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Information Approach in Space Research

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Abstract

The article explores the information approach as one of the methods for obtaining knowledge in space research. The advantage of the information approach is that it systematizes research and systematizes the use of models in solving typical problems. The universality of models in the information approach allows the transfer of knowledge from one area of research to another area of research. The versatility of the models allows you to gain experience. The article describes the current state of the information approach. The main stages of the information approach are described. The main aspects of using the information approach are described. The information approach includes a set of principles and methods. Important components of the information approach include: information space, information field, information technology, information systems, onomasiological modeling, information models, information units, information situations, semasiological modeling, solving applied problems. The basic concept of the information approach uses the concept of an "information field" model. The information approach arose within the framework of earth sciences, but is fully applicable in space research. Space research uses information models and simulations. Space research uses the ideas of geoinformatics and geoinformation models. Models of spatial relationships and georeferences are important in the information approach for space research. The main objective of the information approach in space research is to obtain new knowledge and spatial knowledge. An additional task of the information approach in space research is to obtain information resources and accumulate experience in space research.

Keywords: information, information approach, space research, information field, information modeling.

1. Introduction

Modern space research has a number of features. One of the features of modern space research is the application of the information approach (IA), transformed taking into account space information. The ideas of the information approach are embedded in applied informatics (Polyakov, Tsvetkov, 2002). A variety of models are a tool for cognition in space information research (Raev, 2020). The application of the information approach in space research is based on the widespread use of computer science methods. The information approach systematizes research, as well as systematizes the construction and application of models in solving typical problems. The main information models in space research are spatial models. They are analogues of geoinformation models and are divided into topological, mathematical and informational. Spatial information models, within the framework of the information approach, have the property of universality. The versatility of the models allows you to transfer

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knowledge from one field of study to another area of research. The versatility of the models allows you to accumulate experience. The versatility of the models allows you to build theoretical constructions and find patterns. Topological models usually describe the structure. Mathematical models define functional analytics. Information models define the description and presentation. The universality of mathematical models consists in the use of the same formulas to describe different processes or objects. The universality of topological models consists in a generalized description of structures and, on this basis, the transfer of the study of the structures of different objects. The universality of information models consists in the use of a common space of parameters and a common information field to describe and compare different objects and phenomena. Thus, the information approach uses different types of models. The information approach uses methods of qualitative and quantitative analysis. An addition to the information approach in space research is logical design, which serves as a means of verifying and improving the reliability of research. Information models in space research are mostly descriptive.

2. Results and discussion

The current state of the information approach.

The information approach as a method of scientific research and knowledge of the world around us has more than half a century of history (Neimark, Strongin, 1966; Theil, 1965). Currently, the information approach is widely used in modeling, in education, in psychology, in management, in philosophy, in system analysis, in solving complex problems, in spatial analysis, etc. The information approach is considered as a tool for understanding the world around us (Tsvetkov, 2014; Kovalenko, 2015) and is closely related to the system approach (Bondur, Tsvetkov, 2015) in space research. In practice, a person uses meaningful information or knowledge. The first step of the information approach is to collect information and extract meaningful information from it. In the aspect of research, the information approach is closely related to information technology. In the aspect of describing the surrounding world, the information approach is associated with descriptive models and various theories such as topology, geometry, and artificial intelligence. The information approach is implemented in three aspects: systemic, conceptual and technological.

In the system sense, the information approach is a technological system. It is a coherent set of methods and technologies that form an integral system. In the system aspect, the information approach includes system components that form a technological system. These system components are as follows: reflection of the properties of the real world with the help of tools; formation of information about the world on the basis of reflection; analysis of this information; building information relationships and connections; construction of information models; Modelling and metamodelling

Conceptually, the information approach is a set of principles and methods. The conceptual components of the information approach include: information space, information field, information technology. information systems, onomasiological modeling, information models, information units, information situations. semasiological modeling, solution of applied problems. As the main concept, the information approach uses the concepts of "information field" (*Kudzh*, 2017), "information model", "information relations", "information interactions".

Technologically, the information approach is a system of methods and technologies for solving practical problems of cognition and design of projects. Technologically, the information approach includes the following components:

- information description of the surrounding world based on a connected system: information units (Ozhereleva, 2014), information models and information structures;
- system analysis of the results of the study, including the use of information relations;
- modeling of information relations (Chekharin, 2016);
- modeling of information interactions;
- information and cognitive modeling (Tsvetkov, 2013);
- application of information models for solving practical problems.
- extraction of knowledge from the information field;
- the transformation of tacit knowledge into explicit knowledge (Kuj, 2018).

The description of the surrounding world in accordance with the information approach reflects the hierarchy of the world. At the lower level, information units as the basis of the description. At the next level, information models and the third level of description make up information constructs. The main structural elements of the information approach.

The description of the surrounding world in accordance with the information approach requires the use of a set of qualitatively different models. When collecting information, it is necessary to distinguish and apply fact-fixing and interpretive models. When describing objects and phenomena, it is necessary to distinguish between models for describing processes and models for describing static objects. According to this criterion, descriptive (Ozherelyeva, 2016) and prescriptive models are divided.

The information approach ensures continuity between manual, automated and intelligent research methods. It creates opportunities for improving research methods and accumulating information research experience recorded in objective, independent models and descriptions. The main advantage of the information approach is that it creates opportunities for interdisciplinary transfer of research experience and logical-mathematical methods.

Specificity of the information approach.

The Information Approach in Space Research (IASR) uses osmicgeodesy (Bertiger et al., 2020; Oznamets, 2023) and space geoinformatics (Bondur, Tsvetkov, 2015). IASR uses remote non-contact methods and predominantly angular measurements. The information approach in space research uses spatial logic (Tyagunov, Tsvetkov, 2021) to a greater extent than ground-based methods.

The information approach in space research can be compared with obtaining a satellite image. It includes remote information collection (image acquisition), analysis of primary information (qualitative analysis of the image), structural analysis of information (interpretation of the image), model building, visualization of models, qualitative, quantitative and comparative analysis. Is the information content of satellite imagery higher? Than ground or aerial photography. This makes it difficult to process.

IASR includes the following stages: problem setting; building information models, observation and analysis; obtaining new knowledge.

The stage of setting the problem. This phase includes the following processes:

The conditions of the study or the conditions for solving a scientific problem are formulated.

The general goal and particular goals of the study are formulated

An information object is defined as a model of a real object of research.

The information need of the study is determined – this is the need that arises in the process of scientific research, when the purpose of the study or the solution of a scientific problem cannot be achieved without the involvement of additional information in the form of data, information products or measurements. The information need is formed on the basis of understanding and comprehension of the situation in which the object of study is located. Satisfying the information needs of the study is preceded by solving a scientific problem

Define the information resources of research as a set of technical and methodological tools, information systems, processing methods, theoretical hypotheses available to the researcher.

Stage of building information models

In information technologies and systems, only information models are used for processing. Information models are divided into two classes: description models (semantic models) and processing models (procedural models).

Semantic models are an association of semantic units that reflect the properties of the object of study. They are related to the theory and our knowledge of the object of study. As a result of the study, these models are expanded, refined and new models appear.

Procedural models are a combination of logical information units. They are associated with the logic of information processing, with the computer representation of information. At the stage of building information models, an information search is carried out for models that can be used to process and analyze space research data.

The basic semantic models are: models of information space, models of information situations and models of information positions. At this stage, the following processes are carried out.

An information model of the object of observation – an information object – is formulated.

A model of the information situation in which the object of observation is located is formulated.

A model of spatial relations in which the object of observation is located is formulated.

A model of the information position in which the object of observation is located is formulated.

A model of the information state in which the object of observation is located is formulated.

Models of nested information spaces are formulated:

- the space of the environment in which the object of observation and the observation system are located (long-range field of observation);
- the space of the environment of the object of observation (the average field of observation);

- the space of the object of observation (the near field of observation, including the information positions of the object of observation);
- the space of the environment of the observation system (the field of recording the results of observations, including the information positions of the observation system);
- the space of the observation system (including information resources, models and technologies – observation systems).

Observation and Analysis Phase: This level includes the following processes:

The conditions for the uniformity of measurements are formulated. The vector of the research goal is defined as an ordered list of particular research goals that describes the objective ideal (in the sense of setting a scientific problem) result of the study of the object of observation.

The information field of observations is evaluated as a complex of observed multi-level information spaces and objects, information processes, connections and relations, united by a common semantic meaning – a reflection of outer space. The main function of this field is descriptive

A multidimensional matrix of possible states of the object of observation is determined. The observation cycle is carried out as a repeated repetition of the observation stages until the goal of the study is achieved.

After receiving the data, facts and parameters, the analysis is carried out.

The information situation of the object of observation is determined on the basis of the current assessment of the state of the external environment. The information position of the object of observation is determined on the basis of the current assessment of the state of the object of observation in relation to the external environment in the information field. Modeling and prediction of the dynamics of the states of the object of observation and the environment is carried out.

Level of knowledge. This level includes the stages of constructing a terminological field, building a knowledge base, extracting knowledge of their observation facts and the results of processing spatial data.

One of the main tasks of space research is to obtain spatial knowledge (Tsvetkov, 2016). In scientific research, the concept of geoknowledge (Tsvetkov, 2016) is increasingly being used as knowledge related to spatial relationships. Geoknowledge in space research is considered as a form of knowledge associated primarily with spatial relations in the space of the surface.

Using interdisciplinary transfer, the concept of "spatial knowledge" or geo-knowledge can be used. Spatial knowledge is a form of knowledge related to spatial relations in outer space. Spatial knowledge in space research reflects knowledge about spatial space objects, and knowledge about spatial and non-spatial relationships. Hence the possibility of a broader description of such knowledge. Knowledge about objects in the theory of artificial intelligence, as a rule, uses descriptions based on the traditional linguistic or analytical form.

Spatial knowledge about space objects can be adequately conveyed not only in the traditional form, but also in additional descriptions (maps, digital models, images, pseudo-images, three-dimensional visualizations, spatial topological schemes).

An important ontological characteristic of spatial cosmic knowledge is reference. There is a concept of geo-reference (Hackeloeer et al., 2014) as a means of describing the acquisition of knowledge about terrestrial objects. Spatial relationships are the basis of georeference.

By analogy, you can introduce the concept of "spatial reference" Spatial reference is a means of describing, obtaining knowledge about objects in outer space. It is also based on the application of spatial relations, but in outer space.

A spatial reference, defined by a name that carries the characteristics of a relationship or a description of an object, is called an identifying reference. An identifying reference is associated with the identifier of a space research object and uses three types of relationships*: indication, naming, and designation.*

The choice of the relationship in the identification of the object of space research is determined by the following rules. The relation "designation" is used in a situation of an explicit description of the object of study. In mathematics, it corresponds to an explicit description of a function.

The relation "naming" is used in a situation of implicit description of the object of space research. In mathematics, it corresponds to an implicit description of a function. The relation "naming" is used in the absence of a description of the object, but the presence of other objects associated with the object of study. These objects are in a spatial relationship with the object of study. In mathematics, this relation corresponds to a set of constraints that define the scope of existence.

When introducing a new concept, it is advisable to give similarities and differences with similar concepts. Structurally, spatial knowledge differs from the knowledge used in management and the theory of artificial intelligence. This is due to the following main reasons:

Linguistic aspect. Binding to a specific subject area narrows the scope of the concept;

Integration aspect. The emergence of additional relationships and connections makes it possible to combine different types of information and knowledge and obtain new models and new knowledge on this basis.

Spatial knowledge as a subset is a union of declarative (D), procedural (P), and configurational C sets.

$$GK = D \cup P \cup C \quad (1)$$

The sets D and P have an empty intersection of D P = , $\cap$ so they are disjunctive. In the theory of artificial intelligence, such a description is the basis. In spatial knowledge, another component appears, called configurational. It is this component that distinguishes spatial knowledge from knowledge used in artificial intelligence.$\varnothing$

Another difference between spatial knowledge is the possibility of its visual *display* on maps, diagrams, photographic images and other types of images. When displaying, special transformations are used to represent spatial knowledge in a visual form convenient for analysis. To denote the mapping of the set φ *A* to the set *B*, the notation is used:

$$\varphi: A\ B \rightarrow (2)$$

If x *A*, $\in$ then the set of all elements from *B*, mapped to the element x, is φ denoted by *(*x*)*φ and is called the *image of the element x*. Due to the transformation (2) in spatial knowledge, topological models are widely used. The use of the information approach provides additional opportunities for representing, analyzing and solving problems in space research

3. Conclusion

The information approach in space research differs from the information approach in ground conditions. These differences are due to the methods of collecting information, processing methods, verification methods and the types of logics used. The information approach in terrestrial conditions is object-based, that is, it is aimed at studying individual objects. The term object includes the concept of process. The information approach in space research is situational. He explores situations first. The information approach in space research is dynamic. He explores moving objects. Therefore, it is necessary to use models of "spatial situations" in space research. The specifics of IASR include its distinctive characteristics and implementation features. IASR cannot be reduced only to instrumental and technological processes, as in computer science. The information approach in space research should be considered as an integrated approach that includes modeling and analysis.

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