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Digital Simulation in Space Research

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Abstract

The article explores the features of digital modeling in space research. The content of digital modeling is revealed. The difference between digital modeling in terrestrial conditions and digital modeling in space research is shown. Space research technologies refer to the technologies of spatial analysis and processing of spatial information. The basis for the processing of spatial space information is space geoinformatics. Methods of space geoinformatics serve as the basis for digital modeling. In digital modeling in space research, situational analysis is used. A feature of digital modeling in space research is a significant number of angular measurements that exceeds the number of linear measurements. The features of digital modeling are noted: the transition from a continuum to a countable set and vice versa. The definition of a digital model in space research is formulated. The digital modeling of planetary surfaces is described. The application of onomasiological modeling and semasiological modeling in space research is shown.

Keywords: space research, digital modeling, space geoinformatics, discrete transformations.

1. Introduction

Space research is aimed at obtaining knowledge (Savinych, 2016), spatial knowledge (Tsvetkov, 2015) and geoscience (Tsvetkov, 2016). Geoscience is formed when studying the Earth from space. One of the tasks of space research is to build an information picture of the world. In relation to the Earth's surface, space research is divided into two groups. The first group of research is aimed at the Earth and is engaged in the study of the Earth from space (Drinkwater, 2004), as well as parts of near-Earth space (Barmin et al., 2014). The second group of studies is directed from the Earth and explores the lunar, beyond the lunar and solar space. This group is characterized by a large number of angular measurements (Savinykh, 2021; Tsvetkov, 2021). Space research is characterized by the problem of big data (Power et al., 2021). Digital modeling in space research is also aimed at obtaining spatial knowledge.

2. Results and discussion

Space research as spatial technologies

Space research technologies are based on the processing of spatial information. They belong to the technologies of spatial analysis. Space research belongs to the class of spatial research. Ideologically, they are closer to geoinformatics than to geodesy, so their basis is space geoinformatics (Bondur, Tsvetkov, 2015a). The organization of data and models in modern space

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research is based on the methodology of data construction in geoinformatics. In space research and in space research geoinformatics modeling is more important than in terrestrial geodesy or ground geoinformatics. This is due to the fact that in space research it is difficult to carry out direct and linear measurements, which in terrestrial conditions are not difficult. Because of this, more modeling appears in space research, which is absent in terrestrial sciences. In ground conditions, modeling solves the problems of describing objects and processes, predicting processes and searching for retrospective dependencies. In space exploration, a new kind of modeling is emerging that replaces missing measurements or simulates situations due to incomplete measurements. This means the inclusion of situational geoinformation modeling (Tsvetkov, 2014a) in the process of space research. Situational modeling in real space is a geoinformation situational modeling or geoinformation modeling. There are virtually no bodies or objects in space that are independent of other objects. All objects move in a gravitational field and their movement is affected by planets and stars. It is impossible to fully take into account all interactions and influences. This leads to the third type of modeling – simplifying the motion of cosmic ones or simplifying their relative state.

Content of digital modeling

A universal type of modeling that combines other types of modeling is digital modeling (Peluso, 2004; Hengl, Evans, 2009). Digital modeling has its own peculiarities. The first formal feature of digital modeling is the discrete form of representing information or models. This feature comes from the advent of digital computers. Digital computers worked with discrete information. From this point of view, digital modeling is discrete modeling using computers. The term “digital” means discrete.

The second feature of digital modeling is the compression of information about the object. For example, a digital elevation model is formed as a finite set of three-dimensional points. But these points are enough to build a continuous surface. This feature imposes a condition on the discreteness of the model. The discreteness of the digital model should be such that it allows you to build continuous surfaces, calculate areas and volumes within the framework of the tasks and the specified accuracy of calculations. The second feature actually means the use of analog-digital conversion when collecting information.

The third feature of digital modeling is the indirect representation of information about a space object or a latent representation of the object. An example is the angular measurements of the apparent diameter of the planet (Savinykh, 2021; Tsvetkov, 2021), according to which the true diameter of the planet is restored.

The fourth feature of digital modeling is the use of digital-analog conversion when building a model of an object based on a digital model. The second and fourth features of digital modeling provide a basis for applying the methods of communication theory and information theory to describe and study digital modeling. From the standpoint of mathematics, digital modeling involves the transition from a continuum set to a countable set, and then from a counting set to a continuum set.

It is possible to define a digital model in space research. A digital model in space research is a discrete model that allows you to model measurements, contains latent information and allows you to build analog models from their discrete values.

Digital space modeling is modeling to build a digital model in space research and using a digital model to build continuous analytical surfaces.

Digital modeling of planetary surfaces

Digital modeling of planets is a type of digital space modeling. Digital modeling in space is most often aimed at describing surfaces. The exception is geostatistics (Tsvetkov, 2007, Tolosana-Delgado, Mueller, van den Boogaart, 2019), which describes the internal content of a phenomenon or state. Digital models of planets use the theory of surface modeling. It is developed in terrestrial conditions in practical and theoretical terms. Technology Digital modeling of planetary surfaces is the application of the technology of the case of modeling surfaces in terrestrial conditions. The theory of digital modeling of planetary surfaces is a special case of the theory of information modeling. Information modeling sets the main task of the information description of the object of research.

Digital models of planetary surfaces form as discrete sets of points. The theory of digital modeling of planetary surfaces is described by the theory of information modeling. Information modeling in a broad sense is interpreted as a universal method of cognition and modeling

(Maksudova, Tsvetkov, 2001; Raev, 2020). It uses the general principles of modeling. Information modeling as a method of cognition serves as the basis for the formation of a picture of the world (Tsvetkov, 2014b; Kovalenko, 2015). Information modeling as a method of generalization takes the form of metamodeling (Tsvetkov i dr., 2020; Zaitseva, 2021). In information modeling, the constructive (Shaitura, 2019) and theoretical aspect prevails.

At the first stage of digital modeling of planets, onomasiological modeling is carried out (Pavlov, 2019). It consists in the fact that they collect information about the surface of the planet in the form of point measurements and measurements of the elements of the planet's surface. Onomasiological modeling collects the elements from which models are formed. The formation of discrete models occurs in accordance with the Shannon-Nyquist-Kotelnikov reference theorem. This imposes conditions on the collection of information. Cosmic information is not collected arbitrarily, but with the condition of the subsequent construction of the object or is. This creates a dilemma: a large number of points give a complete description, but increases the information volume of information collected. A large amount of information creates difficulties for analysis and computer processing. A small number of points reduces the information volume of information collected, but may not give a complete description of the object or phenomenon. In terrestrial conditions, information about the surface is collected by direct measurements on the surface. In space conditions, information about the surface of the planet is collected remotely using photography or laser sensing.

3. Conclusion

A digital model is a discrete model containing latent information. The digital model in space research allows you to simulate measurements and form analog models. The formation of discrete models occurs in accordance with the Shannon-Nyquist-Kotelnikov reference theorem. There is a difference between digital modeling in real conditions and digital modeling in space research. Digital modeling in terrestrial conditions uses direct measurements on the ground. Digital modeling in space research uses remote and indirect methods. Digital modeling in terrestrial conditions uses linear measurements on the ground or angular measurements from different points of the basis of observation, which allow the formation of linear metric values. Digital modeling in space research uses mainly angular measurements and estimation and correction methods to obtain linear metric values. Common to both types of modeling is the onomasiological approach, which reduces the analog model to a discrete one.

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