GEOINFORMATION MODELING AS A FUNDAMENTAL METHOD OF COGNITION

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Abstract: The article aims to analyze and disclose geoinformation modeling and its types. It describes geoinformatics as a tool for understanding the surrounding world. The differentiation of geoinformatics into general and applied is given – geoinformation approach and geoinformation analysis as scientific methods of geoinformatics. General geoinformatics is the fundamental science. Applied geoinformatics solve technological problems in the subject area. The concepts of geoinformation modeling and systematic approach to geoinformation modeling are described. The necessity of using information units as a basis for modeling is shown. Digital modeling is represented as an essential component of geoinformation modeling.

Keywords: Cognition, Digital modeling, Fundamental method, Geoinformatics, Geoinformation modeling.

1 Introduction

Geoinformatics is a relatively young science that combines geosciences and computer science. As a technological science, it has developed significantly over time and is currently distinguished in two directions: fundamental science and applied. The fundamental part is called the general geoinformatics, or fundamental geoinformatics [23]. The applied part was formed as applied geoinformatics and solves technological problems in the field of earth sciences and transport, management, and global monitoring. Fundamental geoinformatics interacts with many scientific directions. Its expertise includes set-theoretic analysis, systems analysis, topology, qualitative analysis, various types of statistical analysis, image processing theory, modeling theory, and database theory. This part of geoinformatics is integrated with areas of artificial intelligence [9].

Fundamental and applied geoinformatics explores spatial relationships and spatial knowledge. Both geoinformatics can be considered as a method of cognition of the surrounding world.

Models serve as the basis for information processing in information technologies and systems [2]. The models are widely used in applied research. Modeling creates the possibility of replacing an experiment with mathematical or information manipulations and transferring the results of modeling to the study object. It is the applied value of modeling.

The interdisciplinary significance of modeling lies in the ability to transfer knowledge [29]. Logical and systemic modeling can serve as a criterion for verifying the truth of knowledge. Technologically, modeling is associated with constructing models and creating new modeling methods for new phenomena and objects. In the course of the variety of existing and emerging models, it becomes necessary to generalize models and modeling and create models that could effectively carry out the construction of models and their analysis. One of these generalized modeling technologies is geoinformation modeling.

2 Literature Review

The transition of individual countries and all humanity to an information society means that most of the population works to produce information and information services. A significant part of the community will be a consumer of information products and services. In these conditions, the importance of working with information, information technology, and information resources is increasing. This skill can be summed up in one term, "information modeling" [28].

Currently, technologies for using spatial information are relevant for management and production [17]. A large amount of data has been accumulated as a result of the activities of various geodetic enterprises [18]. However, the large volume and lack of structuredness of the reserved spatial data set create an information barrier and sometimes impede this practical use. The way out of this situation is seen in developing technologies that increase the efficiency of using spatial data. Such technology is geoinformation modeling [27].

Considering integration as a profound process of informatization of society, we can say that informatics and geoinformatics are the basis for integrating the information society. In these conditions, geoinformation modeling becomes the key to mastering and understanding the surrounding world [36].

The ability to work with spatial information means using information resources and computing facilities with maximum efficiency. In current conditions, information resources are a set of information models. Geoinformatics is based on the integration of different sciences, and information processing in geoinformatics is based on models. Therefore, geoinformation modeling is critical in the chain of geoinformation and geodata processing.

3 Materials and Methods

Geoinformation modeling has several types: it is modeling using digital models, spatial data models, using GIS, using geodata, and geoinformation. Common to these types is the use of three integrated data groups, "place," "time," "topic."

Most of the processing methods used in information technologies are based on the concept of an information model - a specific, purposeful formalized display of the existing economic information system with the addition of certain elements that characterize the control system and the controlled object [8]. The majority of processing spatial information methods are based on the concept of a geoinformation model and geoinformation modeling.

3.1 Principles of Geoinformation Modeling

Geographic information modeling provides a formalized representation (algebraic, graphical, etc.) of the data used and their relationships. Therefore, the modern ability to work with information means the ability to carry out geoinformation modeling. Thus, geoinformation modeling can be considered as modern information technology. It includes the ability to create various information models, interpret and apply them [10].

Geoinformation model contains several levels of description: subject, associated with the field of information processing; systemic, related to methods of organization and methods of the processing; fundamental, determined by choice of basic data models, independent of the scope of the information model.

The transition from information to information resources requires a change from a set of data to a group of interrelated models, which have the property of resources. It distinguishes data models from information resource models. Thus, geoinformation modeling requires the ability to work with spatial information as with data and make a qualitative transition from information models to resource ones, from resource to intelligent ones. For this reason, we can say that geoinformation modeling is the basis for creating information resources [23].

This approach defines two concepts in teaching geoinformatics. The first is to train qualified users in the field of geographic information technologies and systems. The second is to change the methodology for applying geoinformatics. It requires a transition from reproductive to creative didactics. It means that the teaching technology based on the replication and transfer of knowledge should be replaced by the teaching technology based on creativity and the development of students' ability to create new knowledge based on the already known ones. The second teaching concept defines geoinformation modeling as a technology for manipulating information and creating new knowledge on this basis.

Geoinformation modeling is based on certain concepts: basic concepts, classification, spatial relationships, systems approach, structural analysis, building information units, choosing transformation methods. The basic concepts are the object of modeling and the method of modeling.

The modeling object can be an object of the surrounding space, an object model, a data set, a system, a process, a problem solution, a predictive estimate, etc. [4, 38]. The modeling method can also be varied. It is determined by a set of permissible conditions and rules for implementing transformations over modeling objects.

In the framework of the entity-relationship model, developed by Steve Chen, the modeling object can be viewed as an "entity," and the modeling method is a "relationship" between different modeling objects' information forms. Classification means, first of all, the definition of classes (subclasses, groups) of models and transformations over them, the definition of the properties of classes and restrictions.

The concept of relations means the definition and selection of classes of relations between objects of modeling such as: spatial, temporal, functional, logical, probabilistic, organizational, quantitative, qualitative. Relationships reflect the multidimensionality of objects and the connections between them. Individual relationships become dominant in specific subject areas. For example, in geoinformatics, spatio-temporal relations become dominant.

3.2 Geoinformatics and Philosophical Approach

Philosophy can generalize various theoretical directions, and this is included in its tasks. It is directly related to the field of information science. Geoinformatics arose as a science-based on the generalization of earth sciences and determined its capabilities in conception and brings it closer to philosophy in this part. Philosophical research helps to carry out the interdisciplinary transfer of knowledge. Geoinformatics implements a multidisciplinary transfer of knowledge [19]. It brings it closer to philosophy in this part too.

The study of the surrounding world includes:

- The study of meaning;
- The study of the process of cognition;
- The analysis of the objectivity of cognition.

It can be done using a philosophical approach. In geoinformatics, based on the study of knowledge using geoinformatics methods, the geoinformation approach and geoinformation analysis as cognition methods are characteristic only for geoinformatics.

Exploration of the surrounding world includes gaining new knowledge [32]. A generalized analysis of new knowledge can be carried out using a philosophical approach. Geoinformatics aims to acquire new knowledge. In doing so, it created new types of knowledge and the existing ones: spatial knowledge and geoscience. The development of geoscience ideas led to the emergence of a new type of expertise - cosmic knowledge.

The work notes the coexistence in real life of two worlds: scientific and every day. There is a gap between these worlds, which philosophy must overcome based on generalization and analysis. Geoinformatics, as a cognitive tool, like philosophy, provides a connection between these worlds.

Thus, geoinformatics as a cognition tool allows one to obtain new knowledge and is a very close science to philosophy in terms of generalization of spatial information and research of real space.

3.3 Geoinformatics and Informatics

Computer science is also a cognitive tool. However, despite fundamental and applied informatics, it is closer to technology than to philosophy, in comparison with geoinformatics due to the lack of a continuous relationship between these sciences. It is most clearly manifested in education. In education, geoinformatics is associated primarily with geodetic knowledge, and secondly, with informatics. Geodetic education trains specialists in geodesy, photogrammetry, cartography, remote sensing of the Earth [3], land use [1], property management, geography, and geology. It does not train computer science specialists. Conversely, computer scientists do not have a continuation in geoinformatics (Figure 1).

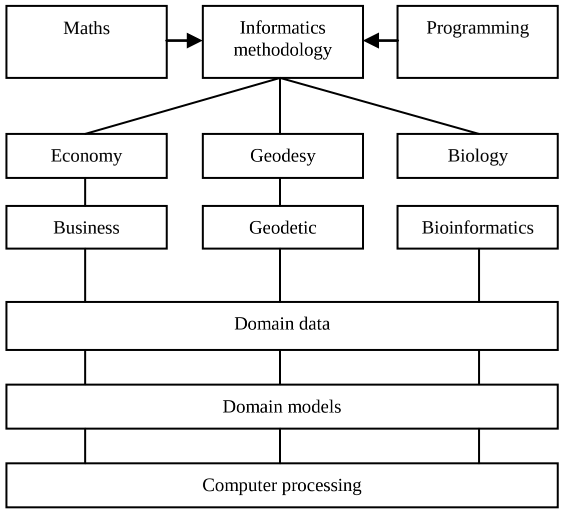

Figure 1 – Interaction of informatics and other sciences

Informatics appears twice in this scheme, at the methodological level (upper level) and the computer processing level (lower level). Each modified computer science processes its data independently. That is, there is fragmentation in processing.

For all directions, domain data is transformed into domain models. Domain models contain the specifics of this domain area [5]. But for processing, these different models are converted into generic computer models that are processed. As a result of processing, specialized data sets are obtained for each subject area.

Unlike computer science, which has two origins, geoinformatics has four sources of origin (Figure 2).

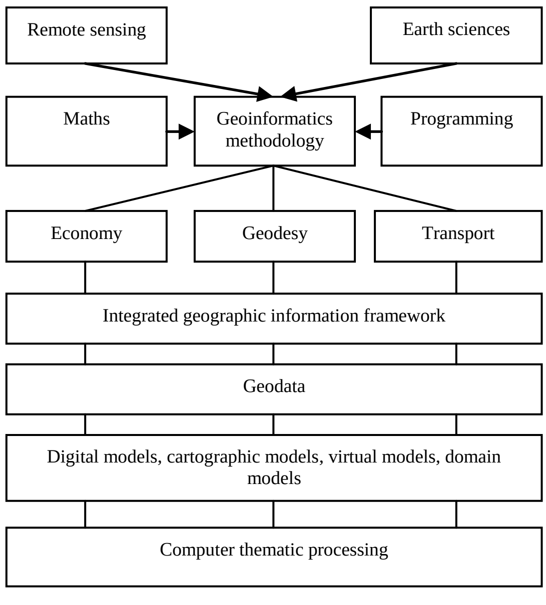

Figure 2 – Interaction of geoinformatics with other areas

The basis for the integration of geoinformatics was CAD technology as a system of integrated graphical information processing. With this technological integration, it became possible to integrate geosciences organizationally into a single system. This integrated system of earth sciences came to be called geoinformatics.

The application of geoinformatics creates complementary datasets available for exchange and complex analysis, including systems analysis. It emphasizes the systemic essence of geoinformatics at the input stage of processing and at the output level - organizing data and models.

4 Results

The systems approach requires an abstract consideration of modeling and connections objects based on the generalized use of the concept of "systems." This concept can be designated, object, process, data set, model. System analysis reveals the most common parts of the structure, connections, and relationships between the "system" elements, the concept of system elements can define all this [16]. The identified elements serve as the basis for further detailing of the "system."

Further detailing is carried out by structural analysis, which is carried out not at the level of abstractions but at the level of functions. The structural analysis allows you to represent the modeling object's structure as a set of functional blocks that transform information models [20]. Unlike systems analysis, which works with abstracted data, structural analysis works with real data. It requires the consolidation of a variety of real data and information flows into a single system. Such a unified system, called an information base, requires the selection of information units. Examples of such information units are conventional signs in cartography. The set of symbols on the map carries an information message that is understandable to a specialist [15].

With a more general approach, one can speak of a "sign" as a kind of information unit. The complete set of signs forms the alphabet and obeys a certain grammar. A message composed of such signs has value or usefulness. The information items selected in the information modeling process must obey certain rules – syntax [33].

5 Discussion

Geoinformation modeling, regardless of the field of application, should meet certain concepts and should be aimed at displaying and studying the surrounding reality. Explanations of the content of geoinformation modeling can be shown using paradigmatic relations [12]. The process of studying objects of the surrounding world can be simplified in the form of the following relations:

object –> content –> display.

When using geoinformation modeling, this process is interpreted as:

spatial object –> essential features and spatial relationships –> geoinformation model.

A feature of geoinformation modeling is its reliance on spatial relationships. A quality of geoinformation modeling is the use of visual modeling. Sign geoinformation modeling is used for visualization. In sign geoinformation modeling, the models are sign formations of any kind: maps, diagrams, graphs, drawings, formulas, graphs, conventional signs, tiles, etc. [13].

When studying phenomena or processes, when revealing latent connections, mathematical modeling is preferable [21]. A mathematical model is a set of formal descriptions (formulas, equations, inequalities, logical conditions) that reflect the real process of changing an object's state depending on various external and internal factors. A feature of geoinformation mathematical modeling is the use of topology and spatial data.

In the study of spatial objects, digital modeling is widely used. In computer science and geoinformatics, digital modeling is about realizing mathematical methods and software capabilities for modeling objects [31].

In the broadest sense of the word, a digital model (DM) is a discrete information model formed for processing on a computer. The digital model is a computer-oriented model. In this sense, it is a generalization of the data-logical and physical model.

In the narrow sense of the word, a digital model is a discrete model of spatial objects, in which one of the required parameters are: coordinates, dimensions, dimensions, coordinate accuracy, scale, etc. Naturally, this model is intended for processing information or geoinformation technologies.

The decisive factor in the digital model's name is that it is formed in a digital code that is perceived by a computer and can be processed on this basis [11]. Digital models can have a hierarchical, relational, network, or complex model as a structural basis [24]. They can be stored in databases or as file structures [25]. Digital models are most widely used in geoinformatics, design, construction, architecture, ecology, etc. [7, 26]

5.1 Formation of Geoinformation Resources

Modern sciences related to information processing receive and form information resources. New information resources include various objects: information models, technologies, databases, knowledge, and information systems. Information systems are subdivided into systems: information retrieval, information processing, information storage, knowledge transfer, training, communications, presentation.

Geoinformatics creates geographic information resources, including geodata, information, digital models, digital maps, databases, information models, processing methods, knowledge, geosciences, and technological systems. It is characteristic that geodata, digital models, digital maps, and geoscience are classified as interdisciplinary resources since they are used in geoinformatics and other areas, such as transport and management [22]. One of the new types of geographic information resources of national importance is the spatial data infrastructure.

It should be noted that geographic information resources are used in education as educational information resources [6]. Such an information resource contains knowledge that is divided into two parts: general scientific and professional. The professional is associated with a specific specialty. Broad scientific knowledge is the knowledge that helps to create an available scientific picture of the world. When using geoinformation resources, interactive or heuristic information processing is of great importance. It is usually used in GIS. For the life cycle, software support is essential, which increases the life cycle of the resource. Heuristic information processing also extends the life cycle. There are such technologies in geoinformatics: updating maps, updating databases, and data banks. In geoinformatics, there is a continuity in software updates [19].

Due to this, geoinformation resources have a long life cycle, and subject models using these resources also increase their life cycle due to an increase in geoinformation resources' life cycle. It creates the effect of integrating information resources of other subject areas with geographic information resources [14]. It underlines the integration effect of geoinformatics concerning other sciences.

6 Conclusion

On a global scale, geoinformatics is a tool for studying global processes and globalization. The concept of "globalization" denotes a wide range of phenomena. Still, at the same time, two main aspects are used: socio-economic problems caused by the development of globalization and technogenic processes caused by globalization's influence [37]. Geoinformatics covers both

aspects. In this way, it plays an integrating role for sciences that investigate and influence globalization processes [30].
Geoinformation models and geoinformation modeling serve as the basis for studying the surrounding world and building a world picture [33]. Geoinformation modeling is based on the use of a resource approach and resource models. Then it has the property of improvement and constant modernization. Informational modeling is based on concepts, which is determined by developing information technologies and technical means. It ensures the continuity and long life cycle of information modeling in the face of rapid changes in hardware and software [34]. Thus, geoinformation modeling and its main form - digital modeling - allow solving a wide range of problems that cannot be solved using other modeling methods.

Geoinformatics is the next step in the development of sciences and a new method of cognition of the surrounding world. The development of geoinformatics applications makes it possible to obtain results that cannot be obtained in applied fields. Geoinformatics creates special and interdisciplinary information resources that can be applied in various fields. Geoinformatics brings analysis methods to different fields. In terms of data organization, geoinformatics introduces a new type of data – geodata [35]. They are a system resource. The integration of geoinformatics with other sciences contributes to the interdisciplinary transfer of knowledge and these sciences' development.

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