NEW TECHNOLOGY OF LUNOKHOD'S PANORAMAS IMAGE PROCESSING FOR DETAIL MAPPING AND ANALYSIS OF LUNAR SURFACE

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Introduction:

PRoViDE (Planetary Robotics Vision Data Exploitation) is a project which aims to assemble a major portion of the imaging data gathered from different vehicles and probes on planetary surfaces into a unique database, bringing them into a spatial context and providing access to a complete set of 3D vision products (http://www.provide-space.eu/).

There were several successful Soviet Lunar missions carried out in 1960-70s. MIIGAiK received archive panoramas from State Archive of Russian Federation for research including panoramic images from 5 such missions: Luna 9, 13, 17, 20, 21. Three of them (Luna 9, 13 and 20) were static ones. During these missions only a few panoramas were taken from the point where the modules landed. The other two missions (Luna 17, 21) had rovers – Lunokhod-1 and Lunokhod-2, respectively. They have taken more panoramas which can be useful for geomorphologic and other analyses of different types of lunar surface. Some of them can be precisely pinpointed on LROC NAC images and photogrammetrically processed to obtain a stereo model.

Algorithm:

Data were provided to MIIGAiK by the Russian State Archive in the form of scanned fragments (originally panoramas represented one image) and some description for them. To load the fragments to the database metadata for each fragment is essential. So we have looked through all the fragments and other data we have about the missions and determined parameters for description (camera type, quality, date of surveying, coordinates of the observation points, sun coordinates, etc.).

Then we have developed an algorithm for assembling panoramic images, reconstruction of unknown exterior orientation, and further processing of panoramas that allowed us to obtain a stereo model:

1. Assembling of a panorama from fragments (Fig. A) and resampling it to a real size (scanned panoramas have the size 5 times larger than the real ones).

2. Creation of an LRO orthoimage for the region where the panorama was taken.

3. Orthorectifying of the assembled panorama and determination of exterior orientation (the azimuth, zenith and coordinates of the Lunokhod location) by means of fitting the panorama to an LRO orthoimage iteratively.

4. Re-projecting of the fitted panorama to the central projection to be used for photogrammetric purposes (Fig. B).

5. If there is a stereo-pair for the panoramic image we can obtain a stereo model (tie-points measurements, bundle-block adjustments).

6. Creation of an orthoimage using the stereo model obtained in the previous stage.

All steps but the sixth have been already implemented. Creation of an orthoimage using the stereo model is in progress.

Difficulties:

- As panoramas were obtained by means of the scanning mirror that made oscillatory and rotating motion a panoramic image represents a part of sphere (spherical projection). It is a non-standard model for usual software.

- The processing of panoramas is complicated by lack of some camera parameters and their calibration (principal point and distortion, other parameters are not defined precisely), exterior orientation, parameters of digitizing. Besides that there are some distortions caused by non-uniformity in the rotation of the scanning mirror.

- Unfortunately there is no a publication source describing camera parameters mounted on Lunokhod-2 and we have to use the same parameters as for Lunokhod-1. It is known that cameras for Lunokhod-2 mission were improved but general parameters used for panoramas processing were not modified.

Summary and Results:

To conclude, we have panoramas from five Soviet Lunar missions. In general for all missions we have about 1800 fragments what equals about 340 panoramas. Most of

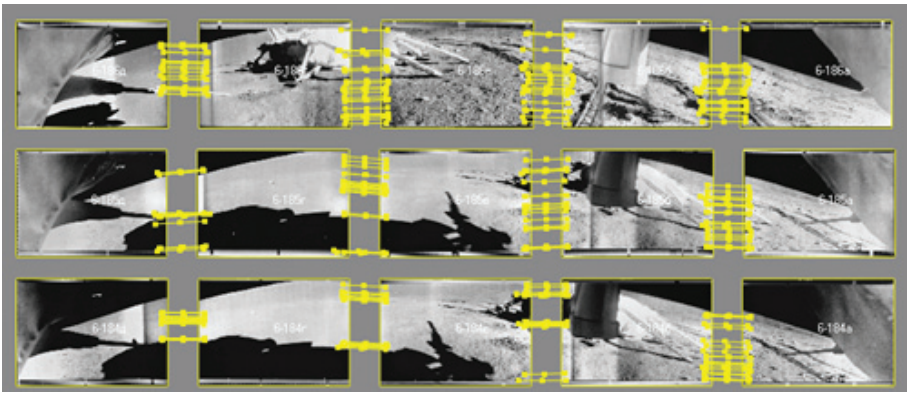

fig. A. Assembling of the panoramic images from fragments using PHOTOMOD software

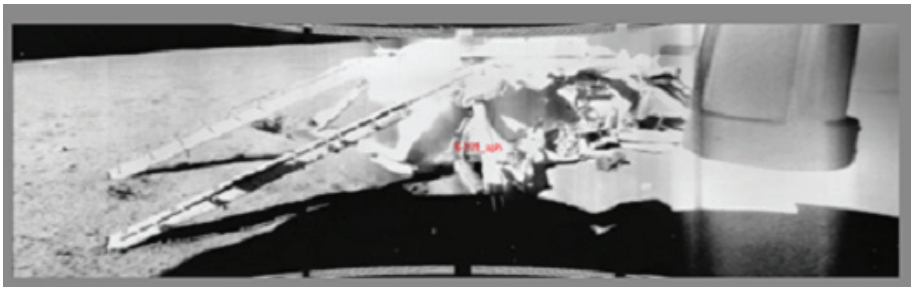

fig. B. Example of a panoramic image in central projection

them (240 panoramas) were taken by Lunokhod-1. We have already created metadata for all of the image fragments, and we uploaded these data for Luna-17 mission into MIIGAiK Geoportal. But these data will be supplemented and refined as the images are processed further. We have developed a unique technology of reconstruction of lost exterior orientation of lunar panoramic images taken during soviet missions Luna which has been implemented using Luna-17 panoramic images. As a result we have determined and improved exterior orientation of panoramas depicting the Luna-17 module and derived a preliminary terrain model to be improved further. The following products are supposed as results of the study:

- assembled panoramas in spherical projection;
- assembled panoramas in central projection (can be used for photogrammetric purposes);
- orthorectified panoramas (Fig. C);
- stereo models or digital terrain models obtained using stereo panoramas.

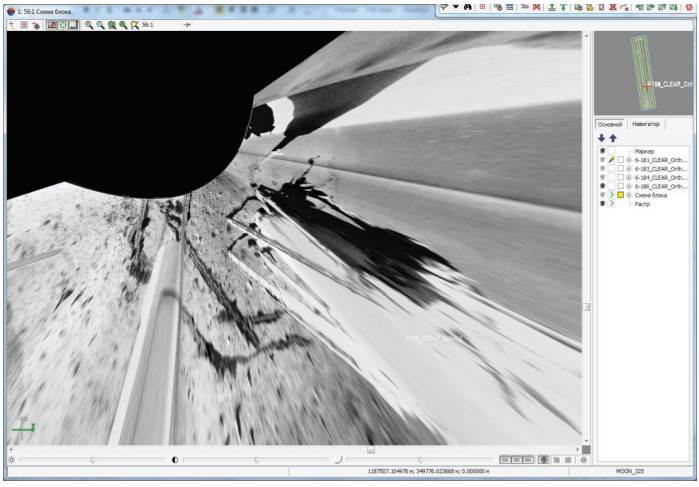

fig. C. Example of orthorectified panorama with a part of module Luna-17 and Lunokhod's track.

Our results will be used for new mapping of lunar surface at high level of detail and geology assessment including morphological analysis of micro-relief and rocks composing it.

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