Published in the USA
European Journal of Technology and Design
Has been issued since 2013.
E-ISSN: 2310-3450
2022. 10(1): 3-8

DOI: 10.13187/ejtd.2022.1.3
https://ejtd.cherkasgu.press

Articles

Geoinformatics as a Science of Space

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Abstract

The article explores geoinformatics taking into account its evolution. The article analyzes new tasks of geoinformatics. The article notes the trend in the development of the Earth sciences, which is the integration of different sciences in geoinformatics. The article analyzes the place of geoinformatics in geosciences and information sciences. The article explores the interaction of geoinformatics with other sciences. It is revealed that geoinformatics is a system of sciences. Geoinformatics connects two areas: information sciences; earth sciences. The construction of spatial models in geoinformatics has been studied. Geoinformatics is considered from different aspects. It is considered as a system that solves applied problems. It is considered as a system for obtaining knowledge and forming a picture of the world. The interaction of geoinformatics with different types of spaces has been studied. Geoinformatics interacts with different real spaces: outer space, ground space, near-Earth space, underground space. Geoinformatics interacts with different abstract spaces: logical space, topological space, geometric space, parametric space and cognitive space. It is shown that geoinformatics solves the problems of information processing and spatial analysis in any space. The analogy of the development of geodesy and geoinformatics is considered. Geoinformatics processes various spatial and information flows. The analysis allows us to conclude that modern geoinformatics is a science of space.

Keywords: geoinformatics, real space, abstract space, earth sciences, informatics, spatial modeling, spatial analysis, system of sciences.

1. Introduction

Currently, in the field of sciences there is a tendency to transfer ideas enriching the ideas of one science into another science. There is a concept that geodesy is the science of space (Savinykh, 2019). The evolution of geoinformatics shows that in this science there is also work with different spaces. Geoinformatics interacts with physical space. Geoinformatics uses topological space and geometric space. Geoinformatics integrates the methods and ideas of other sciences. Such integration of sciences exists in space research. It led to the emergence of space geoinformatics (Bondur, Tsvetkov, 2015) and geodetic astronomy (Gospodinov, 2018) It can be argued that geoinformatics has gone beyond earth's space. Photogrammetric information, geodetic information, cartographic information, satellite information are combined in geoinformatics into common models. Geoinformatics combines different types of information into geoinformation

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Computer science connects different sciences by methods of information processing. Geoinformatics connects sciences with spatial models and spatial relations. Geoinformatics uses different information systems. The main information system in geoinformatics is a geographic information system. Previously, the basis for processing spatial information was computer-aided design systems. They contributed to the emergence of GIS. The ideology of computer-aided design systems served as the basis for the ideology of GIS (Tsvetkov, 1998). Geoinformatics is widely related to other sciences. Therefore, it is advisable to consider its modern connections and relations with other sciences.

2. Results and discussion

Connection of geoinformatics with scientific directions

There is a concept of a system of sciences. Geoinformatics as a science is in the system of sciences. The systematic approach allows us to consider geoinformatics as a system of sciences associated with other scientific areas. These connections determine the place of geoinformatics in the system of sciences. One of the classifications of sciences is carried out by the Higher Attestation Commission of Russia. Fig.1 shows the place of geoinformatics with similar scientific areas in the system of sciences of the Higher Attestation Commission.

In Figure 1, the symbol E indicates the Earth sciences, and the symbol I denotes the information sciences. The classification of sciences in Figure 1 is chosen in accordance with the designations of the Higher Attestation Commission (HAC). It is possible to distinguish some specialties that have explicit or implicit connections with geoinformatics. These specialties have a common number (the first four digits) as the number 25.00. We will give the full names of these sciences. Specialty 25.00.35 denotes geoinformatics. Geodesy has a number of 25.00. 32. Cartography has the number 25.00.33 Specialty with the number 25.00.34 denotes aerospace studies of the Earth, photogrammetry. Specialty with number 25.00.26 denotes land management, cadastre and monitoring of land. Specialty with code 25.00.23 is physical geography and biogeography, soil geography and geochemistry of landscapes. Specialty economic, social and political geography has the code 25.00.24.

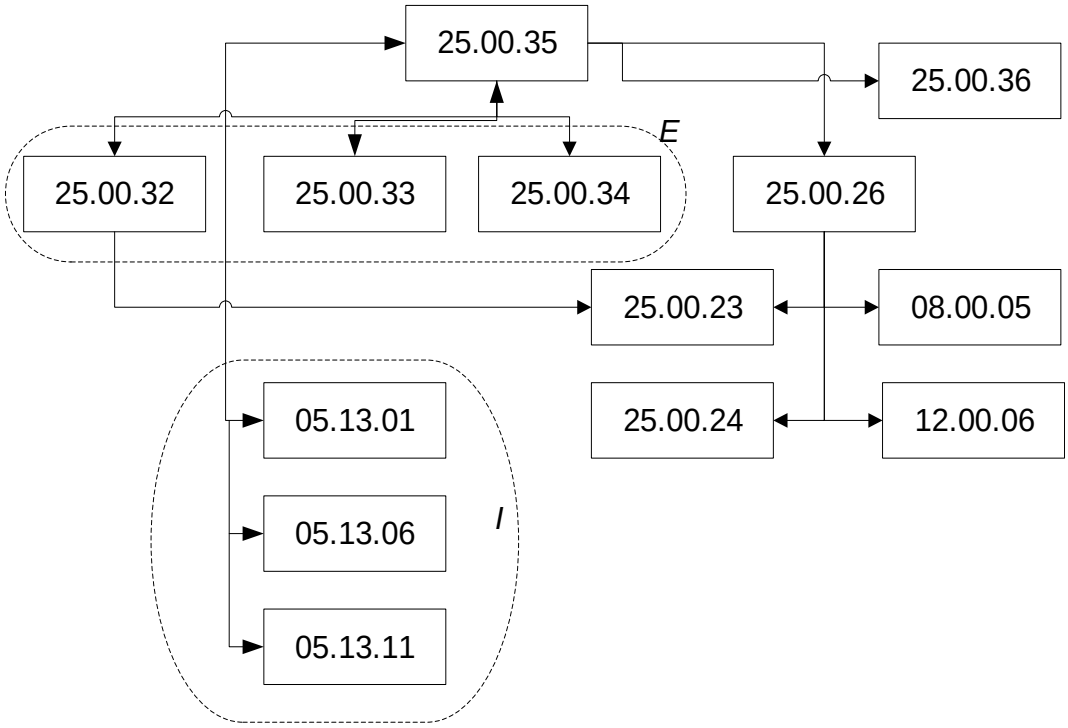

Fig. 1. Connection of geoinformatics with scientific directions

Specialties of information sciences (informatics) are allocated in a separate block. These are specialties under the general number 05.13. According to the classification of the Higher

Attestation Commission, it follows that geoinformatics and informatics are distant sciences. Figure 1 does not highlight all, but only the main or characteristic ones. The specialty with the number 05.13.01 denotes system analysis, management and information processing (by industry). In geoinformatics, system analysis and spatial analysis based on it are used. Specialty 05.13.06 – automation and control of technological processes and industries (by industry). Geoinformation systems solve automation problems, and geoinformation technologies contribute to automation. Specialty 05.13.11 – mathematical support of computers, complexes and computer networks. In geoinformatics, applied information processing programs are used. In geoinformatics, special processing programs are used in geoinformatics information using GIS. Specialty 08.00.05 – economics and management of the national economy. GIS is used as a management system. Geoinformation technologies also solve the problems of management and sustainable development of territories. De facto geoinformatics is related to geoecology, although according to the classification scheme of the Higher Attestation Commission, it is connected through aerospace studies of the earth and photogrammetry. The classification of the Higher Attestation Commission distinguishes between the Earth sciences and information sciences. Information sciences support the Earth sciences and geoinformatics. Based on the analysis, it is possible to define geoinformatics in the system of sciences. The main conclusion: geoinformatics is associated with the Earth sciences and, to a lesser extent, with the sciences of the Earth. Information. Computer science has an interdisciplinary significance. But it is an abstract science. Geoinformatics is an applied science and a science that creates new knowledge.

Geoinformatics can be defined. Geoinformatics is a science that uses methods of collecting spatial information for: information processing, integrated information analysis, obtaining new knowledge based on the use of databases, geographic information systems and computer systems.

Geoinformatics is one of the sciences that contributes to the construction of a picture of the world. The object of fundamental study of geoinformatics is various spaces: space, terrestrial, near-Earth, physical, topological, geometric, parametric.

The main principle of geoinformatics research is a systematic approach (Tsvetkov, 2018).

The object of applied research of geoinformatics are spatial processes; spatial objects; spatial phenomena, geotechnical systems, spatial relations, objects of transport infrastructure.

The main method of geoinformatics is modeling. The result of modeling in geoinformatics are: spatial models of the earth's surface and spatial objects; digital terrain models, cartographic compositions.

Additional methods of geoinformatics are: systems engineering, cognitive modeling, programming, spatial logic and system analysis.

Geoinformatics can be considered as a field of production activity. In this area, it includes the following activities:

- support for the spatial data infrastructure;
- obtaining, accumulating, processing, presenting, disseminating and using spatial information and geodata;
- provision of electronic information services to consumers of spatial and cartographic information;
- development and operation of geographic information systems and software products.

The main advantage of geoinformatics is the use of integrated technologies and integrated data. Geoinformatics allows you to process a wide range of data. Analysis shows that the term "spatial data" is mentioned in the field of geoinformatics more often than the term "geoinformation data" or "geodata" (Savinykh, Tsvetkov, 2014). This gives grounds to consider geoinformatics as a spatial science or a science of space.

Spatial information and spatial models

Spatial information in geoinformatics is stored digitally in databases. The information after processing has a visual form of presentation. Visual information is processed by interactive methods, as well as using cognitive methods. The work (Savinykh, 2016) shows that the Earth sciences create different information flows: graphic, analytical and digital. These information flows are spatial. They require the use of geoinformatics and GIS methods for processing. The use of geographic information systems requires the use of integrated models.

Geoinformatics explores dynamic processes and dynamic spatial models. For example, moving object models are both spatial and dynamic. Investigating dynamic processes requires

creating a support environment. Spatial modeling requires the use of information models and information resources (Tsvetkov, 2016a). At the same time, geoinformatics creates new information models and new information resources.

Geoinformatics uses two types of spatial modeling. The first kind of modeling is not related to geoinformation and geodata. For example, it is spatial logic. This type of modeling is related to topology and geometry.

The second type of spatial modeling uses geoinformation modeling (Tsvetkov, 1999; Bulgakov, 2013). Geoinformation modeling serves as the basis for decision support. Both types of spatial modeling use the methodology of information units (Tsvetkov, 2014).

Updating of spatial models occurs through the use of geomonitoring (Hohensinn et al., 2021).

Complex spatial modeling uses models of information situations (Tsvetkov, 2012). The information situation model describes the totality of objects connected by relationships and relationships. in which spatial objects are located.

The use of models of information situations in geoinformatics entails the use of situational modeling.

The result of spatial modeling is the acquisition of spatial knowledge (Lin at al., 2020) and geoscience (Tsvetkov, 2016b).

Computer-aided design systems in geoinformatics have created a visual processing system.

There is a difference between the application of computer science and the application of geoinformatics. Informatics is used as a tool of specialization, and geoinformatics is used as an integration tool. Informatics specializes in processing, and geoinformatics integrates methods for processing various information. Data collection in computer science is carried out by methods and means of the subject area. In informatics, data is specialized data. For example, informatics in geodesy is designed to solve problems in the field of geodesy. It does not solve problems in the field of cartography, photogrammetry. Informatics in photogrammetry solves problems in the field of photogrammetry and does not solve the problems of geodesy.

Geoinformatics solves the problems of cartography, photogrammetry, geodesy and remote sensing of the Earth. Geoinformatics data is integrated geodata (Savinykh, Tsvetkov, 2014). Geoinformatics data collection is carried out by a set of different technologies. Datageoinformaticians are used in different fields. Integrated data in geographic information systems solve problems in the field of cartography, photogrammetry, space surveying, cadastre, land monitoring, etc. That is, there is a complete opposite of informatics in geoinformatics.

Applied aspect of geoinformatics

The applied aspect of geoinformatics reflects its application for solving applied problems. Geoinformatics can be described as an applied system for solving applied problems. For example, it is used in the study of global processes. Geoinformatics is used in the study of climate change (Singh, 2020). Geoinformatics is used to overcome information barriers (Tsvetkov, 2004) and the use of geotechnical systems. Geoinformatics is used to study geodynamic processes (Gvishiani et al., 2019). Geoinformatics has specialized applications. For example, transport geoinformatics is a specialized area of geoinformatics. Geoinformatics is used to preserve cultural heritage (Xiao et al., 2018). Geoinformatics is used to study landslides (Pirasteh, Li, 2017). Geoinformatics is used to study the spatial growth of cities. Geoinformatics is used to study the quality of groundwater. Geoinformatics is used to study the level of settlement of tourists (Hardy et al., 2020). Such diversity emphasizes the belonging of geoinformatics to various spaces, including social space.

Spatial aspect of geoinformatics

The spatial aspect of geoinformatics is associated with the study of real spaces. Different types of spaces are the object of geoinformatics research. Along with geoinformatics, space is being studied by geodesy, geometry, photogrammetry, and artificial intelligence. All these sciences are united by spatial logic. Geoinformatics is closely related to geodesy, photogrammetry and geometry. Geodesy makes it possible to collect information with geodetic instruments and process it using geodetic methods. Geometry makes it possible to perform spatial modeling using abstract mathematical figures. Artificial intelligence in geoinformatics makes it possible to form spatial knowledge.

It is necessary to distinguish the language of spatial aggregation (Yip, Zhao, 1996), which describes the mutual arrangement of bodies, which is expressed in touching or adjacent to each other, the arrangement "between", "inside", "outside".

Geometry theory is based on abstractions and abstract forms. In real space, point, linear, area and volumetric bodies are distinguished. This division takes place in geoinformatics and serves as the basis for the classification, stratification and analysis of geographic information models. The ideas of geometry are developed in geoinformatics.

Methods of spatial analysis are transferred to geoinformatics. Geoinformatics solves the problems of information processing and spatial analysis in any space. This spatial information can be obtained: on the Moon, on Venus, on Mars, or on Earth. Geoinformatics processes any spatial information. There is a branch of space geoinformatics that processes space information.

These features of geoinformatics expand its concept to the concept of space science. Common in geoinformatics, geometry and geodesy is: the study of space, the study of spatial relations, the study of spatial forms, the study of the mutual arrangement of bodies.

There are differences between geoinformatics and these sciences. Geometry explores abstract spaces, geodesy explores real space, geoinformatics explores abstract and real spaces. Geodetic measurements contain errors. Information in geoinformatics also contains errors+. This poses an additional task in geodesy and geoinformatics – data processing taking into account errors. Geodesy includes Euclidean geometry as a mathematical basis. Geoinformatics includes Euclidean geometry as a mathematical basis, and also includes differential geometry and differential topology. Geoinformatics includes Riemann geometry and makes calculations based on it (Tsvetkov, 2021). Processing measurement errors is a branch of probability theory. Probability theory is included in geodesy and geoinformatics.

Geodesy can be considered as a rigorous science that is based on geometric constructions and works mainly with clear data. Data in geodesy are aggregates of the results of independent measurements or the results of equalization of measurements. Uncertainty in geodesy occurs during coordinate transformations in curvilinear coordinate systems. Uncertainty in geodesy is spatial or geometric character. Processing of measurement results is the completion of geodetic constructions.

Geoinformatics, unlike geodesy, uses spatial logic and works with situations of uncertainty. In geoinformatics, cognitive modeling is used. Geoinformatics mainly works with models and with spatial situations. Uncertainty in geoinformatics includes information uncertainty, semantic uncertainty and uncertainty of the mutual position of spatial objects, that is, it is spatial and geometric in nature. Obtaining spatial knowledge is the completion of processing in geoinformatics.

3. Conclusion

Geoinformatics explores and interacts with different real spaces: outer space, terrestrial space, near-Earth space, underground space. Geoinformatics interacts with different abstract spaces: logical, topological, geometric, parametric, cognitive. Geoinformatics uses different spatial information flows. The analysis allows us to conclude that modern geoinformatics is a science of space. It must be seen as a science of space. Geoinformatics has gone beyond the terrestrial sciences. Geoinformatics as a fundamental science is used as a method of cognition and as a method of constructing a picture of the world. Geoinformatics uses spatial constructions to obtain new knowledge. The development of geoinformatics allows us to state the following. Geoinformatics methods are applicable on the natural satellite of the Earth – the Moon and on any planet. The field of application of geoinformatics is much wider than the surface of the Earth. It is applicable on all celestial bodies, and the Earth is one of such bodies. Consequently, there is no reason to associate geoinformatics only with the Earth. The field of application of geoinformatics is a real space. Geoinformatics should be considered the science of space.

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