PREPARING FOR THEMIS CONTROLLED GLOBAL MARS MOSAICS. B. A. Archinal[1], L. Weller[1], S. Sides[1], G. Cushing[1], R. L. Kirk[1], L. A. Soderblom[1], and T. C. Duxbury[2], [1]U. S. Geological Survey (2255 N. Gemini Drive, Flagstaff, AZ 86001, USA, barchinal@usgs.gov), [2]Jet Propulsion Laboratory (4800 Oak Grove Drive, M/S: 264-379, Pasadena, CA 91109, USA, Thomas.C.Duxbury@jpl.nasa.gov).

Introduction: We have begun work to prepare for producing controlled 2001 Mars Odyssey THEMIS infrared (IR) and visible (VIS) global mosaics of Mars. This effort is being coordinated with colleagues from Arizona State University and on the THEMIS team who plan to address radiometric issues in making such mosaics. We are concentrating on geometric issues.

Several areas of investigation are now in progress, including: a) characterizing the absolute pointing accuracy of THEMIS images; b) investigating whether automatic tie point matching algorithms could be used to provide connections between overlapping THEMIS images; c) developing algorithms to allow for the photogrammetric (bundle) adjustment of the THEMIS IR (line scanner) camera images. Our primary goal in this pilot study effort will be to make several test control THEMIS mosaics and better determine which methods could be used, which require development, and what level of effort is required, in order to make large regional or global controlled THEMIS mosaics.

Camera Pointing Characterization: Estimates of both the "average" and worst case absolute camera pointing of the THEMIS cameras are highly desirable. A knowledge of the magnitude of the possible pointing error for any given image will assist in determining whether any given pair of images overlap. Prediction of image overlap is necessary in turn to initialize any automatic (or manual) tiepoint measurements. These are measurements of the line and sample positions of features common between overlapping images that are used as input to the photogrammetric adjustment ("control") calculation used to estimate precise camera pointing for the specific images in question, and other parameters of interest. Quantification of pointing errors would also help to characterize the accuracy of any uncontrolled image mosaics, both in the determination of absolute coordinates of such mosaics, and in the magnitude of seam errors between adjacent/overlapping images. Finally, these error estimates will be useful in planning the acquisition of images so that pointing errors do not open up gaps between the images.

We are using two methods in order to estimate this type of camera pointing information. First, at a higher level of accuracy, we have begun to measure the positions of features on THEMIS images relative to their positions on an illuminated (shaded relief) MOLA [1] digital image model (DIM). Secondly, we are also simply looking at the image shifts necessary to match images to features on such MOLA image models, e.g. during mosaic generation for other purposes (such as that described in [2]). The MOLA DIM serves as an absolute reference for surface feature coordinates. Its estimated absolute accuracy, at least at its likely one standard deviation level, is 100-200 m (including both the positional accuracy of the MOLA data [3], and errors due to the creation of an illuminated DIM from a gridded product and matching with THEMIS images).

We have begun making such comparisons in the vicinity of the MER landing sites, and will later extend them to other locations on Mars. Consideration of different areas on Mars and times during the mission will allow us to assess the importance of changing conditions such as season, lighting, tracking accuracy, operational changes, etc.

Automatic tie-pointing tests: As already explained, the primary input to photogrammetric solutions is the measured positions of points common to overlapping images. In the past these positions have often been measured manually (e.g. for MDIM 2.1 [4]) or by using automatic techniques supplemented by manual measurement, as was the case for USGS processing of Clementine images [5]. Several authors [6] have published descriptions of automatic tiepointing techniques, but none have been shown to work consistently and in general for planetary images.

Clearly, in the case of THEMIS mosaics, the sheer number of images precludes the measurement of tiepoints by manual methods. For THEMIS IR, global coverage will probably require a few hundred thousand images, and, given a commonly accepted number of 6 tiepoints per image, between 1 and 2 million tiepoint measurements. A mosaic of VIS images would probably require an order of magnitude more tie points (e.g. several million to over 10 million). Therefore some automatic measurement technique is absolutely required, perhaps supplemented by a very minimal number of manual measures, checks, or ties to MOLA control (<<1% of the total number of points). The USGS ISIS software package [7] has some built-in automatic tiepointing capabilities. However, a close inspection of the software has revealed that it is very specific to the measurement of Clementine images or a few other specialized cases. We plan to improve the ISIS software so that – given *a priori* camera pointing accurate to several pixels or less – areas of overlapping images can first be found, and the previously developed ISIS automatic matching algorithms can be applied to find evenly distributed matches in these areas of overlap.

We plan to test the use of these automatic tie-pointing techniques on overlapping THEMIS daytime IR images and overlapping THEMIS VIS images, including tests where such overlapping areas are varied and tests of different types of such images (over different terrain and illumination conditions). This should help to characterize how well such automatic tie pointing procedures can be expected to work, what minimum image overlap area is needed, and how many manual measurements will be needed to supplement the automatic process.

We do expect that further work beyond what we have immediately planned will be necessary to improve any automatic tie-pointing techniques, possibly involving the simultaneous solution of radiometric corrections to overlapping images. The matching of daytime to nighttime IR images will also need to be investigated, since here the images of any given area tend to be negative in appearance between daytime and nighttime - perhaps some simple image reversal techniques or edge detection filtering may be useful for such matching.

Line Scanner Camera Photogrammetric Adjustment: We are also beginning development of algorithms to photogrammetrically adjust line scanner camera images, such as those of the THEMIS IR camera. Geometrically, such images differ drastically from framing camera images where an entire image can be assumed to be acquired simultaneously using one set of camera pointing information. In a line scanner camera, each line is acquired independently, requiring a solution for camera pointing information for each line. Such pointing information is fortunately slowly changing and therefore highly correlated. We plan to recover a set of average pointing and camera position information for each line scanner image and then model with appropriate parameters, e.g. fitted by spline curves, the slowly varying information as it applies to each line. In comparison to other current and planned planetary line scanner cameras, the THEMIS IR camera is ideal for the development of this technique. It is easier to deal with than other existing and planned planetary line-scanner cameras because of a combination of simplicity and low resolution relative to spacecraft motions.

Once the adjustment software has been demonstrated for THEMIS, we intend to adapt it to be able to adjust images from the existing MGS MOC system and the Mars Express HRSC system. We also plan to be able to process images from the planned MRO HiRISE and other future line scanner cameras. These cameras will require the development of additional algorithms, software, and procedures, since they have the added complications of being more strongly affected by spacecraft "jitter" (e.g. periodic motion between lines along track and across track) because of their higher resolution. In addition, these cameras are considerably more complex. HRSC has a total of 9 detector lines for stereo and color imaging, while HiRISE has 3 color detectors, each consisting of multiple, staggered detector segments.

Summary: We are in the process of acquiring image measurement data in order to perform tests that will let us assess the difficulty (and cost) of creating large area or global THEMIS IR and VIS mosaics. Preliminary results of this work will be reported in our poster. Further we have begun to develop the algorithms and software to allow for the photogrammetric adjustment of line scanner camera images, particularly for THEMIS IR images. This work is serving as a pilot study on the feasibility of creating controlled global THEMIS IR mosaics of Mars and—assuming such mosaics are possible—will allow us to assess how they should be done.

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