UDC 519.711.2

ONTOLOGY OF SCIENTIFIC AND EDUCATIONAL INSTITUTIONS INFORMATION

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Background. The idea to automate the process of scientific and educational institutions evaluation is relevant. Such automation requires information about this institutions functioning to be structured and systematized. The study proposes to use the ontology as one of the models of knowledge representation to organize information of scientific institutions for its structuring and systematization, as well as for its further processing and usage.

Objective. The aim of the paper is to develop the approach to ontological model development for the representation of information accumulated by various scientific and educational institutions and organizations.

Methods. Method of ontological modeling was used as modern means of artifitual inteligence to structure, systematize and analize the information of scientific and educational institutions.

Results. As the result of the research the ontology of scientific institutions information was developed using TEDAOS software platform. Ontology was filled with data. At the moment ontology model includes 895 objects and 2837 data elements (attributes).

Conclusions. The ontological representation allows to evaluate the quality of scientific institutions functioning on the basis of national principles for such assessment. The information how to organize the evaluation process as well as generally accepted evaluation criteria are also stored in the ontological model.

Keywords: scientific institution; quality assessment; information; activity; ontology.

I. INTRODUCTION

Today, there are a large number of public and private institutions providing services in various spheres of social life. The demand for such institutions depends on the efficiency of their functioning. It is for the organizations involved in the fields of science and education that the efficiency of functioning is of particular importance, because the quality of services they provide depends on the future level of the state development and the life of its citizens. That is why there are currently some generally accepted principles for evaluating such organizations. The process of such peer review is outlined and approved in the relevant regulatory documents [1].

In the course of their operation, institutions accumulate a great deal of information (when it comes to scientific and educational organizations such information includes scientific articles, reports, employee ratings, economic indicators, etc.) that can be used to evaluate them according to the national criteria. To evaluate the effectiveness of the organization functioning, it is possible to use information that is already accumulated at the level of the organization. The idea to systematize and structure such information will not only facilitate its use at the institution level, but may also enable it to be used by the relevant authorities in the process of evaluating the quality of the institution's functioning. The study proposes to use the ontology as one of the models of knowledge representation to organize information of scientific institutions for its structuring and systematization, as well as for its further processing and use.

The paper describes the approach to ontological model development for the representation of information accumulated by various scientific institutions and organizations.

The structure of the paper is the following: Section 2 shows analyses of related works and backgrounds for the research. Section 3 gives the description of ontology system structure. In section 4, elements of ontological model are depicted. Section 5 describes main features of TEDAOS software platform that is proposed to be used for ontology development. Section 6 presents conclusions and plans for future work.

II. BACKGROUND AND BASIC NOTIONS

In recent years, it has become necessary to create a user-oriented approach to describing the knowledge accumulated in the information systems due to the rapid development and use of artificial intelligence

technology for the development of such systems. Among the existing models of knowledge representation it is the ontological model that has acquired the greatest use. Ontological modeling is one of the approaches to identify the subject domain, based on the idea of the conceptual modeling. The conceptual model of the subject domain describes it as a set of notions (concepts, terms) and relations between them that correspond to entities from the real world [2]. This corresponds to the classic representation of an ontological model, in which ontology is given by three finite sub-sets: concepts, relations, and functions of interpretation. When modeling the domain as a sphere of activity, the relation between concepts is also a concept describing the relation [3]. Class-related concepts are used to describe real-world processes and phenomena. The conceptual model of the subject area is defined as the totality of notions (concepts, terms) and the relations between them, which correspond to entities from the real world. It is implemented in the form of an oriented labeled graph. The substantive domain model for the conceptual model is given by an oriented labeled graph whose vertices are interpreted as information elements corresponding to real objects of subject domain. There are two types of relations in the integration of models: meaningful, determining the relations of one information element to another, and conceptual that determines the relations of the element to the concept of conceptual software [4].

For intensively developing subject areas, the software model is a structure constantly changing and evolving over time. At the same time, we can say that the content model is a means of accumulating changes that, over time, lead to a change in the conceptual model. The use of dynamic ontologies, that are functions of time (or, as an alternative, include many time periods associated with many concepts and relations) will ensure the relevance and adequacy of ontological models and, thus, make them practically applicable for a wide spectrum of tasks.

The ontologies are new intelligent tools for finding resources on the Internet, new methods for representing and processing knowledge and queries [5]. They are able to accurately and efficiently describe the semantics of data for a certain subject domain and solve the problem of incompatibility and inconsistency of concepts. The ontologies have their own means of processing (logical inference), corresponding to the tasks of semantic information processing. So, thanks to ontologies, when accessing the search engine, the user will be able to receive resources in response that are semantically relevant to the request.

Several approaches to the definition of the concept of ontology are known, but the universally accepted definition does not exist, because depending on each specific task it is convenient to interpret this term in different ways: from informal definitions to descriptions of ontologies in concepts and constructions of logic and mathematics [6]. The ontology is an attempt to formalize a certain field of knowledge using a conceptual scheme comprehensively and in detail. Typically, such a scheme consists of a data structure containing all relevant classes of objects, their relations and rules (theorems, restrictions) adopted in this area.

Formally, the ontological model can be specified as:

$$O = < C, R, F >,$$

where C – is the finite set of concepts (concepts) of the domain,

R – is the finite set of relations between concepts,

F – is the finite set of interpretation functions defined on concepts and/or relations.

The ontological approach allows continuous improvement of the model on the basis of basic ontologies through their completion and development [7]. The ontology includes both a description of the subject domain and a description of the relevant resources. The part of the ontology that describes a specific subject domain includes a set of terms and relations semantically meaningful for a given domain, as well as rules according to which statements about the elements of the domain can be constructed.

Among the advantages of using an ontological model there are as follows:

– structuring and systematization of domain information,

– organization of semantic search,

– automated integration with the semantic web duck,

– a large number of existing software and web applications to develop ontological models.

In the era of Big Data, the management and integration of big on-board data provide tremendous opportunities for generating new knowledge. The ontologies, that represent domain knowledge in the form of concepts, their classes, and the interconnections between them, are a versatile tool for overcoming barriers to integrate data and knowledge from diverse sources of information, thus facilitating the search for new knowledge.

It is ontological models that can be used as a universal tool for integrating data and knowledge from diverse sources of information. Using ontologies allows you to structure, organize and classify information. An important characteristic of ontological models is that its

structure a priori fits into the paradigm of the semantic web that makes it possible to automatically adjust and use the developed ontology in the Internet environment. Such a feature is in demand in terms of the development of modern information systems, the main requirement of which is to provide online access to users in real time.

III. ONTOLOGY SYSTEM SCIENTIFIC INSTITUTIONS INFORMATION REPRESENTATION

The functioning of scientific organizations is associated with certain specific features that are not characteristic of other types of institutions. For example, the important indicators of the scientific process are as follows - the number of publications, citations, various scientific indexes and ratings, participation in international projects and programs, completed scientific topics, trained specialists of different qualification levels in different specialties and specializations, and more. That is why the information produced during the operation of such institutions also reflects all levels (aspects) of such functioning. This feature must be taken into account when developing an ontological model. Also, several basic processes are involved in the process of organization of scientific activity: organization of activity of institution; definition of indicators by which it is possible to identify the level of performance of a certain type of activity in an institution; the existence of criteria for evaluating such indicators by which it is possible to evaluate the achievements of the organization and to determine whether its activity meets the requirements; organization of the institution's evaluation process itself.

On this basis, it is proposed that in the general ontology, several ontologies be highlighted in order to represent information accumulated by scientific institutions. As a result of this selection, the overall ontology will be a system of ontologies, each describing the appropriate sub-process within both the activities of the institution itself and the process of its evaluation. The system as a whole will allow both to structure and organize the information accumulated by scientific institutions, and to organize context-independent structures for its further processing and use.

Thus ontology system is a collection of several components (Fig. 1).

The developed system includes such ontologies as:

– Ontology of institutions activities – reflects all possible processes that occur within the scientific process within the activities of scientific institutions.

– Ontology of institutions activities organization – describes general concepts that relate to the organization of scientific activity as a whole.

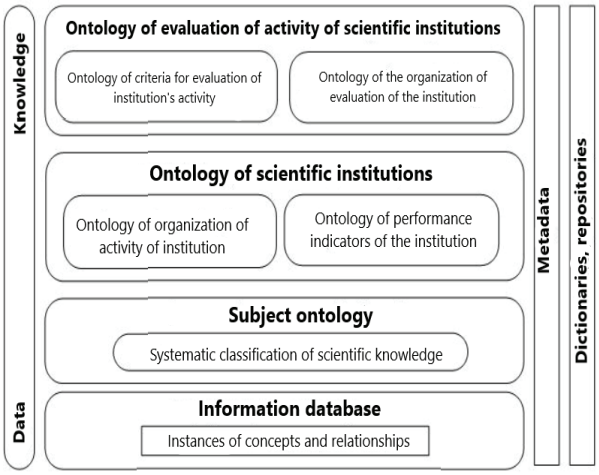

Fig. 1. Ontology system of scientific institutions information representation

– Ontology of institution activities indicators – allows describing in detail the indicators on all aspects of the activity of the institution.

– Ontology of institutions activities evaluation – introduces concepts that make it possible to evaluate the effectiveness of the scientific activity of a particular scientific institution in the framework of its state review or establishment of its scientific level.

– Ontology of institutions activities evaluation criteria – sets criteria for evaluating the performance of the institution.

– Ontology of evaluation process organization – describes the assessment process itself by the relevant authorities.

– Ontology of subject domain – is based on the systematic classification of scientific activity.

Instances of classes and relations defined in an ontology form a database content that contains terms that represent the subject domain. Initial data for the knowledge representation model that characterize the subject area are various regulatory documents, as well as textbooks, manuals, periodicals, reports, information resources and more.

Such an ontology system will not only enable the representation of information accumulated by scientific institutions in the process of activity, but also organize structures for its further use and processing.

IV. ONTOLOGICAL MODEL ELEMENTS

In the process of constructing an ontological model, there is a need to describe its elements. The ontological model includes the following elements [8]:

Ontological model = <classes, attributes, relations, types of attribute values, constraints on attribute values, instances of classes>,

where *classes* are elements of an ontological model that describe the concepts of a particular subject or problem area;

attributes – are elements of the ontological model that describe the properties of concepts and relations;

relations – are defined on classes, and display either the relations of classes with

each other or the relations of classes to data or attributes. There are relations of the following types:

- associative relations – allow to perform meaningful searches through the ontology information space,
- part-to-whole relations – allow you to establish relations between classes at the hierarchy level,
- inheritance relations – is used to pass attributes and relations from parent to daughter,
- class-data relations – allow to associate instances of concepts with class;

attribute value types - specify standard types for class attribute values (for example: string, integer, real, date);

restrictions on the values of the attributes of concepts and relations – is used not for all attributes, but only for those whose values must lie in a certain area, they can not be less/more than a given value or they are determined by a certain rule. For example, the value of the attribute "start date" of some ontology class is constrained by *T (date) = date F(T) > 0*.)

class instances – are an ontology element that displays specific domain data that obey the structure of the ontological model.

In the course of the study, the described ontological model elements were identified for all ontologies proposed in section 3 of the ontology system. The process of detailing the elements of an ontology is an important step in designing a general ontological model that will allow you to set structures for further filling the ontology with domain information (instances of classes).

V. ONTOLOGICAL SOLUTIONS DEVELOPMENT PLATFORM

The practical implementation of the ontological model and its filling was performed using the Transdisciplinary Educational Dialogues of Application Ontology Systems (TEDAOS) platform. The TEDAOS platform provides many software tools for storing and processing knowledge through the development of ontologies. The TEDAOS platform is designed to support the processes of linguistically-semantic analysis of large volumes of spatially distributed unstructured information (Big Data), their structuring, establishing contextual links between the documents being processed, forecasting and supporting the processes of rational choice with the subsequent formation of information-analytic WEB-oriented solutions.

The TEDAOS platform provides [9]:

– networking with large volumes of unstructured and poorly structured information,

– semantic content analysis,

– aggregation and rating of information resources,

– integration with other network information systems and WEB-oriented applications,

– creation of ontological interactive documents,

– detection of latent information in the analyzed information resources.

One of the main features of the TEDAOS software platform is the availability of ontological interface tools in the nomenclature. The ontological interface gives an opportunity to integrate the developed by the user ontology with network information resources and interactive knowledge systems. It provides adaptability to the thematic profile of the activity of each user subject in the TEDAOS environment. The ontological interface is implemented by the procedure of activation of multiple binary taxonomy relations. It is an intellectual means of user interaction with an ontology-based information system, that allows visualizing the results of integration and aggregation of distributed information resources in the process of organizing users communication in an easily accessible visual form [10].

Fig. 2 shows a fragment of an ontological model of scientific institutions information representation developed using TEDAOS.

Fig. 2. Fragment of ontological model for scientific institutions information representation developed using the TEDAOS platform

VI. CONCLUSIONS

The paper presents an approach to the representation of information accumulated in various scientific institutions on the basis of ontological model. The ontological representation allows evaluating the quality of scientific institutions functioning on the basis of national principles for such assessment. The information how to organize the evaluation process as well as generally accepted evaluation criteria are also stored in the ontological model. The associative relations between objects that are determined in ontological model allow linking the institution activities indicators with the evaluation criteria for assessment process automation.

Future researches will focus on further ontology development and its filling with subject domain information, as well as on the novel method implementation for scientific institutions functioning assessment based on ontology.

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Онтологія інформації наукових і освітніх установ

Проблематика. Ідея автоматизувати процес оцінювання наукових та навчальних закладів є актуальною. Така автоматизація вимагає структуризації та систематизації інформації про діяльність цих установ. Дослідження пропонує використовувати онтологію як одну з моделей представлення знань для організації інформації наукових установ для її структурування та систематизації, а також для подальшої обробки та використання.

Мета дослідження. Метою статті є розробка підходу до розробки онтологічної моделі для представлення інформації, накопиченої різними науковими та освітніми установами та організаціями.

Методика реалізації. Метод онтологічного моделювання був використаний як сучасний засіб штучного інтелекту для структурування, систематизації та аналізу інформації наукових та навчальних закладів.

Результати. В результаті дослідження онтологія наукових установ була розроблена за допомогою програмної платформи TEDAOS. Онтологія була наповнена даними. На даний момент модель онтології включає 895 об'єктів та 2837 елементів даних (атрибутів).

Висновки. Онтологічне подання дозволяє оцінити якість функціонування наукових установ на основі національних принципів такого оцінювання. Інформація про те, як організувати процес оцінювання, а також загальновизнані критерії оцінки також зберігаються в онтологічній моделі.

Ключові слова: наукова установа; оцінка якості; інформація; діяльність; онтологія.

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Онтология информации научных и образовательных учреждений

Проблематика. Актуальна идея автоматизировать процесс аттестации научных и образовательных учреждений. Такая автоматизация требует структурирования и систематизации информации о функционировании данного учреждения. В исследовании предлагается использовать онтологию как одну из моделей представления знаний для организации информации научных учреждений для ее структурирования и систематизации, а также для дальнейшей обработки и использования.

Цель исследования. Целью статьи является разработка подхода к разработке онтологических моделей для представления информации, накопленной различными научными и образовательными учреждениями и организациями.

Методика реализации. Метод онтологического моделирования использовался как современное средство искусственного интеллекта для структурирования, систематизации и анализа информации научных и образовательных учреждений.

Полученные результаты. В результате исследования на программной платформе TEDAOS была разработана онтология информации научных учреждений. Онтология была заполнена данными. На данный момент модель онтологии включает 895 объектов и 2837 элементов данных (атрибутов).

Выводы. Онтологическое представление позволяет оценивать качество функционирования научных институтов на основе национальных принципов такой оценки. Информация о том, как организовать процесс оценки, а также общепринятые критерии оценки также хранятся в онтологической модели.

Ключевые слова: научное учреждение; оценка качества; информация; деятельность; онтология.