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ANALYSIS OF THE UNIFIED DIGITAL DATABASE OF OBSERVATIONS OF MODERN SATELLITE LUNAR MISSIONS

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Introduction

The aim of this work is to analyze the unified digital database of optical observations obtained during the satellite lunar missions. A transformation method was created for the coordinate systems, mega-relief and gravitational field of the Moon [1]. The analysis of the possibility of coordinate binding of the near-Moon spacecraft to the reference system using the coordinate positions of the objects of the reference catalogue is performed [2].

Methods

The developed transformation method assumes the presence of a basic selenocentric catalogue of coordinates of supporting objects of the visible side of the Moon (DSC) and catalogues of objects of the libration zone and the far side of the Moon, as well as systems created on the basis of space missions [3]. The creation of a single coordinate system with a center coinciding with the center of mass of the Moon and axes coinciding with the main axes of inertia of the Moon includes the following steps: investigation of systematic and random errors of the used selenodetic systems; transformation of various selenodetic data associated with the corresponding reference systems to the dynamic one, for which we used the dynamic DSC system [4]. A study was made of the LRO system to determine the shift of the geometric center of the Moon (GCM) relative to its center of mass (CMM), which was calculated through the first-order harmonic coefficients [5, 6]. Based on the method described above, the coordinate parameters of the megarelief and the gravitational field are transformed, and as a result, new coordinate positions for 247 000 lunar craters are determined [7].

Results: During the implementation of the project, the following main results were obtained. A unified digital database of observations of satellite missions “Apollo” [8], “Clementine” [9], “KAGUYA” [10], “LRO” [11] and “SMART-1” was built. A scientific and technical analysis of modern space missions was performed to study the topography of the Moon and the existing databases of space optical observations of the lunar surface. Three approaches were developed: 1) Simultaneous scanning of the lunar surface with the exact determination of the coordinates of the point of the laser beam and binding of the spacecraft to the stars, which is technically difficult, as the coordinates of the "incidence" of the laser beam on the lunar surface are almost impossible to determine; 2) Using a system of moonlight LED beacons [12]; 3) Navigation referencing to the electronic selenocentric network based on photogrammetric methods [13].

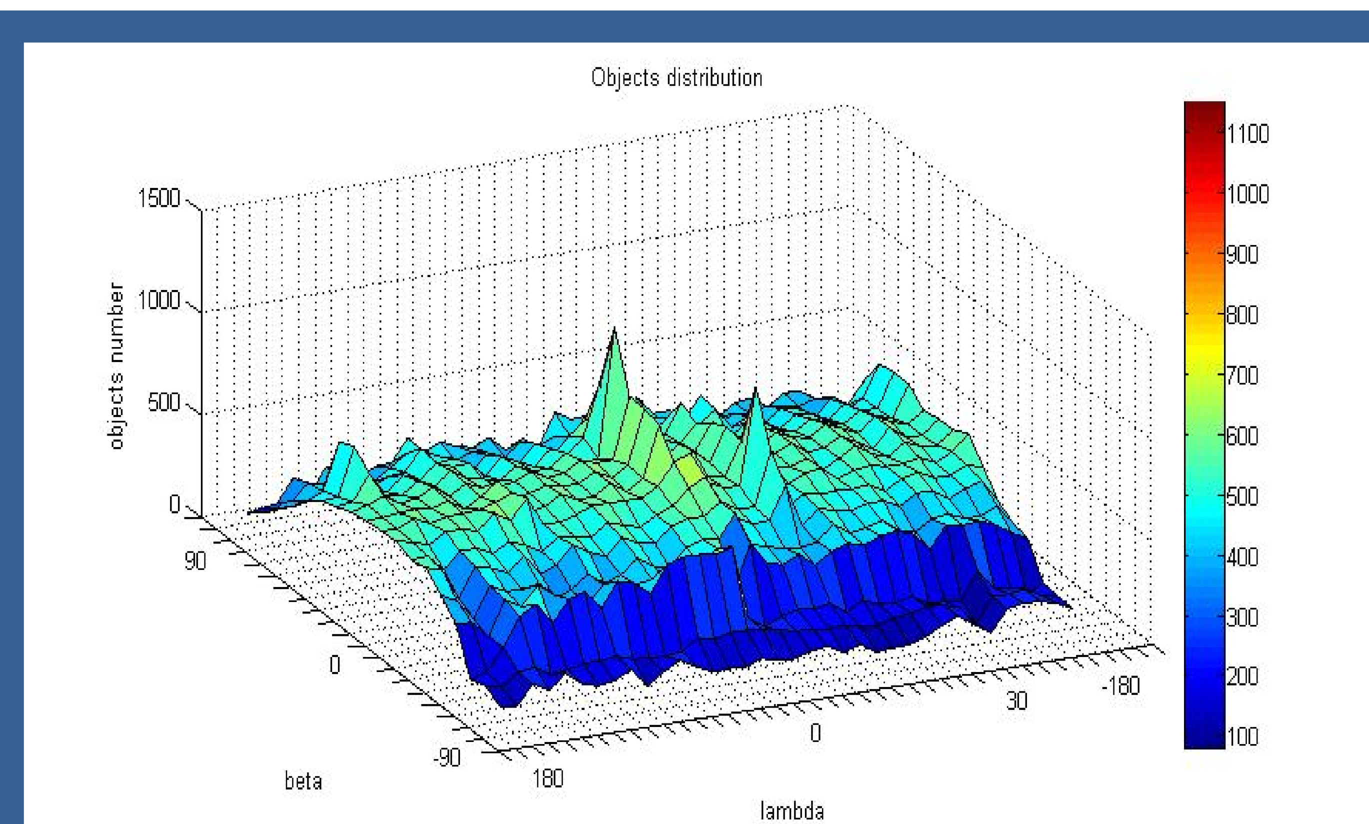

Fig. 1 Distribution of selenocentric objects in the form of a 3D model. Selenographic latitudes in degrees are plotted along the beta axis, and longitude in degrees along the lambda axis. The vertical axis and color chart represent the number of objects.

Conclusion

The selenocentric coordinates of 247 000 lunar craters (more or less evenly covering the entire lunar sphere) were determined based on modern satellite observations (data from Apollo, Clementine, Kaguya, LRO space missions used) Fig. 1. The results obtained in the Project can find their application in the creation of intelligent transport systems in outer space both within the Earth and in near-Moon orbit [14]. A method and a system for its practical use for navigation support of promising space missions to the Moon in terms of photogrammetric referencing of the spacecraft to the simulated navigation system of cartographic support were developed [15]. As a result, this method was verified in simulated lunar in-situ and on-board observations [16]. In addition, the results will be applied in joint projects of space programs on the exploration of the Moon.

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