CONSTRUCTION OF A SYSTEM OF SELENOCENTRIC COORDINATES BASED ON THE RESULTS OF THE LUNAR SPACE MISSIONS "APOLLO", "ZOND", "CLEMENTINE", "KAGUYA", "LRO", AND "GRAIL"

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Introduction: The digital base of selenocentric coordinates is the basis of the lunar navigation system [1]. Currently, the lunar landing ellipse is 9×13 km [2]. Thus, the task of reducing the lunar landing ellipse down to meter is modern and relevant. The use of quantum optical systems for referencing a spacecraft to the selenocentric coordinate system will allow achieving such results [1]. At the same time, it is necessary to use other developments in the field of selenography and analysis of non-atmospheric celestial bodies [3–5].

Methods: In this work, the development of a methodology and software for determining statistical indicators [6] designed for studying the dynamic states of the lunar selenocenter [7, 8] was carried out. This technique was tested for remote sensing of the Moon in order to create a navigation coordinate system using light laser beacons (LLBs) as accurate navigation landmarks. The developed methods can also be used to analyze the physical surfaces of other atmosphereless celestial bodies [9].

Results: The dynamic reference system was constructed based on the results of the lunar space missions "Apollo", "Zond", "Clementine", "Kaguya", "LRO", "GRAIL". A technique for constructing a digital model of the selenocenter based on the author's approach was created. To simulate the position of the selenocenter, the approaches of adaptive modeling of dynamic regression were used to improve the accuracy of the model and its predictive behavior. In this case, regular effects were taken into account for a reliable estimate of the desired parameters. A software package "Automated system for dynamic regression adaptive modeling" (ASDRAM) was developed. Using ASDRAM, one can optimize the structure of the regression model, predict its behavior, determine the stability of polyharmonic series (PHS), analyze the presence and absence of significant PHS harmonic components, and evaluate the correlation between them (perform cross-spectrum analysis). The program was tested in the analysis of the dynamics of the Earth's pole using regression modeling methods. The development of the method and modeling of its practical application for remote sensing of the Moon were carried out in order to create a navigation coordinate system using LLBs as accurate navigation landmarks. For this purpose we: 1) analyzed the technical structure of LLBs; 2) developed a method for referencing satellite images produced by remote sensing to LLBs, and considered the conditions for its application when creating a model of a highly accurate navigation reference system using an interconnected spacecraft (SC)–LLBs system; 3) assessed the accuracy of measuring the location of the LLBs depending on the height of the SC orbit; 4) performed a comparative analysis of the produced results and obtained parameters for the practical application of the proposed method.

Conclusions: As a result of this study, for the first time a method was developed and modeling of satellite images referencing to LLBs was carried out. The use of LLB must improve the accuracy of determining the position of the considered objects on the lunar surface. In this case, it is assumed that LLBs are point objects accurately referenced to the Moon's coordinate system. The development of methods for analyzing the structure of the surface of non-atmospheric celestial bodies was carried out. The obtained results can be used when performing planetary chemical studies of the Moon [10] and analyzing its dynamic characteristics [11, 12].

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