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Making selenocentric reference coordinates net in the dynamic system

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Abstract

In this work the task of the making selenocentric inertial reference net is solved. The purpose is making summary reference net by expansion KSC-1162 selenodetic system using 12 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. 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. Methods and Analysis results

The reference selenodetic net KSC-1162 was made in the dynamic coordinate system. Analysis KSC-1162 catalogue shows it corresponds to an essential requirements. It has enough reference points to cover main areas of the lunar visible side. Reference points accuracy for plan coordinates is ± 40 meters and it is ± 80 in height.
The purposes of investigation are increasing concentration accuracy and expansion of selenodetic control system based on optimal coordinate transformations.
At present the best method of the expansion selenodetic reference net wide lunar area is the use of the coordinate transformation matrix. Constituents of matrix and displacement vectors can be obtained by transform available general points in KSC-1162 and transformable in its system catalogues.
On expansion the KSC-1162 (system X) there is the major problem of the precision determination matrix constituents and vectors displacement origin coordinates under transformation from the coordinate system Y in another by the use of general points:

$$X = AY + X_0, \qquad (1)$$

where A is the orientation matrix, X_0 is the displacement vector of the origin of coordinates system Y relative to zero-mark of the coordinate system X. The currency of these precision solution increases under coordinate extrapolation. This is very important for lunar far side objects it’s located outside a set of reference points.
The adaptive regression modeling (ARM – approach) postulate that the coordinate transformation structure of the model (1) is unknown for each couple catalogues and it need to find from set competitive parameters. In general the equation (1) can be rewritten as regression matrix equation:

$$Y=X\beta+\varepsilon, \qquad (2)$$

were ε – error vector, vector β is first row in matrix A. Apparently the members of the vector for the simple event (2) are simultaneously estimated under structure identification.
The matrix A often mismatch conditions of the orthogonality transformation from Y in X by reason of the determination coordinate error both systems and probable multicollinearity estimations:

$$A^T A= E, \quad \det A=1. \qquad (3)$$

In this connection the equation (1) can consider as general deterministic conversion together with conditions (3). This task is solved by numerical optimization method accurate within difference of centers X and Y systems.

Program complex was made in free programming environment SharpDevelop 3.2 in program language C# with using modern software technologies for OS Windows such as OOP, .NET and Windows Forms.

Catalogue systems were converted to KSC-1162 with orientation matrix A and displacement vector X_0 for the model (1) received by a digital method and by nonmetering orthogonality conditions method. These catalalogues are ACIC, AMS, ARTHUR, Baldwin, Goloseevo-1, Goloseevo-2, MILLS-2, SCHRUTKA-1, SCHRUTKA-2, SAI [1], Kiev [2], The Unified Lunar Control Network 2005 (ULCN 2005) [3], Valeev [4].

From Table 1 and Table 2 we have shown values of the orientation constituents of matrix A, displacement vectors X_0 and outside standard errors S_Δ ($S_{\Delta x}$, $S_{\Delta y}$, $S_{\Delta z}$) calculated for 10 percent control points of the quantity general objects.

Table 1: There are couple catalogues (KSC-1162, ULCN). They have 450 general objects.

Method	Matrix A	X_0 10^{-5}	S_Δ 10^{-5}
Numerical method; Models (1), (2)	1.00000 0.00016 0.00005 -0.00016 1.00000 -0.00007 -0.00005 0.00007 1.00000	2 5 5	47 44 47
Method of least squares; Model (1)	0.99997 -0.00009 -0.00008 0.00018 0.99982 0.00046 0.00010 0.00010 0.99964	5 -24 30	53 38 82

Table 2: There are couple catalogues (KSC-1162, Kiev-4900). They have 659 general objects.

Method	Matrix A	X_0 10^{-5}	S_Δ 10^{-5}
Numerical method; Models (1), (2)	1.00000 0.00003 0.00050 -0.00003 1.00000 0.00022 -0.00050 -0.00022 1.00000	-1 3 -4	43 34 43
Method of least squares; Model (1)	0.99996 0.00009 -0.00070 0.00020 1.00000 0.00033 0.00047 0.00035 0.99953	13 -39 30	42 37 78

6. Summary and Conclusions

From analysis the Table 1 and results method of least squares can reach conclusions:

1. The KSC-1162 system is similar to ULCN in the limit general points accurate within elements displacement vector for orthogonal transformation coordinate (1) and (3);
2. The using model (1),(3) the accuracy transformation coordinate (СКО S_Δ) along earthbound coordinate ς beside model (1) test in two time better;
3. The elements vector X_0 in model (1) subject to approximation S by least square method along all coordinates is statistically nonsignificant. This makes it possible to use results numerical method for transformation coordinate.

References

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