Implementation of Information Needs of ostis-systems Users

Sergei Samodumkin
Belarusian State University of
Informatics and Radioelectronics
Minsk, Belarus
Email: Samodumkin@bsuir.by

Abstract—**The possibilities of knowledge bases of intelligent systems allow you to represent and structure knowledge about the world around you and derive this knowledge about it, thereby satisfying the user's information need. In this paper, the formal specification of the *Question language* for intelligent systems is clarified, which allows describing and interpreting any classes of *questions* of *users of intelligent systems* developed on the basis of OSTIS technology**

Keywords—**OSTIS, intelligent system, question language, information need**

I. Introduction

One of the key features of an *intelligent system* is that the *user* has the opportunity to formulate his information need. One of the ways to express such a need is a *question* [1], [2]. In the process of dialog communication, there is always a context that defines additional information that contributes to the correct understanding of the *meaning* of the message. The peculiarity of the presentation of information in the *knowledge bases* of *ostis-systems* simplifies the formation of the user's information needs, since the information presented in the *knowledge bases* is already structured and the relations set on a certain concept are known, in relation to which the question-problem situation is resolved. The paper [3] shows that the question-problem situation cannot be solved within the framework of formal logic and the nature of the issue can be understood in the system of subject-object relations. Due to the fact that when forming *knowledge bases* of *ostis-systems*, subject-object relations are formed within a given *subject area*, thereby simplifying the expression of information needs by the user by means of *SC-code* [4].

In order to identify specific types of relations, types of questions and classes of answers in papers [5], [6], the need for semantic classification of question-and-answer texts is justified. At the same time, the conceptual basis for the formalization of questions is the language of questions and erotetic logic [7], which allows you to ask question-answer relations.

Within the framework of this work, fragments of structured texts in SCn-code [8], [9] will often be used, which are simultaneously fragments of the source texts of the knowledge base, understandable to both humans and machines. This allows you to make the text more structured and formalized, while maintaining its readability. The symbol ":=" in such texts indicates alternative (synonymous) names of the described entity, revealing in more detail certain of its properties.

II. The purpose of developing

The purpose of developing ***Question language for ostis-systems*** and its subsequent developing is to implement the possibility of understanding the actions carried out by the *ostis-system* when forming an answer to the *question* posed. In the process of forming a conclusion to the *question* posed, the following options are possible:

- the answer to this question exists in the *knowledge base* and a *fragment of the knowledge base* is localized in the context of the *user's* information needs expressed by means of *SC-code*;
- the answer is related to the resolution of some problem situation, which is contained in the context of the *question* and the formation of the *answer to the question* is assigned to the *problem solver*.

Question language for ostis-systems
:=   [Proposed version of the language for describing questions and answers to them in ostis-systems]
∈   *sc-language*
⇒   *syntax of language**:
   Syntax of Question Language for ostis-systems
   ⊂   *SC-code syntax*
⇒   *denotational semantics of language**:
   Denotational semantics of Question language for ostis-systems
   :=   [Ontology of classes of signs and relations for describing the formulations of questions in SC-code]
   ⊃   *Semantic classification of questions*
⇒   *operational semantics of language**:
   Operational semantics of Question Language for ostis-systems
   :=   [Collective of sc-agents displaying answers to the questions asked by the ostis-system user]

III. SYNTAX OF QUESTION LANGUAGE FOR OSTIS-SYSTEMS

Question Language for ostis-systems belongs to the family of semantic compatible languages – *sc-languages* and is intended for the formal description of the search prescription of *ostis-systems* in order to meet the information needs of the *user*. Therefore, the **syntax of the Question Language for ostis-systems**, like the *syntax* of any other *sc-language*, is the *Syntax of SC-Code*. This approach allows you to:

- unify the form of presentation of *questions* and *knowledge*, with the help of which answers to the *questions* posed are built;
- use a minimum of means to interpret the *questions asked by users*;
- reduce the output of answers to most of the *questions* asked to the search for information in the current state of the *ostis-system knowledge base*.

IV. DENOTATIONAL SEMANTICS OF QUESTION LANGUAGE FOR OSTIS-SYSTEMS

Denotational semantics of the Question Language for ostis-systems includes *classes of questions* and corresponding *classes of answers* necessary for the specification of the formulations of *questions* and *answers* to them, as well as *classes of signs* and *relations* included in the structure of any *question*. *Semantic classification of questions* of the *Question Language for ostis-systems* is based on the idea described in the paper [5]. Any **question** in *Question Language for ostis-systems* is a *specification of an action* to search for or generate *knowledge* that satisfies the information need of the *user* initiating this *question*. That is, the *question* — is nothing more than a *problem* by which the user's need for some information is expressed, possibly stored or output in the *knowledge base* of the *ostis-system*.

Each *question* can be uniquely correlated with a certain set of *answers to* this *question*. Each *answer to the question* represents a certain *sc-structure* of the *semantic neighborhood of the main sign* disclosed in this *answer to* the *question*.

question

:=   [request]

:=   [not a procedural formulation of the task of searching (in the current state of the knowledge base) or generating knowledge that meets the specified requirements]

:=   [in what way]

:=   [request for a method (method) for solving a given (specified) *class of problems* or a *plan for solving* a specific specified *problem*]

:=   [problem aimed at satisfying the information needs of a certain customer entity]

⊂   *problem*

answer to the question

:=   [response to the request]

:=   [query result]

:=   [result of solving the problem of finding or generating knowledge that meets the specified requirements]

:=   [semantic neighborhood of the *main sign*, the knowledge of which satisfies the information need of the user]

⊂   *knowledge*

Among all classes of *signs within the framework of a given question* of the *Question Language for ostis-systems*, the most common classes of *signs* in the hierarchy can be distinguished:

sign within the framework of a given question

⊂   *sign*

⇒   *splitting**:

{•   *main sign within the framework of the question asked*

        :=   [key sc-element within the given question]

        :=   [*sign* about which the question is asked]

    •   *non-core sign within the framework of the question asked*

        :=   [*sign* that stands in some relation to the *main sign within the framework of the question asked*]

}

sign within a given question is any *sign of a concept* or *entity* belonging to that *question*. Between the *signs, within the framework of the given question*, a set of relationships of *relations* that are part of various *subject areas* is set. In addition, **any relation within the framework of a given question** is a *relation* between the *signs* of the *subject area* belonging to the given *question*. Among all classes of *relations within the framework of a given question*, one can distinguish a class of **basic relations within the framework of a given question** and a class of **composite relations within the framework of a given question**.

attitude within the framework of the question asked

:=   [a certain relationship between the signs of the *subject area* in the context of the *question*]

⊂   *attitude*

the basic attitude within the framework of the question asked

:=   [*a class of relations* that unites *relations in a given question*, reflecting the same type of *meaning* and revealing a certain feature of the *signs* of the *subject area*]

⊂   *attitude within the framework of the question asked*
⇒   *decomposition**:
{•   *state attitude*
•   *action attitude*
•   *composition attitude*
•   *set-theoretic attitude*
•   *temporal attitude*
•   *spacial attitude*
•   *quantitative attitude*
•   *qualitative attitude*
}

For instance, *relations within the framework of a given question*, such as "plays*", "sleeps*", "swims*", are combined into a *class of state relations* on the basis of expressing the state of the *sign* (that is, these relations reveal the feature *sign* of the *subject area* — "to be in some state").

compound relation within the framework of the question asked
:=   [a stable combination of two *action attitudes*: an action aimed at the *parameter of the question′*, and an action aimed at *answering the question**]

For instance, an element of a *composite relations within the framework of a given question* between the *signs*: "*Oil refinery*", "*oil*" and "*petroleum products*" — can be represented as an "Oil refinery that processes oil into petroleum products".

Semantic classification of *questions* makes it possible to contrast each type of question with a limited set of permissible, in other words, *semantically correct information structures* that convey the correct *meaning* of the *question* depending on the class of the *question*. At the same time, the **semantic classification of questions** allows you to divide a lot of *questions* into classes, each of which requires the disclosure of some of the same type of *meaning* given by the class of this *question*.

question
⇒   *decomposition**:
{•   *question requiring the derivation of the semantic neighborhood of the main sign*
    ∋   *example′*:
        •   *Question. What is the city of Minsk*
•   *question that requires disclosure in the answer of the basic relation of the main sign*
    ∋   *example′*:
        •   *Question. Which is lighter: iron or wood*
•   *question requiring disclosure of the*

composite relation of the main sign in the answer
⇒   *explanation**:
    [This class of *questions* corresponds to the classes of *answers* in which the *main sign* is revealed through a *composite relation*.]
∋   *example′*:
    •   *Question. What are the principles of component design in intelligent computer systems of the new generation*
•   *question requiring disclosure in the answer of an arbitrary combination of the basic relation and/or the composite relation of the main sign*
∋   *example′*:
    •   *Question. How is the intelligence level of a cybernetic system determined?*
•   *question that requires disclosure of more than one main sign in the answer*
∋   *example′*:
    •   *Question. Prove the Pythagorean theorem*
}

question requiring disclosure in the answer of the basic relation of the main sign
⇒   *decomposition**:
{•   *question requiring disclosure in the response of the composition attitude of the main sign*
    :=   [a class of questions in the answers to which the *main sign S* is revealed through its *composition attitude* in conjunction with its constituent signs *P* and *Q*]
    ∋   *example′*:
        •   *Question. Which administrative districts are part of the City of Vitebsk*
            ⇒   *answer to the question**: {Zheleznodorozhny district of Vitebsk, Oktyabrsky district of Vitebsk, Pervomaisky district of Vitebsk}*
•   *question requiring disclosure in the answer set-theoretic relation main sign*
    :=   [class of questions in the answers

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to which *the main signS* is revealed through its *set-theoretic relation* in conjunction with another sign *P* containing *S* as part of]

∋   *example′*:

- Question. Which region is Smolevichi district a part of
  ⇒   *answer to the question**: {Smolevichi district is part of the Minsk region}

- *question requiring disclosure in the answer state relations main sign*

  :=   [a class of questions in the answers to which *main signS* is revealed through its *state relation*]

  ∋   *example′*:

  - Question. Which cities of the modern territory of the Republic of Belarus had Magdeburg law
    ⇒   *answer to the question**: {Volkovysk, Grodno, Mozyr and others had Magdeburg law}

- *question requiring disclosure in response action relationship main sign*

  :=   [a class of questions in the answers to which *the main sign S* is revealed through its *action relation* in conjunction with another sign *P*]

- *a question requiring disclosure in the answer temporal relation main sign*

  :=   [a class of questions in the answers to which *the main signS* is revealed through its *temporal relation* in conjunction with another sign *P* on some timeline]

  ∋   *example′*:

  - Question. Which event happened earlier: The First Section of the Polish-Lithuanian Commonwealth or the Battle of Borodino
    ⇒   *answer to the question**: {The first section of the Polish-Lithuanian Commonwealth was before the Battle of Borodino}

- *question requiring disclosure in the answer spatial relationship main sign*

  :=   [class of questions, in the answers to which *main sign S* is revealed through *spatial relation*, reflecting its position in space relative to another sign *P*]

- *question requiring disclosure in the answer quantitative relation main sign*

  :=   [class of questions in the answers to which *quantitative relation* is revealed *main sign*]

  ∋   *example′*:

  - Question. What is the height of Dzerzhinskaya Mountain

- *question requiring disclosure in the answer qualitative relationship main sign*

  :=   [class of questions, in the answers to which *qualitative relation* is revealed *of the main sign S* in conjunction with another sign *P*]

  ∋   *example′*:

  - Question. The territory of which administrative region is larger: Minsk or Brest

}

question requiring disclosure in the answer of an arbitrary combination of base relation and/or compound relation main sign

⇒   *decomposition**:

{●   *question requiring disclosure in the answer of an arbitrary combination of composite description relation main sign*

  :=   [class of questions whose answers reveal arbitrary combinations of *basic relationship* and/or *composite relationship of the main sign S* in conjunction with other signs]

  ∋   *example′*:

  - {S consists of P, Q, W. S translates X and Y and runs before Z}
    ⇐   *answer to question**: Question. What is S

- *question requiring disclosure in the answer of an arbitrary combination of compound definition relation main sign*

- *question requiring disclosure in the*

answer of an arbitrary combination of compound definition relation main sign

∋ *example′*:

- *{Minsk is the capital, which is located in the Republic of Belarus}*
  ⇐ *answer to question*: Question. How is the city of Minsk defined*

- *question requiring disclosure in the answer of an arbitrary combination of a compound relation of the reason main sign*

  ≔ [class of questions, the answers to which reveal the condition for the existence of some relations *the main sign S* in conjunction with other signs]

  ∋ *example′*:
  - *Question. Why is the travel time from Minsk to Borisov less than the travel time from Minsk to Orsha*

- *question requiring disclosure in the answer of an arbitrary combination composite relation of the consequence main sign*

  ≔ [class of questions, the answers to which reveal the consequence of the existence of some relations *the main sign S* in conjunction with other sign]

  ∋ *example′*:
  - *Question. What follows from the fact that the distance from the city of Minsk to the city of Borisov is less than the distance from the city of Minsk to the city of Orsha*

}

question requiring disclosure of more than one main sign in the answer

⊃ *question requiring disclosure in the answer detail ratio of signs standing in some relationship with main sign*

≔ [class of questions in the answers to which there is a detailing of signs standing in some relationship with *the main sign S*]

∋ *example′*:
- *Question. What is the connection in the same network between the city of Minsk and the city of*

Svetlogorsk

⇒ *answer to the question*: {The city of Minsk is located on the Svisloch River, which flows into the Berezina River, which flows through the city of Svetlogorsk}*

Thus, for each *question ostis system user*, you can find a class *questions* on which you can implement *output of answers* to this *question*. Described by *Semantic classification of questions* allows:

- automatically structure *questions users* according to the description of these *questions*;
- and also form *answers to* these *questions* taking into account *non-procedural formulations* of these *questions*.

V. Operational semantics of Question language for ostis-systems

Each class of *questions* must correspond to a certain *team of sc-agents* implementing the output (search or generation) from *knowledge baseostis-system* of the corresponding answers to the *questions*. It should be noted that depending on the degree of fullness of *knowledge base answers* may be contained in *knowledge base* or absent in the current version of *knowledge base*. If there is in *knowledge base an answer to* the question posed by *question*, the user's information need is implemented by *information retrieval sc-agents* [10], otherwise — depending on *classes of questions*, the implementation of the output of answers is carried out by specialized *sc-agents*, which in the process of work additionally perform computational tasks or perform synthesis based on *logical inference*.

All *sc-agents* that output *answers to* posed *questions* form *team of sc-agents* — **interpreter of the Question Language for ostis-systems**, with which you can interpret any classes *questions*. *a Question Language interpreter for ostis-systems* can be implemented in different ways: in the form of *a team of scp-agents* or *platform-dependent sc-agents*.

Conclusion

Let's list the main provisions of this work:

- the information need of *ostis-system* users can be expressed in the form of *questions*, and the satisfaction of this information need — in the form of *answers to* the *questions* asked;
- the conclusion of *answers to* the *questions by the user of the ostis-system* can be carried out by searching for *knowledge* in the current state of *knowledge base* of this *ostis-system*, or by generating new knowledge that is missing in *knowledge base* of this *ostis-system*;

- each *question* can be presented in the form of some *task specification* initiated by *ostis-system user* to meet their information needs, and *answer to* this *question* — in the form of *semantic neighborhood the main sign within the given question*;
- for each *question*, the corresponding class of *questions* can be found in *Semantic classification of questions*.

REFERENCES

[1] S. Samodumkin, "Technology of intelligent questions-and-answers systems," 2009.

[2] ——, "Semantic technology of intelligent questions-and-answers systems," *Reports of the Belarusian State University of Informatics and Radioelectronics*, no. 7 (45), pp. 67–72, 2009.

[3] L. Averyanov, "Pochemu lyudi zadayut voprosy[why do people ask questions]," *M.: Sociolog*, p. 152, 1993.

[4] V. Golenkov, N. Gulyakina, and D. Shunkevich, *Otkrytaya tekhnologiya ontologicheskogo proektirovaniya, proizvodstva i ekspluatatsii semanticheski sovmestimykh gibridnykh intellektual'nykh komp'yuternykh sistem [Open technology of ontological design, production and operation of semantically compatible hybrid intelligent computer systems]*, V. Golenkov, Ed. Minsk: Bestprint, 2021.

[5] J. S. Suleymanov, "Issledovanie bazovyh principov postroeniya semanticheskogo interpretatora voprosno-otvetnyh tekstov na estestvennom yazyke v aos[study of the basic principles of constructing a semantic interpreter of question-answer texts in natural language in aos]," *Obrazovatel'nye tekhnologii i obshchestvo[Educational technologies and society]*, vol. 4, no. 3, pp. 178–192, 2001.

[6] ——, "Sistema semanticheskogo analiza otvetnyh tekstov obuchaemogo na estestvennom yazyke[the system of semantic analysis of student response texts in natural language]," *Ontologiya proektirovaniya[Design ontology]*, vol. 1, no. 1, pp. 65–77, 2014.

[7] N. Belnap *et al.*, "Logika voprosov i otvetov[logic question and answer]," 1981.

[8] (2023, Feb) IMS.ostis Metasystem. [Online]. Available: https://ims.ostis.net

[9] V. Golenkov, N. Guliakina, I. Davydenko, and A. Eremeev, "Methods and tools for ensuring compatibility of computer systems," in *Otkrytye semanticheskie tekhnologii proektirovaniya intellektual'nykh system [Open semantic technologies for intelligent systems]*, V. Golenkov, Ed. BSUIR, Minsk, 2019, pp. 25–52.

[10] D. Shunkevich, "Ontology-based design of hybrid problem solvers," *Otkrytye semanticheskie tekhnologii proektirovaniya intellektual'nykh system [Open semantic technologies for intelligent systems]*, pp. 101–131, 2022.

Реализация информационной потребности пользователей ostis-систем

Самодумкин С. А.

Возможности баз знаний интеллектуальных систем позволяют представлять и структурировать знания об окружающем мире и выводить эти знания о нём, тем самым удовлетворяется информационная потребность пользователя. В данной работе уточнена формальная спецификация *Языка вопросов* для интеллектуальных систем, позволяющая описывать и интерпретировать любые классы *вопросов пользователей интеллектуальных систем*, разработанных на основе Технологии OSTIS.