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Symbolic and Figurative Information Units

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Abstract

The article examines two important classes of information units. The multidimensionality of the use of different information units is shown. The article explores symbolic information and figurative information units. The similarities and differences in these groups are shown. The common feature is the systematization of information units into three types: symbols (elements), words and sentences. The divisibility criterion of the original information set determines the type of information unit. The difference between structural and semantic information units is shown. An onomasiological method for obtaining information units in the information field is described. A semasiological method for constructing models using information units in the information field is described. Information units are used in two directions: to detail the description of natural phenomena; for modeling or design. The difference between procedural and object information units is shown. An analysis of information units belonging to different areas is given: computer linguistics, computer language, complex system, information field. A set-theoretic description of information units of different directions is given. There is structural similarity between symbolic information units. It lies in the fact that information units of different types are divided into symbols, words and sentences. The article proves that information units can be considered as the result of analysis. The typological similarity between symbolic information units in linguistics, programming and systems analysis is shown. Figurative information units are more informative compared to symbolic information units. The qualitative difference between the figurative information units pixel and voxel is shown.

Keywords: computer science, information models, information units, symbolic information units, figurative information units, taxonomy.

1. Introduction

Information units are elements of the information field (Tsvetkov, 2014a). In information field theory, information units denote indivisible elements of the information field. Indivisibility is the main feature of information units. There are different criteria for divisibility and indivisibility. The divisibility criterion determines the type of information unit. Divisibility by structure determines structural information units. Divisibility into different types of meaning determines the types of semantic units.

Information units do not exist separately, but are always included in the system of information units (Ozhereleva, 2014). An example of a system of information units is the alphabet of any language. Many information units have a symbolic or formal representation. Such information units

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are called iconic or symbolic information units. There are information units that have a visual figurative representation. Such information units are called figurative information units.

Information units are used in two directions: to detail the description of natural phenomena; for modeling or design. The first direction is related to onomasiological (Bolbakov et al., 2022) modeling. The second direction is related to semasiological modeling (Gurgov, 2023).

Symbolic information units are used in discrete mathematics, applied computer science, logic, and applied geoinformatics. Information units are used in linguistics. Any language can be considered as a collection of information units. Symbolic information units are used in information theory (Ivannikov i dr., 2007).

Figurative information units are used in geometry, in programming, in spatial logic, in cartography, in Feynman diagrams, in design, in topology. Figurative information units are used to write processes as vector fields. There are studies describing information units (Markelov, 2014) or their application. However, to date no attempt has been made to write a general theory of information units. The importance of information units is great, but there is little theoretical research in this area. This determines the relevance of the study of information units.

2. Discussion and results

Information units as a result of analysis.

Any analysis involves division. Analytical division creates formal information units. Image analysis creates figurative information units. An example of a figurative information unit for describing the external environment is a pixel (Gibson et al., 2020), which is a flat object that forms part of a photograph of a snapshot or raster image. An example of an information unit for modeling the external environment is the voxel (Deng et al., 2021), which is a volume element. Figure 1 shows a flat and volumetric information unit.

Fig. 1. Pixel and Voxel

Pixel and voxel have two differences. The first difference is obvious: a pixel is a flat unit, a voxel is a three-dimensional information unit. The second difference between them is in application. The pixel describes the existing reality, that is, it is used for description. The voxel is used to construct a new reality, that is, for modeling.

Associated with the acquisition of information units is the direction of onomasiological information modeling, in which information units are obtained when studying objects. Onomasiological modeling in the information field explores objects and processes by breaking them down into elements. The opposite direction is semasiological modeling. Semasiological modeling in the information field creates models using information units. It is necessary to emphasize the difference in the application of onomasiology and semasiology in linguistics and in the information field.

Symbolic information units.

The description of symbolic information units can be done using a formal approach. From the standpoint of set theory, units are elements of sets. In the field of linguistics, the following types of linguistic information units are distinguished in order of increasing complexity: symbols, words, sentences, phrases. These same types are transferred to the information field. Symbols (elements) or the simplest structural information units have a description

$$x_0 \in ANL \quad (1)$$

In expression (1) x_0 is an elementary structural information unit (element). The ANL set corresponds to the natural language alphabet. Symbols, as a rule, have no meaning. Symbols are characterized by morphology. Characters are obtained by structural division of text. Therefore, they are called structural information units.

Symbols form words, information units of a higher level. Words or semantic (Tsvetkov, 2014b; Nomokonov, 2015) information units have a description

$$x_1 \in Lex. \quad (2)$$

In expression (2) x_1 is an elementary semantic information unit - a word. The Lex set corresponds to the vocabulary of a given language. For example, the Bulgarian language has 35,000 words, the Russian language has 500,000 words. Languages may vary. There are many natural languages. These languages are spoken and written by people in different countries. There are artificial languages, for example, programming language, integrated circuit language, map language. Words as terms can form a semantic network. Elements of the semantic network are information units. The difference between the semantic information unit of a word is the presence of an interpretation for such a unit. This interpretation is called a determination or definition. The Lex set includes not only words, but also definitions for them. Words are obtained by semantic division of the text without taking into account terminological relations.

A sentence is a more complex information unit compared to a word. A sentence belongs to the class of composite semantic information units. Sentences are also called predicative information units. They have a description.

$$x_2 \in (x_1, Lex, Rel, Sint). \quad (3)$$

In expression (3) x_2 is a compound semantic information unit, a sentence, which includes words. The set (Lex, Rel, Sint) corresponds to the vocabulary of a given language, Rel is the terminological relationship between words, Sint is the syntax of a given language. The syntax of a language also determines the set of acceptable relationships between words, including syntactics. The syntax of a language determines the possibility of word formation and the formation of terminological relationships.

A phrase is a more complex information unit compared to a sentence or phraseological information units. They have an extended description.

$$x_3 \in (x_2, Lex, Rel, Sint, Con). \quad (4)$$

In expression (4) x_3 the compound semantic information unit is a phrase that includes sentences. The set (Lex, Rel, Sint, Con) corresponds to the vocabulary of a given language, a set of admissible relationships between words, a set of contextual expressions Con of a given language. In natural language, Con is expressed by pronouns, that is, substitutes for information units of words. This is done to keep the description compact and to avoid repetition in the description. There are relationships between symbolic information units.

$$x_0 \in x_1, Sint1 \quad (5)$$

$$x_1 \in x_2, Sint2 \quad (6)$$

$$x_2 \in x_3, Sint3 \quad (7)$$

In expression (5) Sint1 is the syntax for forming words from symbols. In expression (6) Sint2 is the syntax for forming sentences from words. In expression (7) Sint3 is the syntax for forming phrases from sentences and words. The considered division of information units belongs to the field of computer linguistics.

In the field of programming, groups of information units are also distinguished. Program operands or structural information units

$$y_0 \in APL. \quad (8)$$

In expression (8) y_0, the elementary structural information unit is an argument or a valid symbol of the programming language. The set of APLs corresponds to the alphabet of a programming language. Operators or semantic information units are described in (9)

$$y_1 \in Lex1. \quad (9)$$

In expression (9) y_1 is an elementary semantic information unit operator corresponding to a word. The Lex1 set corresponds to the vocabulary of operators of a given language. There are other semantic information units (machine words).

$$y_2 \in CC. \quad (10)$$

In expression (9) y_2 is an elementary semantic information unit – a machine command corresponding to a word. The set of SS corresponds to a set of commands on the computer

Sentences (program blocks or macro instructions) or composite information units have the form

$$y_3 \in (y_1, Lex1, CC, Rel, Sint). \quad (10)$$

In expression (10), y3 is a composite semantic information unit, a macro-command corresponding to the sentence. The set (Lex1, CC, Rel, Sint) corresponds to the allowable stock of sentences, in accordance with the allowable relations between Rel and the allowable syntax Sint.

In the field of systems analysis, there are also groups of information units. System elements or structural information units are the smallest units

$$z_0 \in \text{ASys}. \quad (11)$$

In expression (11), z_0 is an elementary structural information unit of the system corresponding to the symbol. The set ASys corresponds to the alphabet of system elements. The next group of units is related sets of elements or composite information units

$$z_1 \in \text{Lex1}. \quad (12)$$

In expression (12), z_1 is a composite information unit of the system corresponding to a word. The Lex1 set corresponds to the vocabulary of the constituent elements of the system. The system contains not only descriptive, but also procedural information units.

$$z_2 \in \text{APSys}. \quad (13)$$

In expression (13) z_2 is a composite procedural information unit of the system corresponding to the procedural word. The set APSys corresponds to the alphabet of elementary processes in a given system.

There are blocks in the system.

$$z_3 \in (\text{ASys, APSys, Lex1, Rel, Sint}). \quad (14)$$

In expression (13) z_3 is a composite procedural information unit of the system corresponding to the proposal. Set (ASys, APSys, Lex1, Rel, Sint). corresponds to the permissible supply of elements and blocks, in accordance with the permissible Rel relations between the elements of the system and the permissible Sint syntax for constructing the system structure.

In the field of systems analysis, there are two qualitative types of information units: structural and procedural. In linguistics, there is only one type of elementary information units.

In the field of information analysis or information field theory, groups of information units are also distinguished. Information field elements or symbolic information units

$$w_0 \in \text{AF}. \quad (15)$$

In expression (15) w_0 is an elementary structural information unit of the field corresponding to the symbol. The set AF corresponds to the alphabet of field elements. Composite information units or information models have the following description

$$w_1 \in \text{Lex1}. \quad (16)$$

In expression (16) w1 is a composite information descriptive unit of the field corresponding to the word. The Lex1 set corresponds to the vocabulary of the field's constituent descriptive elements. There are procedural information units in the field.

$$w_2 \in \text{APr}. \quad (17)$$

In expression (17) w2 is a composite information procedural unit of the field corresponding to the word. The set APr corresponds to the alphabet of elementary field processes. In the field there are larger information units - blocks or enlarged information models

$$w_3 \in (\text{AF, APr, Lex1, Rel, Sint}). \quad (18).$$

In expression (18) w_3 is a composite information procedural unit of the field corresponding to the sentence. The set (AF, APr, Lex1, Rel, Sint) corresponds to the permissible supply of elements and blocks, in accordance with the permissible Rel relations between the system elements and the permissible Sint syntax for constructing the model.

Thus, there is a typological similarity between symbolic information units. It lies in the fact that information units are divided into symbols, words and sentences.

Figurative information units.

Figurative information units are formed by dividing the original figurative set in the information field. As a rule, the original figurative set is heterogeneous. Division in the information field is performed from top to bottom, that is, from larger to smaller images. Begin dividing using categories or qualities. Figurative information units are easily modeled by areas or sets. The original heterogeneous set is divided into homogeneous sets or images. Complex and simple images contain information units.

The division of complex images into simple ones is carried out using the “similarity/difference” method. This method is implemented through cluster analysis. Within the

cluster, division is performed using dichotomous analysis (Tsvetkov et al., 2018). Then I check the images within the cluster for dependence and independence. For this purpose, correlative (Tsvetkov, 2012) analysis and oppositional (Deshko, Tsvetkov, 2021) analysis are used.

As a result of dividing the initial information set of images, sets of simple images are obtained, which are checked for proportionality to different information units and models. Simple siu information units or image elements are not related to other information units of the same type.

$$(siu_i) \wedge (siu_j)=0;\ i \neq j \quad (19)$$

Composite information units of images ciu are a linear combination of simple information units.

$$ciu=A1\ siu_1 + A2\ siu_2 + Ai\ siu_i \quad (20)$$

In expression (20), A1, A2, Ai are constant coefficients that are determined empirically. Block information units of images or IM models are a functional combination of simple and compound information units.

$$IM=F1(siu_i) + F2\ (ciu_k) + F3\ (siu_L, ciu_p) \quad (21)$$

Expression (21) structurally corresponds to expression (20). Figure 2 shows figurative information units. The number 1 denotes a figurative information unit, which is an analogue of a symbol. This is a point object.

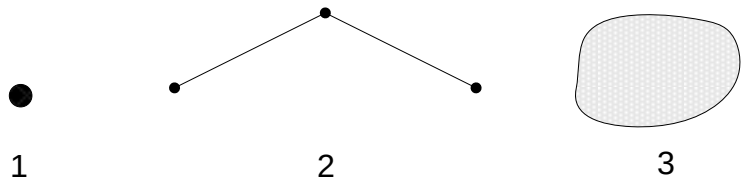

Fig. 2. Figurative information units

The number 2 denotes a figurative information unit, which is an analogue of a word. This is a linear object consisting of two straight segments. The number 3 denotes a figurative information unit, which is an analogue of a sentence. This is an areal object that describes a certain area.

The point figurative object ox_0 belongs to the set of points of this graphic language PL

$$ox_0 \in PL. \quad (22)$$

Unlike the symbol, the dot has an additional morphological characteristic – color. A linear figurative object (Figures 2, 2) or a composite figurative information unit ciu belongs to the set of lines of this graphic language PL

$$ciu \in PL. \quad (23)$$

It has a structure as a linear combination of simple segments.

$$ciu=A1\ siu_1 + A2\ siu_2 \quad (24)$$

Unlike the word, a linear object has additional morphological characteristics: color, line thickness, line type, length, orientation, starting and ending points, shape.

An areal figurative object (Figures 2, 3) or a composite information figurative unit aiu – an analogue of a sentence belongs to the set of areas of a given graphic language PL

$$aiu \in PL.$$

It has structure and shape. An areal object has additional morphological characteristics: color, border thickness, border type, perimeter, area, shading or filling type, shape. The areal figurative object is homogeneous, that is, it has the same shading or filling over the entire area.

3. Conclusion

Symbolic information units are simpler to describe compared to figurative information units. They contain less information uncertainty. Symbolic and figurative information units are similar in type. They can be thought of as symbols, words, and sentences. Information units act as standardized elements of analysis in the study of reality. Figurative information units have a larger number of parameters. Figurative information units are more informative (Nomokonov, 2015) compared to symbolic information units. Symbolic and figurative information units are standardized means of description when describing reality. This description applies to the general picture of the world. The use of information units is diverse. Information units are used as a tool to

ensure the connection of the categories “information”, “information resources”, “knowledge”. Information units are used as elements of semiotics. Semiotic signs are information units. Information units are used as elements of application systems. Information units are used as elements of decision-making processes and as elements of decision support processes. Information units serve as the basis for a comparative analysis of objects and processes. Information units serve as the basis for information design. Despite the widespread use of information units, they are not always called information units. This hinders the generalization of the experience of their application and the development of the theory of information units. The method of using information units is promising for solving many problems.

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