AUTOMATIC DETECTION OF LUNAR CRATERS BASED ON TOPOGRAPHY RECONSTRUCTION FROM CHANDRAYAAN-1 M3 IMAGERY. S. Lončarić[1], G. Salamunićcar[1,2], A. Grumpe[3], C. Wöhler[3]. [1]Faculty of Electrical Engineering and Computing, University of Zagreb, Unska 3, HR-10000 Zagreb, Croatia, sven.loncaric@fer.hr; [2]AVL-AST d.o.o., Av. Dubrovnik 10/II, HR-10020 Zagreb-Novi Zagreb, Croatia, gsc@ieee.org; [3]Faculty of Electrical Engineering and Information Technology, Dortmund University of Technology, Otto-Hahn-Str. 4, D-44227 Dortmund, Germany, {arne.grumpe | christian.woehler}@tu-dortmund.de

Introduction: An overview of 112 crater detection algorithm (CDA) related publications from numerous authors is given in two recent papers [1, 2]. Almost all of them are based on either digital elevation maps (DEMs) (e.g. [3], [4] and [5]) or optical images (e.g. [6], [7] and [8]). The possibility of using DEM-based CDA for optical images has been recently proposed in [9], but is still in the early stage of development.

Datasets and Methods: We make use of the Chandrayaan-1 Moon Mineralogy Mapper (M^3) data set and laser altimetry data to construct a DEM of high lateral resolution, which can be used for our DEM-based CDAs. Used/developed datasets and methods are as follows:

Chandrayaan-1M^3 dataset: The Moon Mineralogy Mapper (M^3) data set has a resolution of ~140 m per pixel. It is used as an input for our image-based DEM construction algorithm as it provides pixel-synchronous 85-channel multispectral image data and height data. The multispectral data are combined into one optical image by computing a weighted mean over the channels. To avoid the thermal radiance component, channels with center wavelength above 2 µm are neglected.

Topography reconstruction. In order to reconstruct a DEM of the lunar surface from an optical image, a modified version of the shape from shading algorithm proposed by Horn [10] is used. To maintain accuracy on large scales we added an error term to the optimization problem which describes the deviation of the resulting DEM from the laser altimetry DEM at a lower lateral resolution than the original image. Although a single image is sufficient to construct the DEM, our method takes into account the non-uniform surface albedo, where initially a strongly blurred and thus almost uniform albedo map is assumed. In an iterative manner, the DEM is then reconstructed and simultaneously the albedo map is recovered on decreasing spatial scales. Details about the algorithm can be found in [11]. The lateral resolution of the resulting DEM comes close to that of the M^3 images.

Crater detection algorithm. The used interpolation-based CDA is based on previous work [5] and relies on a specially developed interpolation method [12], which is suitable for detection of small craters.

Brightness/contrast correction. This method performs automated: (1) brightness and contrast corrections of the image(s) used for our DEM construction algorithm [2]; and (2) emplacement in the newly created 1/512° global image mosaic. The objective is to provide a data set for the subsequent manual evaluation of crater candidates. This is useful when the 1/512° LOM is not available (farside) or is in lower quality, because CLEMBASE and LASGW are available only in 1/256° and 1/64° resolution, respectively.

Manual evaluation of crater-candidates. Each crater-candidate is either (using the methodology from [2]): (1) rejected; or (2) corrected (coordinates and diameter) before inclusion into the resulting catalogue.

Results: For the selected region (1.64°E–3.06°E, 23°S–27°S), the number of crater candidates for our refined DEM is 387 (60 with $0.24 \leq p$, 327 with $0.12 \leq p < 0.24$, where p is the associated probability), and the number of correct detections is 125 (43 and 82, respectively). Out of these 125 craters, 54 are not detectable with 1/512° LOLA data using the same probability thresholds, and others are mostly detected with more precisely defined coordinates and diameters.

Conclusion: The proposed crater detection approach has been tested successfully, as shown in Fig. 1. Ongoing work involves the reconstruction of all parts of the lunar surface covered by the M^3 dataset. Future crater detection activities will be based on DEMs of still higher resolution obtained from other spacecraft images. The results of ongoing data processing activities will be published at www.bv.e-technik.tu-dortmund.de/Contents/FO_Planetary_DEM.html.

References: [1] Salamunićcar G. and Lončarić S. (2008) *Adv. Space Res.*, *42*, 6-19. [2] Salamunićcar G. et al. (2011) *Planet. and Space Sci.*, *59*, 111-131. [3] Michael G. G. (2003) *Planet. and Space Sci.*, *51*, 563-568. [4] Bue B. D. and Stepinski T. F. (2007) *Trans. Geosci. Remote Sens.*, *45*, 265-274. [5] Salamunićcar G. and Lončarić S. (2010) *Trans. Geosci. Remote Sens.*, *48*, 2317-2329. [6] Bandeira L. et al. (2007) *Trans. Geosci. Remote Sens.*, *45*, 4008-4015. [7] Cooper G. R. J. (2003) *Computers & Geosciences*, *29*, 941-948. [8] Flores-Méndez A. and Suarez-Cervantes A. (2009) *Lecture Notes in Comp. Sci.*, *5856*, 287-294. [9] Salamunićcar G. and Lončarić S. (2010) *LPS XXXXI*, Abstract #1421. [10] Horn B. K. P. (1990) *International Journal of Computer Vision*, *5*, 37-75. [11] Grumpe A. and Wöhler C. (2011) *this volume*. [12] Salamunićcar G. and Lončarić S. (2010) *COSPAR 38*, Abstract #B02-0042-10.

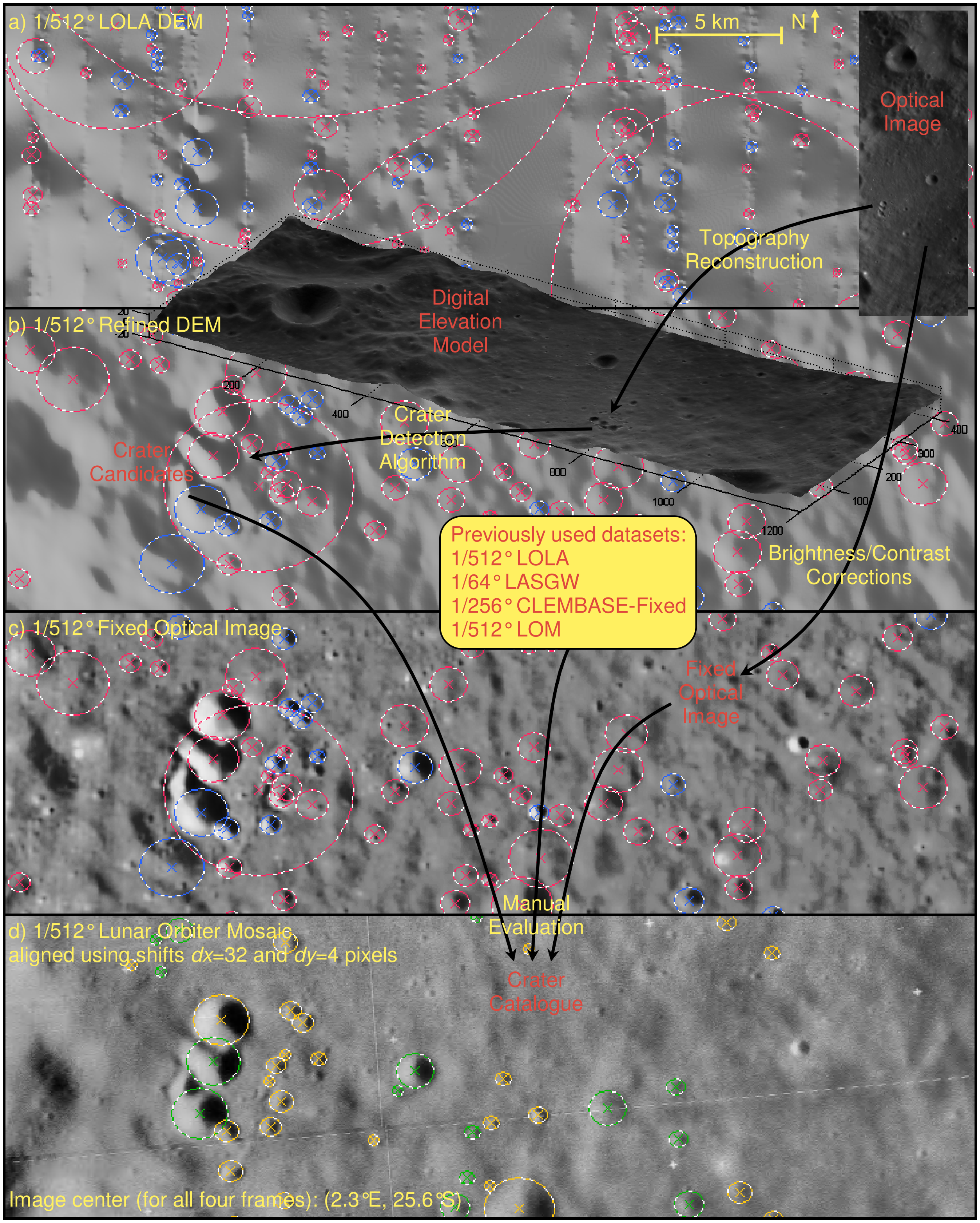

Figure 1: The output of our CDA for the 1/512° LOLA DEM (a) and the 1/512° refined DEM (b), where the output for the refined DEM is shown on the shaded DEM (b) and on the brightness/contrast fixed M^3 image (c). The high-probability ($0.24 \leq p$) crater candidates are shown in blue, low-probability ones ($0.12 \leq p < 0.24$) in red color, with p as the associated probability assigned by the CDA. The bottom frame (d) shows the constructed crater catalogue superposed on the 1/512° LOM image, wherein only the green craters are detectable with 1/512° the LOLA DEM.