Joint Meeting

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Lunar Data Workshop

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International Society for Photogrammetry and Remote Sensing (**ISPRS)**

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Advances in Planetary Mapping and Spatial Databases

Moscow State University of Geodesy and Cartography (MIIGAiK),

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Abstracts

Fusion and Interactive Rendering of 3D Vision Products in Various Scales for the Characterization of Planetary Surfaces

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Imaging of planetary surfaces has been performed for more than 4 decades, both from orbit and by camera devices mounted on planetary probes such as rovers and landers. The set of images collected so far starts on full-planet level and continues with image data collected during descent and landing. Rover and lander imagery contains further scales from panoramic stereo sequences taken from adjacent sites down to hand-lens and even microscopy level. The FP7-SPACE project PRoViDE tries to perform a fusion of 3D and 2D imaging products in different levels of detail, exploiting these various available image data scales. The fusion result is fed into a real-time rendering tool that allows seamless interactive virtual navigation and measurements, starting with planetary level down to the highest resolution available from the close-range instruments.

The presentation will point out the major steps of current and future PRoViDE development, driven by objective stated by the Planetary scientist. The current version of the real-time rendering tool will be demonstrated using a current set of representative multi-scale data. We will jointly discuss the benefit of such a tool for landing site selection & characterization, and address the technical challenges of data fusion and representation. The discussion should lead to a common understanding of requirements to the fusion and visualization aspects to be covered throughout the remaining PRoViDE period until end of 2015, also in strong synergy with the forthcoming ExoMars 2018 Rover mission.

Geology of Phobos

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The martian moon Phobos is 26 x 22.8 x 18.2 km in size, and the major landforms on its surface are craters and grooves. On the surface of Phobos were identified ~1300 craters ≥200 m in diameter, ~70 craters ≥1 km, and ~30 craters ≥2 km; Stickney, the largest crater on Phobos, is about 9 km in diameter. Most craters are undoubtedly of impact origin although some small craters may be pits formed by drainage of regolith into subsurface fractures. The presence of the observed impact crater population implies that the upper hundreds of meters to a few kilometers of Phobos are heavily fractured. Using the available digital terrain model (DTM) of Phobos, the 23 craters larger than 2 km in diameter have been subdivided into three morphologic classes on the basis of freshness and state of degradation. This Phobos crater subpopulation has a considerably larger number of steep-sided craters compared to lunar highland craters of the same size: we interpret this as a combined effect the topographically rough background surface of Phobos as well as its very low surface gravity.

We conclude that the surface of Phobos is an arena for a complex of geologic processes. The leading role belongs to impact cratering with associated target destruction, material ejection and subsequent deposition partly with a temporary stay in near-martian space. Shaking by impacts and surface stirring by day-night temperature changes cause granular surface material to move down along-slope carried by very low, but nevertheless efficient, surface gravity. Sample return missions are crucially important for a better understanding of the geological processes operating on Phobos. In addition to Phobos material, a returned sample will probably contain pieces of material of Mars.

The Phobos Information System

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We have developed a Geo-information system (GIS) for Phobos, based on data from the Mars Express and Viking Orbiter missions, which includes orthoimages, global maps, terrain- and gravity field models, all referenced to the Phobos coordinate system. The data are conveniently stored in the ArcGIS software system, which provides an environment for mapping and which allows us to carry out joint data analysis and miscellaneous data cross-comparisons. We have compiled catalogs of Phobos craters using manual and automated techniques, which includes about 5500 and 6400 craters correspondingly. While crater numbers are biased by available image data resolution and illumination, we estimate that our catalog of manually detected craters contains all Phobos craters >250 m which is a total of 1072 and catalog of automated detected craters are complete for craters >400 m (360 craters). Statistical analysis of these large craters reveals a surplus of craters on the anti-Mars hemisphere, whereas differences in crater abundance between leading and trailing hemisphere cannot be confirmed. Using terrain model information, we estimate the depths of 70 craters larger than 1 km.

We also have compiled catalogs of lineaments, and boulders. In particular, we mapped 546 individual grooves or crater chains, which extend in length from 0.3-16.2 km. We identified and determined the sizes and locations of 1379 boulders near crater Stickney. Cross-comparisons of gravity field models against distribution patterns of grooves and boulders are currently under way and may shed light on their possible origins. Finally, we have developed a Geo-portal, which allows the science community to conveniently search for, analyze, and download data of interest from our system. Additionally we provide access to color electronic maps (e-maps) with support for layers based on Phobos geodatabase and ArcGIS tools.

Cartography Support for Luna-Glob – a Future Russian Mission to the Moon

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Introduction: The goal of this work is to provide cartographical support for characterization of potential landing sites of Russian space missions Luna Glob and Luna Resource. Here we present results of the analysis carried out for the sub-polar surface. It allows detect different hazards for the landing modules of spacecrafts.

Resources and products:

For mapping we used various DTMs and images with different resolutions. GLD-100 (Scholten et al., 2012) was used for characterization surface in global scale DTM; LOLA DEM (Neumann, 2010) was used for images orthorectification. We have rectificated a big count of the images automatically. After that it was used for digitizing craters and boulders on the potential landing sites areas. All craters were included in electronic catalogue that created as geodatabase and contains coordinates and other parameters of craters. Using data from this catalogue could be prepared map of spatial density of craters. Based on height values from LOLA DTM were created derivative products such as map of slopes and map of roughness (Karachevtseva et al., 2012).

All of data and mapping products are loaded in the GIS-project, which allows operatively get the spatial information about surface objects and characteristics for the whole sub-polar area, including the candidates landing sites on the various scales.

Alignment-Calibration and Processing of HIRISE CCD Data

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The HiRISE camera on board the Mars Reconnaissance Orbiter features a complex sensor plane. The plane has 14 individual CCD detector arrays, equipped with different filters. 2 CCDs carry near infrared-, 2 CCDs carry blue-green- and 10 CCDs have red filters. All CCDs have a the same size equal 2048 x 128 pixels. The sensor array is operated in the push broom mode. All together full size images for the red channel have a width of 20264 pixels, other channels an image width of 4048 pixels. For producing full red channel image, however, we have to adjust for misalignments between the CCDs, not accounted for in the nominal calibration data files. For example, this offset is near ±10 pixels for the red channel dataset. For solving misalignments we use automatic sub-pixel correlation. This software uses full EDR dataset (obtained from NASA PDS Imaging Node) and SPICE kernels for nominal calibration data.

Change Detection on the Moon: Looking for Blue Flash Events from the 1960s to the Present-Day

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Digital image mosaics at 100m/pixel of the Moon from Lunar Orbiter (1960s), CLEMENTINE (1990s) and LROC (2010s) have all been co-registered manually using affine transformations. Only the LROC mosaic is properly orthorectified so there will be terrain-induced distortions in some places in the other 2 datasets. Using the LROC-WAC DTM generated in Berlin a hill-shading correction was applied to each mosaic using the closest solar angle range available as LROC images are acquired at different solar angles. The "blue flash" database kept at NASA-JSC was then employed to search for new cratering events which could be detected at 100m and the results of this search will be shown. Plans for future data mining of change detection will be described along with the overall strategy to employ crowd-sourced measurements from MoonZoo.

Results from New Recent Photogrammetric Analysis of Ganymede Images

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Introduction: While Ganymede has been observed frequently by spacecraft, including Pioneer, Voyager, Galileo, Cassini, and New Horizons, only data from Galileo and the two Voyager`s are useful for precise map-ping. We have recomputed the Ganymede control point network to support spacecraft navigation and coordi-nate knowledge in future proposed Ganymede lander missions. We benefit from new orbital models for the Galileo spacecraft, currently available. Our network is currently based on 102 images (Voyager: 94; Galileo 8) and has and 420 control points. Based on the control net, we have produced regional and global image mosaics and maps. Coverage for Ganymede is nearly complete except for polar areas (which includes multispectral data). However, large differences exist in data resolutions (minimum global resolution: 30 km/pixel). Only few selected areas enjoy coverage by highest resolution images. Results of our preliminary study will be reported at the meeting. In future we expect to increase the accuracy of our control point network and map using updated pointing information for Galileo instrument (B. Semenov, JPL, pers. communication). Based on the new control point network we suggest to obtain Digital Elevation Models (DEMs) [2] from stereo images for selected areas, new estimations for the figure parameters of the satellite, as well as measurements of Ganymede`s rotational axis orientation and librations. Our map will also be an important tool for studies of surface geology and morphology. We will also extend our work to include the outermost Galilean satellite Callisto.

References: [1] Nadezhdina I., Zubarev A., Zharov A., Zharov O., Nikitina A., Rubtsova N (2012) Creating of new global control point networks of Io and Enceladus; [2] Nadezhdina I., Patraty V., Shishkina L., Zubarev A., Zhukov D., Karachevtseva I., Oberst J. (2012) Global shape estimates and GIS cartography of Io and Enceladus using new control point network.

Cartographical Aspects of Martian Moons Modeling

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Phobos orbits round about 9378 km from the center of Mars and Deimos – 23500 from the center of the planet. These celestial bodies have irregular shape and there are different ways to model their form and surface. Hypsometrical maps and three dimensional models are one of the most significant components of Solar System thematic cartography and result from digital terrain models (DTM) processing. They give possibilities to investigate different relief features, to develop space missions including landing on celestial bodies, and to find out space object origin and geology. It is important in popularization of space science and can be used in educational work.

We have created hypsometric map and 3D-models of the Martian satellites. The map of Phobos and Deimos hemispheres was compiled in orthographic projection at a scale 1:60 000. 3D-models of Martian satellites were created by extrusion the three-dimensional body from the sphere of a fixed radius according to elevation values from DEM. The special color height scale with the equal interval of 500 m was designed with respect to the real colors of the satellites' surface. Suggested techniques of mapping and modeling could be applied for any celestial body with irregular shape for that we have DEM with a determined precision.

Planning Deimos Observations with Simulations of Various Quasi-Stationary Orbits

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The Solar system hosts large numbers of small planetary satellites of great interest to scientists. However exploration of such bodies requires complex mission scenarios because the satellites typically move close to the primary and their own gravity fields are too faint to support Kepler-type orbits for the spacecraft. To address this problem we consider quasi-orbits, in which the spacecraft moves in an orbit very similar to that of the satellite, but at slightly different eccentricity and inclination. From the satellite, the spacecraft appears like being in orbital motion. This type of mission scenario is studied for a spacecraft moving near the Martian satellite Deimos.

We study the dynamics and life times of Deimos' quasi-orbits, and we investigate illuminating and observing conditions for mapping and line-of-sight conditions with Earth ground-stations for communication. Our preliminary results show that conditions for surface illumination and ground contact may be complex and require careful mission planning.

Implementation of an ISIS Compatible Image Matching Tool for 3D Stereo Reconstruction

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The department for Planetary Geodesy at TU Berlin is developing routines for photogrammetric processing of planetary image data to derive 3D representations of planetary surfaces. The ISIS software, developed by USGS, Flagstaff, was chosen as the primary processing platform since it is open source, very well documented and widely used within the planetary science community. However, ISIS does not provide a full photogrammetric stereo processing chain. Several components like image matching, bundle block adjustment (until recently) or digital terrain model (DTM) interpolation from 3D object points are missing. Hence, our group aims to complete this photogrammetric stereo processing chain by implementing the missing components, taking advantage of already existing ISIS classes and functionality. With this abstract we would like to report on the development of a new matching software that is optimized for both orbital and close-ranged planetary images and compatible with ISIS formats and routines.

The matching software is a C++ application with multi-threading support. The input images do not need be rectified beforehand. Internally, the matcher detects the geometrical differences and minimize them with a grid-based feature matching approach. The transformation parameters are calculated for the whole image or smaller sized grids with the help of SURF features. The matching is applied to the transformed grids based on the area-based matching algorithms like normalized cross-correlation (NCC) and least-squares matching (LSM). NCC delivers an approximate value of disparity. LSM refines the result to sub-pixel accuracy.