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The union selenocentric reference system

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Abstract

In this report the task of the making selenocentric inertial reference net is solved. The purpose is making summary reference net by expansion Kazan selenodetic system [4] using cosmic and ground selenodesic catalogues. The prospective analysis of this net was performed. These selenocentric reference catalogue covers full visible and a part of far lunar sides.

1. Introduction

Modern cosmic technologies need the accurate coordinate – temporal support including reference frame realization, inertial and dynamic system orientation and studying dynamic and geometry celestial bodies. That refers to dynamic and geometric selenocentric lunar parameters.

The catalogue based on mission "Apollo" and reference nets of the west lunar hemisphere made by missions "Zond 5", "Zond 8" cover small part of the Moon surface [1]. Three ALSEP stations were used to transform "Apollo" topographic coordinates. Transformation mean-square errors are less than 80 meters and measurement's errors are about 60 meters. On this account positions inaccuracy near and between ALSEP stations are less 150 meters. The offset from place of the location ALSEP enlarges the supposed mistake is more than 300 m and this is a major part of the lunar surface [2]. For the visible side of the Moon there are several coordinate systems and among them the most informative is Kazan catalogue which was built at the Engelhardt Astronomical Observatory (EAO) [4], and catalogue of 264 craters based on the same observations. We should notice 4900 craters system was built by Gavrilov et al. in Golosiyivska Observatory of Kiev. In contrast to Kazan built in a dynamic coordinate system, Kiev catalogue obtained in a quasidynamic coordinate system.

It should be noted although the Moon is investigated by space orbiter currently ground-based observations are still relevant and so the best way of selenodesic studies should be considered a reasonable combination of space and ground methods of lunar observations. Ground and space astrometry both are required because they complement each other.

Having a base selenocentric coordinate catalogue of reference objects on the visible side of the Moon Kazan and series ones of a libration zone and the far side of the Moon including heterogeneous systems the construction of Unified Coordinate Reference System in the dynamic coordinate system (the center and the axes coordinate this system coinciding with the center of mass of the Moon and the principal axes of inertia) includes the following steps:

-investigation of systematic and random errors in the Kazan catalogue;

-thickening and expansion of the Kazan catalogue both on the visible and the far sides of the Moon and libration zone too.

2. Description of the software package "Transformation selenodesic coordinates" (TSC)

The software package is designed in SharpDevelop 3.2 in C # using modern programming techniques under OS Windows such as the PLO, NET and Windows Forms. The architecture of the program can be divided into two independent parts: the core and the GUI. In accordance with an object-oriented programming paradigm (OOP) the core contains classes that implement the basic functionality and graphical frontend responds for the interaction with the user. This architecture simplifies the interaction with other software complexes, for example, the kernel can be moved to other projects.

Graphical frontend is based on using API Windows Forms. The frontend interacts with the user and eliminates a lot of errors associated with incorrect user actions. Below is a brief description of the modules that makes up the core.

Primary data processing modules. Preparation of data for solving the basic problem is provided by three modules with assignments: transferring spherical coordinates to rectangular objects, transferring objects in rectangular coordinates to spherical, the search for common objects in a rectangular coordinate system.

The modules formation of of deterministic models. With these modules we can determine the matrix orientation elements and displacement vectors of the centers of the coordinate system for the model (1)

$$\mathbf{X} = \mathbf{AY} + \mathbf{X}_0 \quad (1)$$

with the orthogonality conditions (2)

$$\mathbf{ATA} = \mathbf{E}, \mathbf{det}\,\mathbf{A} = \mathbf{1} \, (2)$$

analytical [5], numerical [6] and parametric methods.

TC module was designed to transform the rectangular coordinates of the $\mathbf{Y}$ in the $\mathbf{X}$ transition matrix for A and displacement vector $\mathbf{X}_0$.

3. The method of making selenocentric system

In solving the problem of high-precision condensation and expansion of fundamental selenocentric net Kazan on the visible side of the Moon and lunar far side were obtained following new results:

a) the analysis and investigation of the accuracy of basic net contained in ULCN were carried out;

b) the decryption of common objects for coordinate systems which are being explored was executed;

c) the extension of the mathematical content package TSC was carried out [5,6];

d) the development of TSC as an expert system of universal transformation planet-desic coordinates was executed;

e) the possibility of applying the ARM-approach to the problem TC on common objects, which allows to find optimal parameter estimation and model structure of TC was confirmed;

f) the method of structural-parametric identification of the adequate model of the TC, based on ARM-approach, in terms of interpolation (concentration) and extrapolation (extending) selenocentric net was developed.

g) TSC software allowing in an automated way of identifying common objects to obtain the coordinates of the objects considered directory in the system Kazan as in the orthogonal transition matrix for the deterministic models was developed;

d) the union catalog in the Kazan which gives a view of the discrepancies between the coordinates for the original and reduced versions of catalogs for different models was obtained.

4. Summary and Conclusions

The union selenocentric reference system was published: http://libweb.ksu.ru/ebooks/06-IPh/06_dc000002.pdf

The solutions carried out in this work allows us to make fundamental global coordinate system on the Moon which will serve as the basis for the mass of the homogeneous expansion by photographic materials from the spacecraft during steady-state study and practical exploration of the Moon.

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