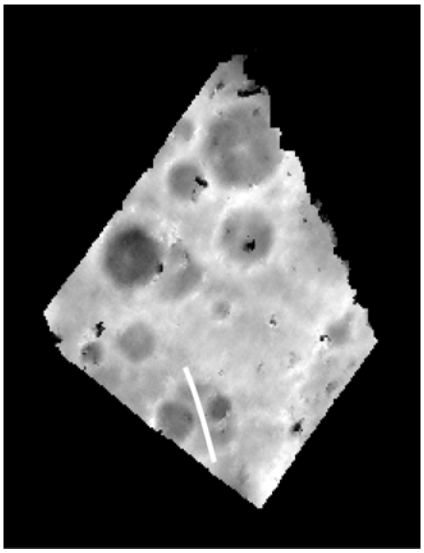




Example 1 – Clementine: Figure 1 shows a DEM (top) derived from 5 nadir-pointing images from orbit 333 combined with 5 tilted-camera images from adjacent orbit 338. The region shown is 150 km long, 60 km wide, and is located near the Orientale basin. The large crater in the image (Crater Kopff) has a diameter of 41 km. Heights vary from 1900 m to 2800 m (relative to the 1734.4 km radius reference sphere).

The area outlined by the white box is also shown (below) as a shaded relief plot.

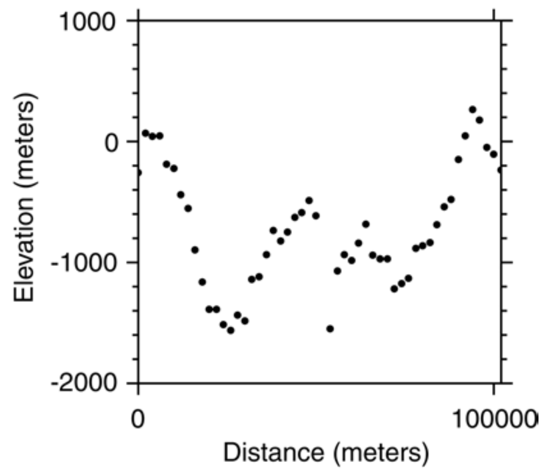
Figure 2. DEM derived from Mariner 10 stereo pairs.



Example 2 – Mariner 10: Figure 2 shows a DEM generated from Mariner 10 stereo pairs 166788 and 166695, a region of the Beethoven Quadrangle of Mercury (111.4ºW – 101.2ºW, 7.8ºS – 4.7ºN). The correlation box size used to create this DEM was 23 by 23 pixels. Images of the Beethoven Quadrangle were acquired at low incidence angles, thus making recognition of features difficult within the images. Initial analysis of DEMs of this region [6] indicate previously unrecognized impact craters. An example of a subdued crater not previously recognized [7] is shown with a profile (Figure 3).

Future Work: We will develop additional ways to identify and reduce blunders produced by the stereo matching process. We will also complete a rigorous error analysis. We hope to produce a stereo matcher that is robust, user-friendly, and that can be used by the planetary science community on a variety of image datasets.

Figure 3. Profile across the subdued crater identified in Figure 2.



References: [1] Herrick R. and Sharpton V. (2000) JGR 105, 20245-20262. [2] Oberst et al. (1997) EOS 78, 445-450. [3] Smith D. et al. (1999) Science 284, 1495-1503. [4] Andre S. et al. (2003) EOS 84, F964. [5] Acton C. (1995) Proc. 26th LPSC, 1. [6] Andre S. et al. (2003) LPSC XXXIV, #2026. [7] King J. and Scott D. (1990) USGS Report, Misc. Invest. Series I-2048.