SIGN-SYMBOLIC SYSTEMS

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Abstract

The article explores symbolic systems as a special type of complex systems. The relationship between the concepts of “sign” and “symbol” and symbolic means are analyzed. Four research methods of analyzing a language as a symbolically symbolic system are investigated: linguistic, semiotic, systemic and informational. The article describes the symbolic system using the information approach and demonstrates the presence of emergence in sign-symbolic systems. The article shows that a sign-symbolic system is best described as an informational construction. The main functions of sign-symbolic systems are the following: representation, communication, information and externalization of implicit knowledge.

Keywords: Complex systems, sign, symbol, symbolically symbolic systems, linguistics, information approach.

I. Introduction

The current state of development of information sciences cannot be considered as satisfactory. With its pronounced communication nature, Claude Shannon’s Information Theory does not address semantics-related issues. Essentially, information evolves as a science dealing with computer-based information processing and does not focus on the theory of information processes. According to the authors, the notion common to all information sciences is that of the information field and model existing within this field. The information field as a system allows for the
application of a systems analysis, the formation of new complex systems and the introduction of models from other disciplines, such as linguistics, with a view to producing new descriptions aimed at responding to challenges in computer linguistics and computer interpretation. The construction of any new system requires the application of the systems approach and of systems analysis. Currently, the use of the systems approach and the notion of complex system are being further developed and enlarged. As revealed in the research study, the contemporary theory of complex systems comprises self-organizing and living systems, suggesting that this theory can be developed by bringing ideas from other areas into systems analysis. The existence of a close relationship between linguistics and information science and between linguistic models and information models, suggested the authors the idea of conducting research on complex systems from a linguistic perspective. What makes this study relevant and timely is the current research trend showing an interdisciplinary shift of knowledge aimed at searching for new idea and models in the field of systems analysis.

Another relevant issue is the need for computer interpretation of text contents, notably those of large volumes. Sign-symbolic systems can become the key to this issue.

The study aims to investigate the new sign-symbolic approach to shaping and describing systems that is not in use in computer science and information technology yet.

The chief purpose of the investigation is to explain the notion of the new complex system, i.e. the sign-symbolic system, to specify its content and distinctive features and to introduce the notion of information field into information sciences as being an integrating factor.

There are various systems and their models. In many cases, a system is a structured object. Others are process or linked object systems. The research novelty of this study lies in the investigation of innovative systems, which can be defined as description systems. What makes such an investigation possible is the application of several concepts in information science. The first one is to use the notion and essence of information field as the environment in which information processes and interactions take place. The second concept is to use information units as information field elements. Using information units in the information fields makes it possible to compare and bring linguistic idea to and back from the information field. The third concept is to break information units down into semantic information units and symbolic information units. The former (words, sentences) have content and meaning, and the latter carry out structural functions and play an auxiliary role. The “word” (and “sentence” too) is a semantic information unit, emergent in relation to symbols forming it. The content/structure relationship is peculiar to sign-symbolic systems.

By tradition, a system is called a coherent combination that comprises a multitude of components, elements, links and relationships. A system is structured and has the property of consistency. Many systems also possess another property, emergence,
which means that the property of the whole is not equal to the properties of its components. The notion of system enables detection of various patterns and laws and assessment of systematization and of consistency. The systems approach allows comparison of related systems and their behavior patterns. Recent research has also been conducted on various complex systems. Among diverse complex systems that have been subject to research, systems can be grouped into the following categories: complex organizational systems, complex technological system complex technical systems, complex applied systems, complex computing systems, complex information systems, complex organizational systems, complex computing and organizational systems, complex problem-oriented systems, complex organizational and technical systems and living systems. All complex systems contain their formal description. From a systemic viewpoint, a description can also be a system. A complex system that has not been subject to research in information science is known as a sign-symbolic system.

II. Materials and Methods

This study’s focus on three research areas makes it interdisciplinary. Based on proven studies in linguistics and linguistic semantics, this research also draws on research findings in natural language. Studies on the information field, information units, information interactions and information languages provided the framework for our second research area. Finally, research work in the field of system analysis were the third research area integrated into the present study. The method of bringing information from other, non-technical, areas into system analysis served as a means for combining data provided by various research areas into a coherent whole. The research plan is based on the tripartite model best described as follows: element, descriptive means and system of elements.

The “sign and symbol” of the linguistic field were considered as “elements”, and research on the sign and symbol was conducted with a view to searching for and creating model equivalents in the information field. The investigation of descriptive means consisted in research on sign and symbolic means and systems in linguistics. Research on the context of the sign and symbol was conducted as a search for conformity to the notion of semantic context in the information field. Research on the system of elements was based on the study of natural language as a system, whereas the language/sign relationship served as a basis for research. Language is regarded as a system, and signs as the system’s elements. Research on specific features of natural language was aimed to form information languages. The research method consists in finding similarities between semantic models and information field models used to form new information models. In their turn, the latter were used to form sign-symbolic systems in the information field.

III. Research Results

Sign and Symbol

The first part of the research study aims to examine the sign and the symbol. The sign and the symbol are tools describing the outside world and means of the
cognitive perception of the world and of social space, as well as the backbone of the language and meta language creation. Importantly, a different approach to these notions in linguistics and the information field needs to be highlighted.

As a basic function, the sign and the symbol have the representation function in linguistics. From a linguistic perspective, the sign and the symbol always have a pronounced visual representation.

As for the information field, the sign and the symbol act as information units: a semantic information unit corresponds to the sign, and a symbolic information unit corresponds to the symbol. In the information field, the sign and the symbol have a visual representation as well as a hidden representation, for instance, a machine word.

The sign and the symbol have three main functions in the information field. The first one deals with information transfers using computer technologies. The second function of the sign and the symbol consists in implementing informational interactions between entities, models and systems. The third function of the sign is the representational one, i.e. the same as in linguistics. It is, however, different from the linguistic representational function in that the sign and the symbol have a stable visual presentation in linguistics whereas, in the information field, the sign and the symbol have a hidden computer presentation and can be expressed with various visual forms. The sign and the symbol can be encoded in the information field, and their encoding depends on meaning or quality. As an example, Symbol 1 can design a whole number or a real number. It can design a symbol. Symbol 1, just like many other digital symbols, can be variable in quality nominal scales or quantity ones.

In the information field, the sign and the symbol are of polymorphous nature, which, on one hand, offers many options for using it and, on the other hand, creates ambiguity in their interpretation.

In the information field, the sign and the symbol are transformed into information units. Words and sentences are the semantic information units corresponding to the sign, and symbols are the symbolic information units corresponding to the symbol. Information units act as a basis for description of and research on information processes and information interactions. Symbolic interactionism (derived from the word “interaction”) has long been evolving in semiotics, regardless of informatics. Information interaction in the information field is the equivalent of symbolic interactionism in the semiotic field.

The sign and the symbol as entities of the information field are the information units or elements of the information field. These notions reveal and define the properties of the real world’s entities. The symbol is traditionally considered as the element of the sign. For instance, map signs on topographic maps may contain symbols. Signs are related to hieroglyphic and pictographic designations. Sign and symbolic means are widespread in visual modeling and visual analysis.

In Cassirer’s idealist concept and his too broad understanding of symbolism, the multidimensional and varied human activity is reduced to the symbolic one. This point of view is well represented in philosophical works. This area presents a
viewpoint, according to which images, photographs and pictures, among others, cannot be grouped among signs because their common feature is their resemblance to the represented object. The rationale for this is that such resemblance is not mandatory for the sign. This viewpoint is, however, erroneous because, in terms of information, the mentioned entities are redefined with respect to the notion of sign, which does not exclude their integration into a simpler multitude showing fewer features.

An image regarded as a model from a cognitive perspective is a sign because it always acts as a substitute for the real object of the world. As such, the image performs a representative function, and the sign fulfills the same function.

Signs and symbols perform, to varying degrees, the functions of informing, representation, communication and carrier of implicit or hidden knowledge. Furthermore, signs and symbols are carriers and representatives of activity.

No restrictions are imposed on the nature of the object designed: these can be objects, properties and relations of the objective world. Restrictions are imposed on the sign, however. Restrictions arise from syntax within the system of signs, which has nothing to do with natural entities.

The modeling theory makes a broad use of the term “sign” as a generic term in relation to its varieties. In this approach, any substitute for a real object and any model acts as a sign. Such an approach produces a variety of signs and creates the need for their arrangement. In practice, distinction made between different types of signs depends on the sign’s relationship to designed entities and to other signs. This results in the narrow conception of the sign as a generic notion and, thus, highlights its affinity with the symbol.

The sign’s relationship to designed entities and to other signs in the information field leads to the notion of information relationships. Information relationships model and describe the sign’s relationships. The sign and symbol of the linguistic field correspond to the information units of the information field, and this concordance provides a rationale for researchers to search for sign-symbolic systems in the information field.

Sign-Symbolic Means and Systems

Research on sign-symbolic means constitutes the second part of the present study and focuses on the connection between the system and its elements. Examination of any system, including natural language, requires investigation of this system’s descriptive means. Let us consider the notion and essence of “sign-symbolic means”, for this notion comprises the sign’s representing essence and the fact that it constitutes the meaning form of some content. In research literature, the sign’s substantive characteristic is reflected in special terms (the sign’s form; matiere, etc.).

As noted previously, in linguistics, the sign’s main function is representation. Sign-symbolic means are needed to have it carried out. The term “sign-symbolic means” provides a better idea about the sign’s essence. Furthermore, it makes it possible to
cover various types of ways of dealing with signs and to analyze them regardless of the sign.

The term “sign-symbolic means” has a broader meaning in the information field than in semiotics or linguistics and allows for the information interpretation of the term “sign-symbolic systems”.

When analyzing various semiotic notions, such as “sign”, “sign situation” or “sign construction”, the information approach enables construction of their information equivalents: “information unit”, “information situation” and “information construction”. When analyzing various semiotic systems and sign systems, the information approach enables construction of their information equivalents, “sign-symbolic means”, and the term “sign-symbolic systems”.

Analysis of sign-symbolic means in the semiotic fields has its peculiar features. Consequently, the sign reflects not only the natural property of an object, but also its functional property that manifests itself in the sign’s actions.

Analysis of sign-symbolic means in the information field is different from analysis made in the semiotic field. The information approach provides an opportunity to detect the sign’s information nature and to observe the sign function’s evolution as an opportunity to use these or those information models as a sign.

The sign’s complex structure is echoed in the “semantic triangle” model that includes the following three essences: sign, meaning and object. Being one of the models of sign-symbolic means, it is graphically represented as a triangle whose vertexes have the following meanings, respectively: 1) object, object, phenomenon: denotatum; 2) sign; and 3) idea about an object/object: designatum.

The model of sign-symbolic means can comprise four elements that define the sign’s information situation: a designation object, a sign, an idea about an object, a subject, a perceiving sign and their relationship. Importantly, in terms of information, the notion of sign situation is a variety of information situation.

The trinitary and dyadic relationships can be identified for the symbolic analysis of the sign situation. The trinitary relationship sets Frege’s triangle: sign – meaning – objective reality. As for the dyadic relationship, it determines communication: sender – recipient. The sign’s specific features result from the first type of relationships. The sign is a substitute for an object, it has a meaning, and various relationships exist between the sign and objective reality. A feature known as the sign’ intentionality derives from the dyadic relationship.

Sign-symbolic means are given a new interpretation in considering their semantic context. In semiotics and linguistics, the sign is usually examined separately whereas, in the information field, information units are examined in a specific situation that explains their behavior and helps interpret them. In the information field, there is a semantic contextual model which is one of the information equivalents of sign-symbolic means.

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Sign and Language

Research on language as a system is the third part of the present study. This system produces various systems, one of them being the sign-symbolic system. The systems approach examines the system as a combination of related elements. In semiotics and linguistics, such a system is natural language. Natural language is a voluminous system whereas information languages are always the simplified version of such a system.

Language is one of the forms of sign-symbolic systems. The sign can be examined in a small way and in a big one. In a small way, the sign is a symbol, i.e. the element of the alphabet. The alphabet is part of language. In a big way, the sign is a designation going beyond the limits of the alphabet. In a big way, the sign can go beyond language. With the increase of interest in signs, the term “language” is used in the related research literature along with the term “sign” to refer to the system of signs and rules of using them. Specialized languages exist in the information field, and notions, such as “language of graphics”, “language of information science”, “language of maps” and “language of architecture”, are widely used, each of them having their sets of designations, structural laws and interpretations. The sign and the symbol form the sign-symbolic system, and there are two methods for conducting research on the sign-symbolic system – the linguistic one and the semiotic one. It is possible to bring these methods to the information field and add them to the systems method and the information one. This gives grounds for asserting that, in the information field, methods for researching sign-symbolic systems are broadere, and construction of a greater number of models and interpretations is possible.

The linguistic method is a structural and functional method used to conduct research on language as a system. This approach examines various levels of language, patterns peculiar to language as well as the arrangement and coherence of language. The linguistic method often limits research on sign-symbolic systems to natural language, i.e. it analyzes languages as the language of words. Comprising all kinds of symbols and signs into it is regarded only in terms of their figurative uses in language.

What distinguishes the semiotic method is its general focus on the study of the properties of sign systems associated, in a way, with some value. The semiotic method can be defined as research on the sign/significance relation. In this case, any signs can acts as objects under investigation. Considered as such, language is a “sign-symbolic system” that performs a cognitive and communicative function in human activities.

The semiotic approach attributes various sign systems to languages. Researchers discuss issues related to what signs the notion of “language” can refer, what makes it possible to attribute this or that sign to language and what results from the assignment of various sign means to the “language” category. The approach to signs as being language enriches the semiotic analysis, and comparison of sign systems to natural language highlights the specific nature of various sign means.

The systems method or systems approach aims to study language from a systemic
perspective and as a coherent system. It detects language’s elements, connections and structure as well as its system. One of the main language building principles is its systemic nature. Ferdinand de Saussure pointed out other language building principles: division of language activities into language (a social phenomenon, or a certain code of rules existing outside individuals, yet mandatory for the latter) and speech (specific expression of language); perception of language as form; and autonomy of language. These principles brought forward by Saussure contributed to the evolution of linguistics. The systems approach formally represents language as a complex symbolic system ($LS$)

$$LS = <Pr, Str, E, C, R, RuC, RuIn>, \quad (1)$$

In the above expression, (1) $Pr$ is the ensemble of the parts of language; $Str$ – the structure of language; $E$ – a multitude of elements of language (language information units); $C$ – a multitude of connections in the language system; $R$ – a multitude of relationships between elements and parts of the language system and subsystems; $RuC$ – a multitude of rules for building language constructions; and $RuIn$ – a multitude of rules for interpreting language constructions. Therefore, the following accounts for the attribution of signs to the language system: rigid rules for combining information units, for forming language constructions and for interpreting language constructions. The expression (1) can be applied to construct information languages.

The systems approach makes it possible to present information language ($LI$) as a complex system by analogy with the semiotic expression (1).

$$LI = <Str, SemIU, SymIUSem, IR, Sint>, \quad (2)$$

Information language is homogeneous and, as a rule, has no parts to it. In the expression (2), $Str$ is the structure of language; $SemIU$ – semantic information units; $SymIU$ – symbolic information units; $Sem$ – semantics or rules of semantic interpretation; $Sint$ – syntax or rules for building language constructions. The expression (2) is the rationale for attributing information units to information language and requires rigid combination of information units, rules for building and interpreting information units.

The information approach perceives language from a semantic perspective as a carrier of information and knowledge. Among the specific research aspects of this approach are efficacy of language description and reality and the semantic richness of information language constructions. The information approach defines the following specificities of sign-symbolic systems as language systems.

- Information units as carriers of communication;
- Emphasized semantic context in which communication takes place;
- Predicative information units;
- Contextual information units;
- Associative information units;
- Polyvalent description using various information units.
Various entities, including information units, can constitute the sign-symbolic system resulting in information constructions. At the same time, information constructions can have the property of sistemicity and/or logic coherence. Information constructions as subsystems of the language system can be complex or simple.

Let us start with providing a definition of emergency of information constructions. Emergency is the property of a coherent information construction that consists in the manifestation of properties disappearing when this constructions is broken down in parts. The emergency of information constructions produces an effect that is not peculiar to this whole’s parts. Importantly, information’s emergency can appear only in information constructions that have the properties of coherence and integrality. In the system, emergent information is called system information. This special information is intrinsic to the system as a whole and alien to its parts.

An information construction possessing the property of emergency can be interpreted as a descriptive or prescriptive (procedural) model. In the first case, it provides information and, in the second one, it presents a set of rules. Consequently, two completely different emergent information constructions can be distinguished. Descriptive information constructions can belong to the information, cognitive or intellectual system.

Prescriptive information constructions belongs to an active system, cognitive or intellectual. In this case, the intellectual system can be defined as the generalized human system or simply the system. The cognitive system is a symbiotic relationship between humans and machines.

Emergency becomes manifest during the interpretation of information constructions, in particular, when the property of interpretability comes into view. The information that makes the interpretation of a phenomenon possible is emergent, and the term “emergent interpretation” exists in a theory known as interpretivism. Interpretivism is the possibility of interpretation which is the effect of emergency. The very appearance of interpretivism is what emergency is about. In the study, interpretivism is examined by identifying the network of information system (IS) researchers following in the interpreting tradition by studying the role played by major and alternative IS periodicals and analyzing the discourse aimed at supporting interpreting assertions. This work makes a valuable contribution to the analysis of the general evolution of information systems and brings some conceptual ideas to the theory of emergentism. Another term in use is emergent analysis. In this study, emergency is related to the sustainability of socio-ecological systems, and the sustainability-based approach makes use of the following terms related to synergy and emergency: nonlinear dynamics, threshold values, uncertainty and self-organization. Periods of
systems’ gradual changes are shown to interact with periods of rapid changes. Such
dynamics exists at temporal and spatial scales and is able to produce the effect of
emergency.

At the same time, a distinction is drawn between existing emergency and possible
emergency when talking about research results. For instance, in this is related to the
possibility to add the social aspect to technological evaluations. Studies in this focus
area include understanding of social processes. Among such processes are the
following: social training and social memory, mental models and knowledge system
integration, script vision and construction, leadership, agents and groups of actors,
social networks, institutional and organizational inertia and changes, adaptability,
transformability and adaptive management systems used to manage main ecosystem
services. Combined into an integrated model, such an information ensemble produces
the effect of emergency and can be regarded as emergent information.

Research allows for the definition of the sign-symbolic system in the information
field. Sign-symbolic systems are a variety of complex systems shaped by language
and symbolic constructions. They have structure, elements, semantic relationships
and connections, rules relating to interpretation and construction. In the information
field, sign-symbolic systems use information models, information units and
information constructions.

Research results allow the authors to present the sign-symbolic system (SSS) as a
complex system.

\[
SSS = <\text{Str}, \text{IC}, \text{IM}; \text{SemIU}, \text{SymIU} \text{Sem}, \text{IR}, \text{Sint}>, \quad (3)
\]

In the expression (3), \text{Str} is the system’s structure; \text{IC} – information constructions;
\text{SemIU} – semantic information units; \text{SymIU} – symbolic information units; \text{Sem} –
semantics or semantic interpretation rules; \text{IR} – information relationships; \text{Sint} –
syntax or rules for building language constructions; and \text{IM} – information models.

Information constructions acts as conceptual models and enable implementation of
concepts in the system. Information models are used to perform computer processing
and to apply artificial intelligence and computer interpretation methods to the
semantic analysis of language constructions.

IV. Discussion

Currently, information-related sciences are not a fully developed field.
According to Shannon, information science and information theory do not provide an
information-based description of many phenomena. The term “information
technologies” does not reflect the theoretical framework of information processes. In
the view of the authors, the introduction and application of the notion of information
field will open up new opportunities to integrate and develop the theory of
information sciences and of information processes. The term and notion of
information field is still rarely used in information sciences, and transfer of models
and ideas from one field to another is not congruent because something is lost and
something new emerges during such a transfer. What makes interdisciplinary
modeling valuable is its novelty. There is just one natural language and many information languages, and this is the reason why transfer of models of natural language constructions produces many information copies of such constructions. Sign-symbolic systems are of interest to researchers working on methods of computer information interpretation.

Sign-symbolic systems in linguistics do not linearly mirror sign-symbolic systems in the information field. New implementations appear, when this notion is transferred to the information field.

The authors have not managed to reach a comprehensive solution to issues related to construction of sign-symbolic systems, which is due to a great variety of information field models that need to be arranged and, additionally, bound to sign-symbolic systems. The main objective set by the authors will determine whether such systems can be constructed and further developed.

As part of the study, the authors brought up the issue of information emergency that also needs further research.

V. Conclusion

Sign-symbolic systems in the information field can be perceived as one of the new types of complex systems. These systems are directly applicable in computer linguistics and computer interpretation and can be, complementarily, applied in in formatiology, cognitology and structural linguistics. Information science studies them to a lesser degree as purely formal information constructions. The following specialized models are to be used to conduct research on sign-symbolic systems: sign situation, information situation, information construction, information units, paradigmatic and syntagmatic relationships. Sign-symbolic systems are currently at the early stages of development. They are of various forms and manifest themselves in a variety of ways, and their main functions are as follows: representation, communication, informing and externalization of implicit knowledge. Sign-symbolic systems in the information field are closely related to language systems, but there has been little research into their morphology and syntax so far. In the information field, sign-symbolic systems use a greater number and diversity of models than in semiotics and linguistics, hence the possibility to regard such systems as a booster of new models and ideas.

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