Lecture 5. System, information, knowledge

The purpose of the lecture: to discuss an introduction to the essence and meaning of the basic, but poorly formalized (and therefore usually defined simplistically, taking into account the needs of the subject area) concept of "information" from the point of view of systems analysis.

Lecture plan:
Introduction
1 Concept of information
Conclusion

Keywords: data, knowledge, entropy, Information theory, information, knowledge, Increment, environment, input, output, input information, output information, intrasystem information, system structure, activity, structural information, system of linear algebraic equations, accuracy, noosphere , evolution, property of information, information flow, exchange rate, empirical method, theoretical method, empirical-theoretical method, survey, identification, deduction, heuristics, Historical method, logical method, Prototyping, open system, monitoring, expert assessments, assessment, verification , tuple, domain, relation, operation, addition, subtraction, multiplication, division, input, empirical, theoretical, method.

Contents of the lecture:

Introduction

The concept of information is one of the basic, key concepts not only in systems analysis, but also in computer science, mathematics, physics, etc.

1 Concept of information

At the same time, this concept is poorly formalized, because of its universality, volume, vagueness, and is interpreted as:

- ✓ *any entity that causes changes in some information-logical (infological - consisting of messages, data, knowledge, abstractions, structural diagrams, etc.) model representing the system (mathematics, systems analysis);*
- ✓ *messages received by the system from the outside world in the process of adaptive control, adaptation (control theory, cybernetics);*
- ✓ *negation of entropy, reflection of the measure of chaos in the system (thermodynamics);*
- ✓ *connections and relationships that eliminate uncertainty in the system (information theory);*
- ✓ *the probability of choice in the system (probability theory);*
- ✓ *reflection and transmission of diversity in the system (physiology, biocybernetics);*
- ✓ *reflection of matter, an attribute of consciousness, "intellectuality" of the system (philosophy).*

We will consider the systemic understanding of this category, without at all denying the above concepts and, moreover, using them as needed.

The cognition process is a hierarchical system of information actualization, in which knowledge at each next level of the hierarchy is an integral result of knowledge actualization at the previous level. This is the process of integrating information resources, from those obtained through simple sensory perception to complex axiomatic and abstract theories.

Data - syntactic signals, images, updated with the help of some data source. They are considered without regard to their semantic meaning.

Information is a certain sequence of information, knowledge that is actualized (received, transmitted, transformed, compressible, registered) with the help of some signs of a symbolic, figurative, gesture, sound, sensorimotor type.

Information is data, considered taking into account some of their semantic essence.

Knowledge is information that ensures the achievement of a certain goal and structure.

From a worldview point of view, information is a reflection of the real world. Information is an increment, development, actualization of knowledge that arises in the process of goal-setting intellectual activity of a person.

No information, no knowledge appears immediately: their appearance is preceded by the stage of accumulation, systematization of experimental data, opinions, views, their understanding and rethinking. Knowledge is the product of this stage and such a systemic process.

Information (in the system, about the system) in relation to the environment (environment) is of three types: input, output and internal.

Input information is the one that the system perceives from the environment. This kind of information is called input information (in relation to the system).

Output information (in relation to the environment) is that which the system issues to the environment.

Internal, intrasystem information (in relation to a given system) - that which is stored, processed, used only within the system, updated only by subsystems of the system.

Example. A person perceives, processes input information, for example, data on the weather on the street, forms an output reaction - this or that form of clothing. In this case, internal information is used, for example, genetically embedded or acquired physiological information about the reaction, for example, about the "frost resistance" of a person.

The internal states of the system and the structure of the system have a decisive influence on the relationship of the system with the environment - intra-system information affects the input and output information, as well as the change in the intra-system information itself.

Example. Information about the financial stability of a bank can influence its activities. The accumulated (within the system) socio-economic negative information (manifested, for example, by social activity in the environment) can influence the development of the system.

Example. Information genetically embedded in DNA molecules and acquired information (stored in memory) affect behavior and human adaptation to the environment. In the first generation machines, the internal structure was determined by thousands of lamps, each of which separately had low reliability, i.e. such a system was unreliable in operation. This affected the input information, the functioning of the system, for example, such computers were not capable of working in multitasking mode, in real time (processing messages as input data was received).

In animate and inanimate nature, information can also be transmitted by some structure. Such information is called (often it can be conventionally referred to as information) structural information.

Example. Structural rings of a tree cut carry information about the age of the tree. The food structure of a predator (or trophic structure) carries information about the predator and its habitat. The fin structure of a fish often carries information about the depth of its habitat. The structure of a firm can explain many of the phenomena and behavior of a firm.

Information in relation to the final result of the problem is:

- ✓ *initial (at the stage of starting to use the actualization of this information);*
- ✓ *intermediate (at the stage from the beginning to the end of information updating);*
- ✓ *resulting (after using this information, completing its updating).*

Example. When solving a system of linear algebraic equations, information about the solution methods, implementation environment, input data (sources, accuracy, etc.), system dimensions, etc. is the initial information; information about the compatibility of the system of equations, the numerical values of the root, etc. - resulting; information about the current states of the coefficients of the equations, for example, when implementing the Gauss scheme, is intermediate.

Information (according to its variability during actualization) is:

- ✓ *constant (never changed when it is updated);*
- ✓ *variable (changed when updated);*
- ✓ *mixed - conditionally constant (or conditionally variable).*

It is also possible to classify information on other grounds:

- ✓ *by stage of use (primary, secondary);*
- ✓ *by completeness (excessive, sufficient, insufficient);*
- ✓ *in relation to the goal of the system (syntactic, semantic, pragmatic);*
- ✓ *in relation to the elements of the system (static, dynamic);*
- ✓ *in relation to the structure of the system (structural, relative);*
- ✓ *in relation to the management of the system (managing, advising, transforming);*
- ✓ *in relation to the territory (federal, regional, local, referring to a legal entity, referring to an individual);*
- ✓ *by availability (open or public, closed or confidential);*
- ✓ *by subject area, by the nature of use (statistical, commercial, regulatory, reference, scientific, educational, methodical, etc., mixed) and others.*

Information in a philosophical aspect is:

- ✓ *ideological;*

- ✓ *aesthetic;*
- ✓ *religious;*
- ✓ *scientific;*
- ✓ *household;*
- ✓ *technical;*
- ✓ *economic;*
- ✓ *technological.*

All this (together with the personal aspect of a person as a species) constitutes the noosphere of society - a higher state of the biosphere, which has arisen as a result of evolution, structuring, ordering (both static and dynamic) and harmonization of relations in nature and society under the influence of the goal-setting activity of mankind.

This concept was introduced by V.I. Vernadsky as a reflection of the concept of the stage of evolution of society and nature, i.e. a system within which a harmonious, sustainable development (evolution) of the "Society" and "Nature" systems, as well as the gradual merging and harmonization of the sciences about nature and about society, can potentially be realized.

Basic properties of information (and messages):

- ✓ *completeness (contains everything you need to understand the information);*
- ✓ *relevance (necessity) and significance (information);*
- ✓ *clarity (expressiveness of messages in the language of the interpreter);*
- ✓ *adequacy, accuracy, correctness of interpretation, reception and transmission;*
- ✓ *interpretability and comprehensibility to the information interpreter;*
- ✓ *reliability (displayed to messages);*
- ✓ *selectivity;*
- ✓ *targeting;*
- ✓ *confidentiality;*
- ✓ *informativeness and significance (of displayed messages);*
- ✓ *mass character (applicability to all manifestations);*
- ✓ *coding and efficiency (coding, updating messages);*
- ✓ *compressibility and compactness;*
- ✓ *security and noise immunity;*
- ✓ *accessibility (interpreter, receiver);*
- ✓ *value (assumes a sufficient level of consumer).*

Information can turn out to be harmful, affecting negatively the consciousness, for example, bringing up the perception of the world from indifferent or uncritical to negative, "angry", inadequate. The flow of information is a strong enough irritant.

Example. Negative information can be information about the collapse of a commercial bank, about a sharp rise (fall) in the exchange rate, about changes in tax policy, etc.

Information does not exist without other types of resources: energy, substances, organizations, just as they cannot exist without information. Any interactions of systems (subsystems) are always material-energy-informational.

Revealing (systematization, structuring), description (formalization), study, application of invariants of these interactions is the main task of science as a human activity.

The methods of obtaining and using information can be divided into three groups, sometimes delineated only conditionally:

1. *empirical methods or methods of obtaining empirical information (empirical data);*
2. *theoretical methods or methods of obtaining theoretical information (building theories);*
3. *empirical-theoretical methods (mixed, semi-empirical) or methods of obtaining empirical-theoretical information.*

Let's briefly characterize the empirical methods:

- ✓ *Observation - collection of primary information or empirical statements about the system (in the system).*
- ✓ *Comparison - the establishment of common and different in the system or systems under study.*
- ✓ *Measurement - search, formulation of empirical facts.*
- ✓ *An experiment is a purposeful transformation of the system (systems) under study to reveal its (their) properties.*

In addition to the classical forms of their implementation, recently such forms as polling, interviews, testing and others have been used.

Let us briefly characterize the empirical-theoretical methods.

1. *Abstraction is the establishment of general properties and sides of an object (or objects), the replacement of an object or system with its model. Abstraction in mathematics is understood in two senses: a) abstraction, abstraction - a method of studying some phenomena, objects, which allows both to highlight the main properties most important for the study, aspects of the object or phenomenon under study, and to ignore the insignificant and secondary; b) abstraction - description, representation of an object (phenomenon), obtained using the abstraction method; especially important in computer science is such a concept as the abstraction of potential feasibility, which allows us to investigate constructively objects, systems with potential feasibility (i.e., they could be feasible if there were no resource constraints); the abstraction of actual infinity (the existence of infinite, non-constructive sets, systems and processes) is also used, as well as the abstraction of identification (the possibility of identifying any two identical letters, symbols of any alphabet, objects, regardless of where they appear in words, structures, although their informational value is this may be different).*
2. *Analysis - the separation of the system into subsystems in order to identify their relationships.*
3. *Decomposition is the separation of a system into subsystems while preserving their relationships with the environment.*
4. *Synthesis is the connection of subsystems into a system in order to identify their interconnections.*

5. *Composition is the connection of subsystems into a system while maintaining their relationships with the environment.*
6. *Induction - gaining knowledge about a system from knowledge about subsystems; inductive thinking: recognizing effective solutions, situations, and then problems that it can solve.*
7. *Deduction - obtaining knowledge about subsystems from knowledge about the system; deductive thinking: defining a problem and then finding a situation that solves it.*
8. *Heuristics, the use of heuristic procedures - gaining knowledge about the system from knowledge about the subsystems of the system and observations, experience.*
9. *Modeling (simple modeling) and / or using devices - gaining knowledge about an object using a model and / or devices; modeling is based on the ability to highlight, describe and study the most important factors and ignore the secondary ones in formal consideration.*
10. *The historical method is the search for knowledge about the system by using its prehistory, which actually existed or is conceivable, possible (virtual).*
11. *The logical method is a method of searching for knowledge about a system by reproducing some of its subsystems, connections or elements in thinking, in consciousness.*
12. *Layout - obtaining information on the layout of an object or system, i.e. by representing structural, functional, organizational and technological subsystems in a simplified form that preserves information that is necessary to understand the interactions and connections of these subsystems.*
13. *Actualization - obtaining information by activating, initializing meaning, i.e. transfer from a static (irrelevant) state to a dynamic (actual) state; at the same time, all the necessary connections and relations of the (open) system with the external environment must be taken into account (it is they that actualize the system).*
14. *Visualization - obtaining information using a visual or visual representation of the states of the updated system; visualization assumes the ability to perform operations in the system such as "move", "rotate", "enlarge", "reduce", "delete", "add", etc. (both in relation to individual elements and subsystems of the system). This is a method of visual perception of information.*

In addition to these classical forms of implementing theoretical and empirical methods, recently such forms as monitoring (a system for observing and analyzing system states), business games and situations, expert assessments (expert assessment), imitation (imitation), verification (comparison with experience and a conclusion about training) and other forms.

Let us briefly describe the theoretical methods.

- ✓ *Climbing from the abstract to the concrete - gaining knowledge about the system based on knowledge about its abstract manifestations in consciousness, in thinking.*

- ✓ *Idealization is the acquisition of knowledge about a system or its subsystems by means of mental design, representation in thinking of systems and / or subsystems that do not exist in reality.*
- ✓ *Formalization is the acquisition of knowledge about the system using signs or formulas, i.e. languages of artificial origin, for example, the language of mathematics (or mathematical, formal description, representation).*
- ✓ *Axiomatization is the acquisition of knowledge about a system or a process with the help of some axioms specially formulated for this and rules for deriving axioms from this system.*
- ✓ *Virtualization is the acquisition of knowledge about the system by creating a special environment, setting, situation (in which the system under study and / or its investigating subject is placed), which in reality, without this environment, it is impossible to realize and obtain the corresponding knowledge.*

These methods of obtaining information are systematically applied in any field of activity (Fig. 5.1).

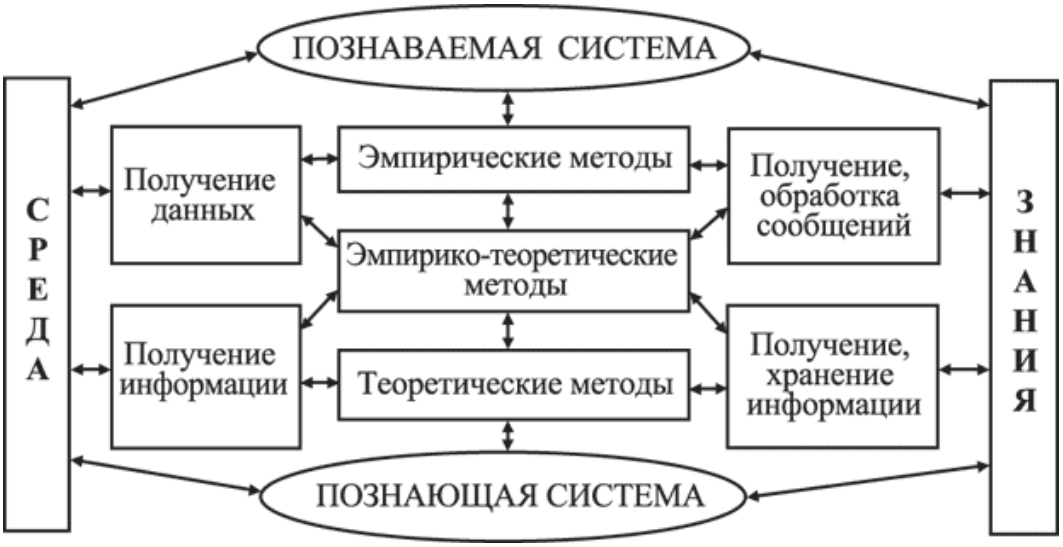

Figure 5.1. System cognition structure

Example. To build a planning and production management model within a country, region or large industry, you need to solve the problems:

- ✓ *determine the structural connections of the system (both vertical and horizontal), levels of management and decision-making, resources; at the same time, methods of observation, comparison, measurement, experiment, analysis and synthesis, deduction and induction, heuristic, historical and logical, prototyping, etc are more often used;*
- ✓ *define hypotheses, goals, possible planning problems; the most used methods: observation, comparison, experiment, abstraction, analysis, synthesis, deduction, induction, heuristic, historical, logical, etc .;*
- ✓ *construction of empirical models of the system; the most used methods: abstraction, analysis, synthesis, induction, deduction, formalization, idealization, etc .;*

- ✓ *search for a solution to the planning problem and miscalculation of various options, planning directives, search for an optimal solution; the most commonly used methods: measurement, comparison, experiment, analysis, synthesis, induction, deduction, actualization, prototyping, visualization, virtualization, etc.*

Information, thus, can be considered as a tuple A = <X, Y, f>, where the carrier X is information, knowledge about the subject area, the set Y is messages reflecting this information, the relation f is the encoding relation between elements X, Y , i.e. their actualization.

Example. Let X = {spouses, children of spouses}, Y = {"Ivanov Petr Sidorovich", "Ivanova Olga Nikolaevna", "Ivanov Oleg Petrovich", "Ivanova Natalia Petrovna", "mother", "father", "son", " daughter"," parents"," children"}, the relation f can be specified (verbally) by listing connections of the form:"Ivanov Oleg Petrovich - spouse of Ivanova Olga Nikolaevna","Ivanova Natalia Petrovna - daughter of Ivanova Olga Nikolaevna", etc.

Example. Let X = {arithmetic operations}, Y = {"- (taking the opposite number)", "+ (addition)", "- (subtraction)", "x (multiplication)", "/ (division)", "√ surd (square root extraction)"}, f is defined as" unary operation "matching.

Thus, the main task of science is to construct, research, actualize or store sets with a given class X of the same type of tasks, Y - a class of structures and resources associated with these tasks, and f - the processes of their comparison and actualization using some resources.

We solve such problems in everyday life, but at the same time, often the rule f cannot be found or constructed explicitly or constructively. In this case, one has to replace the desired law f with suitable explicit or constructive representations f, X, Y and/or Z (see Fig. 5.2) and apply these representations every time.

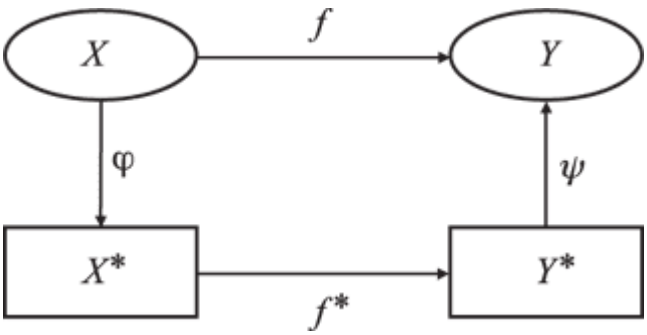

Figure 5.2. Invariant of all problems of science to be solved

The rule φ specifies the rule for encoding or interpreting the input alphabet, the rule ψ specifying the rule for decoding or interpreting the output alphabet, i.e. input and output codes (rules, functions). At the same time, the laws are valid:

$$y = f(x) = \psi(f \times (\varphi(x))).$$

The rule f* is chosen so that, unlike f, it could be found and/or studied, applied. For each message x from X, a triad is defined:

$$(x, y^*, y): x^* = \varphi(x), \quad y^* = f^*(x^*), \quad y = \psi(y^*).$$

Information is the content of a message, a message is a form of displaying or updating information. Information always has a carrier, updating information is associated with a change in the carrier, resources.

Example. Information about the essence of the product can be stated in advertisements transmitted by various messages (on television, on radio, in the newspaper, etc.). Moreover, the compliance of this advertisement with reality can be regardless of the type of messages, i.e. there is a third party of information (except for its abstract essence, its presentation by messages) - the correspondence of the information contained in the information with the manifestations of the real system.

Conclusion

Information is the content of a message, a message is a form of displaying or updating information. Information always has a carrier, updating information is associated with a change in the carrier, resources.

Control questions

See the manual on the organization of students' independent work.