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Topography and orthoimages of asteroid (21) Lutetia

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Abstract

During the flyby of asteroid (21) Lutetia by the Rosetta spacecraft in July 2010, the OSIRIS imaging system acquired several hundred images of Lutetia's surface. We analyzed 84 multi-spectral NAC images with stereo-photogrammetric methods. A 3D point control network was used within a photogrammetric block adjustment to derive improved orientation data (pointing and position) for the Rosetta spacecraft and corrections for the pre-flight estimates of Lutetia's position in space. We selected a subset of 10 OSIRIS NAC images to derive more than 12 millions of object points for surface reconstruction through stereo processing. A final 60 m raster DTM was generated covering about 78% of the Northern hemisphere. Based upon this DTM, we derived accurately co-registered orthoimages, for multi-spectral mapping of the surface of Lutetia.

1. Introduction

The primary target of ESA's Rosetta mission is comet 67P/Churyumov-Gerasimenko. The trajectory was designed to allow close encounters with two main belt asteroids during cruise. After a flyby at asteroid 2867 Steins in September 2008, the spacecraft Rosetta passed asteroid (21) Lutetia at a flyby distance of about 3,160 km on July 10, 2010.

2. Data base

During the Lutetia flyby the OSIRIS camera system acquired few hundred images. The image resolution ranges from 5 km/pixel to 60 m/pixel for NAC and from 50 km/pixel to 320 m/pixel for WAC images. From 202 NAC images we selected 84 images with a resolution better than 380 m/pixel for photo-grammetric analysis. A subset of 10 images provides sufficient illumination and stereo conditions for 3D surface reconstruction.

3. Photogrammetric analysis

Our analysis is based on stereo-photogrammetric algorithms and respective software realizations that have developed over the past years. They have already been applied successfully to several planetary image data sets [1], [2], [3], [4], [5].

3.1 Photogrammetric block adjustment

The goal of photogrammetric block adjustment is to obtain improved data for the spacecraft position and the OSIRIS NAC pointing. Starting from the nominal orientation data, multi-image matching was applied to image data in overlapping areas to derive ~3,500 conjugate points (commonly termed tie points). The redundancy of the normal equation system, wherein the 3D coordinates of the surface points and the orientation of all 84 images are the unknowns, is ~18,800. We could improve the accuracy of the 3D surface points by a factor 10, from more than 1,000 m to ~100 m. Furthermore we have used our 3D control network to improve the ephemeris of Lutetia (by about 23 km in the radial direction on its orbital plane) [5].

3.2 Surface reconstruction

The adjusted orientation data were used for the derivation of a digital terrain model (DTM). We selected 10 images near Closest Approach (CA), taken with the filter combination F22 (orange filter). The images range from 59 to 73 m/pixel in resolution and from 50° to 115° in sun phase angle. Each of the selected stereo images was used as a master image with the other images as stereo partners. Again, multi-image area-based matching [6] was applied in order to derive image coordinates of 12 million homologue points. We combined the derived set of image coordinates for the matched points with the geometric calibration and adjusted orientation data in order to compute 3D object (surface) points by means of forward ray intersection. As the result, we obtained several sets of Lutetia body-fixed Cartesian object point coordinates and a measure for the achieved relative accuracy, indicated by the 1 σ RMS of the 3D forward ray intersection, i.e. +/- 40 m. This level of precision reflects the sub-pixel accuracy of the photogrammetric block adjustment. Object points from all stereo models were merged to one common set of 3D points and interpolated to the final map-projected 60 m raster DTM.

3.3 Orthoimage generation

Precise image co-registration to the pixel-level is a pre-requisite for a variety of investigations (e.g. for photometric or spectrometric analyses). Based upon the DTM, we were finally able to rectify all images to the map geometry of the DTM.

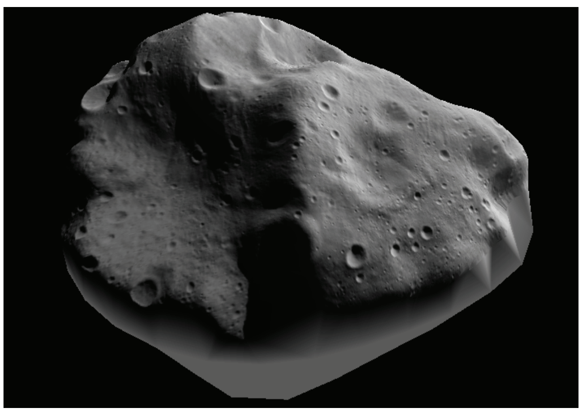

Figure 1: 3D view of the DTM and orthoimage data.

4. Conclusion

Using stereo-photogrammetric adjustment techniques we could estimate corrections for the ephemeris of Lutetia and derived improved orientation data from OSIRIS NAC images taken at Rosetta's flyby in July 2010. Based upon the adjusted orientation a high-resolution DTM of almost the entire Northern hemisphere of Lutetia has been calculated. We used this DTM for precise ortho-rectification of multi-spectral OSIRIS NAC images. These map-products (DTM and multi-spectral orthoimage data) constitute important tools for a variety of geological studies and will provide new insights into Lutetia's surface morphology and conduce to detailed spectrometric and photometric investigations.

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References

[1] Giese, B., Neukum, G., Roatsch, T., Denk, T., Porco, C.: Topographic modeling of Phoebe using Cassini images, Planetary and Space Science 54, 1156–1166, 2006.

[2] Gwinner, K., Scholten, F. Preusker, F., Elgner, S., Roatsch, T., Spiegel, M., Schmidt, R., Oberst, J., Jaumann, R. Heipke, C.: Topography of Mars from global mapping by HRSC high-resolution digital terrain models and orthoimages: characteristics and performance. Earth Planet. Sci. Lett. 294, 506–519, 2010.

[3] Preusker, F., Oberst, J., Head, J. W., Watters, T. R., Robinson, M. S., Zuber, M. T., Solomon, S.C.: Stereo Topographic Models of Mercury after three MESSENGER Flybys, Planetary and Space Science, reviewed, 2011.

[4] Preusker, F., Scholten ,F., Knollenberg, J., Kührt, E., Matz, K.-D., Mottola, S., Roatsch, T., Thomas N.: The Northern hemisphere of asteroid (21) Lutetia – Topography and orthoimages from Rosetta OSIRIS NAC image data, Planetary and Space Science, submitted, 2011.

[5] Scholten, F., Oberst, J., Matz, K.-D., Roatsch, T., Wählisch, M., Robinson, M.S. and the LROC Team: GLD100 – The Global Lunar 100 Meter Raster DTM From LROC WAC Stereo Models, LPSC 2011, #2046, 2011.

[6] Wewel, F: Determination of conjugate points of stereoscopic three line scanner data of Mars 96 mission, Int. Arch. of Photogr. & Remote Sensing, XXXI (B3), 936-939, 1996.