Practical application of systemizing expedition research results in the form of taxonomy

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Abstract. Data processing is complicated nowadays due to its vast amount and low structuration level. Perspective field to provide such structuration is exceptional studies because, in most cases, they foresee measuring parameters planned before such expeditions. Therefore, it is possible to define the parameters that will be measured and prepare forms to fill them during the expedition. This study substantiates the way of processing such data in the form of ontologies, providing structuring and interoperability of expedition data by providing a similar structuring approach. The case of using such an approach based on real-life expedition study in the field of the environment of the National Center "Junior Academy of Sciences of Ukraine" is described. The approach foresees using Excel to define the parameters that will be measured during an expedition in the form of table's columns. Each row in such a table will represent the place or name of the research object. An additional column is devoted to inserting geolocation. After providing the research, such files are uploaded into Polyhedron system and ontology is generated. Such ontologies are stored and integrated into ArcGis and can be used to present their own results and provide background research by other researchers.

Keywords: ontological journal of expedition, geoinformation systems, GIS, expeditional reseach

1. Introduction

The formation of a student's personality adapted to modern life requires the use of new priorities in the selection of methods and forms of education in the higher education sector. Due to the need for students to process large amounts of information, the formation of their ability to think critically is a priority [3, 13, 33]. Also, one of the main tasks of modern education is the

formation of the student's creative thinking [5, 30, 32]. When designing the educational and training environment, special attention should be paid information technology component, focusing on the use of scientific and engineering methods. This need is most relevant for the educational environment of higher education institutions of engineering profile, as it operates to form students' research abilities. For the educational environment, it is essential to build systematic training, which should be based on the active use of these methods in the work of specialized departments. It was provided that students more effectively studied while he provides his research. It is due to the interdependence of the object's parameters he studies [4].

Scientific and engineering methods are the basis of any research process [21], regardless of the specific field of knowledge. Both methods have been practised for a long time and are now recognized by the international scientific community as the primary tools for scientific and educational research activities. The contextual content of the scientific method can be schematically represented. The scientific research method is presented in the form of an algorithm in figure 1.
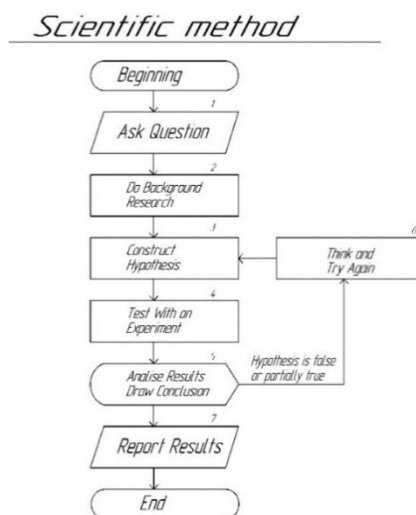

Figure 1: Stages of the scientific research method.

The formation of students' research skills following the scientific method in the educational process should begin with formulating a scientific problem or question, which is determined in the context of a more significant scientific problem. The researcher is interested in a particular issue (formulation of the question) and conducts theoretical and literary research in this area (previous research). Additionally, the researcher can create a hypothesis (constructing a hypothesis) about the object under study [4]. The next step is to develop an installation for research and experimental test of the hypothesis ("is experiment works?").

Quite often, the investigated installation cannot provide confirmation or refutation of the hypothesis, and then the researcher must return to the stage of preparation of the laboratory installation and make changes to it. In the case of obtaining results based on which it is possible to draw certain conclusions about the hypothesis, the results are analyzed [23, 31]. The results that confirm the hypothesis or refute it draw up (presentation of results). If the hypothesis was

refuted, the researcher builds a new hypothesis based on the obtained data (returns to the step of constructing the hypothesis).

At the stage of background research, the researcher searches for information according to various criteria, one of which is the geographical relevance of the results. To find information about a particular object, the student must familiarize himself with similar research conducted previously. However, the most relevant for a young researcher is to get acquainted with scientific works that have been performed geographically close to the object of interest of the researcher.

Additionally, an important problem in conducting a literary review by a student: is the accumulation of "information garbage". Therefore, it is essential to develop ways to solve this problem, so the *aim of the study* is to propose a method of visualization and structuring of data obtained in expeditionary research, which other researchers could potentially use to conduct the literature review phase. The proposed approach is based on taxonomies and ontology approach due set of factors described below.

1.1. Features of the ontological systems

Ontology is a section of philosophy, the doctrine of existence, which explores the general principles, principles of existence, structure, and patterns. In computer science, ontology is a discipline associated with the construction of a specific system of concepts that describes a particular subject area. The content of concepts is reflected through concepts. Formally, in an ontology, a concept is identified with an object (class) connected to other classes. A class is defined as a set of instances with common properties and contains descriptions of the actual instances and their properties.

In this article, an "ontology" is a term that means some software or web system that consists of nodes with specific data. All nodes are arranged in a particular hierarchical order, often referred to as a tree or graph. The node from which all branches go is called the parent. The other nodes are called subsidiaries. If there are no additional branches in the graph from the child nodes, then this graph is called simple. The graph that describes concepts and their relations is called ontology. An ontology necessarily entails or embodies some sort of worldview concerning some domain. The helicopter view is often conceived as a set of concepts, entities, attributes, or processes, their definitions, and their interrelationships; this is referred to as conceptualization [22]. Also, all ontologies consist of vocabulary and some specification of the meaning or semantics of the terminology within the vocabulary. The various ontologies are also distinguished by their degree of formality in the specification of meaning [22].

The particular computer program Grafeditor [9] can be used to visualize the creation of ontological models. The initial for inputting data for the Grafeditor are descriptions of objects represented by many semantic characteristics. The main ontology components in Grafeditor are a node (vertex). It is an elementary component of the ontology and a data array. The root node is the type of node that defines the main direction of the ontology. Secondary nodes are a set of all nodes except the main one. Finally, link is a relationship between nodes of an ontological graph that indicates the structural relationships between the nodes of an ontology.

A range of open-source tools devoted to creating ontologies are available. They are called ontology editors. Today a variety of developing environments are used to create ontologies like Protégé 3.5 [18], Apollo [2], SWOOP [12], OilEd [15], IsaViz [11], Polyhedron. We propose

to use cognitive IT Polyhedron. The core of the Polyhedron system contains advanced and improved functions of the TODOS IT platform, which were previously used to provide semantic web, systematization, transdisciplinary support, and GIS connectivity [28].

Cognitive IT Polyhedron can use the feature of ontological interface tools [17, 25]. This system has a web-oriented interface and provides the creation of interactive knowledge systems, which provide adaptability to the thematic profile of each user subject in the Cognitive IT Polyhedron environment. The ontological interface is implemented by the procedure of activation of multiple binary taxonomy relationships. It is an intelligent means of user interaction with an ontology-based information system that allows visualizing the results of integration and aggregation of distributed information resources to organise user communication in an easily accessible visual form [28].

IT Polyhedron is based on a multi-agent approach. Usually, the resources on which the information is located are narrowly targeted. Combining such resources as agents of Cognitive IT Polyhedron is the ontology-oriented system that provides transdisciplinary and interactivity of any educational and scientific research [27]. In the environment of the Polyhedron system, the construction of all chains of the process of transdisciplinary integrated interaction is ensured: a semantic content analysis of text documents; taxonomy; highlighting the properties of taxonomy concepts; formation of the ontology of the choice problem; transdisciplinary integration of contexts, based on properties-criteria concepts that determine the ontology of choice; the inclusion of documents found in the global environment through the recursive procedures of the system and the linguistic corpus [28].

Usually, the resources on which the necessary information is located have a narrow subject orientation. Combining such resources as its agent in the ontology-oriented, the Cognitive IT Polyhedron system allows for transdisciplinary and interactive components in educational research.

Due to active states being hyper-ratio plural partial ordering [14, 29], cognitive IT Polyhedron is an innovative IT technology for ontological management of knowledge and information resources regardless of the standards of their creation.

The innovative component of Cognitive IT Polyhedron has its unique features. For example, there is a function comparison with some standards called auditing. One of the applications in ecology is the use of environmental standards to compare and determine the status of specific objects. For example, previously, it has been scientifically justified to apply this methodology use of this method to estimate water quality in reservoirs [26].

1.2. The concept of expositional ontological journals

One way to reach such the aim of study is to take a comprehensive approach to using geographic information systems (GIS) [1, 10, 20] and an ontological journal. Recently, many methods have been developed to visualize scientific information, taking into account the geographical relevance of scientific data. New in the field of data analysis and visualization is the method of using GIS to present expedition results. The student and teacher's use of such information, presented in the form of the proposed approach, allows for improving the quality at the stage of previous research.

GIS is the most natural and convenient way of presenting geospatial information [25]. How-

ever, the GIS construction can be a rather complicated process if available geospatial data is presented in documents containing weakly structured or even unstructured information. Manual handling of such documents can be an extremely labour-intensive process, and the processing of large amounts of such documents is almost impossible. Therefore, before working with weakly structured or unstructured documents, it is necessary to structure them. During this process, the data is presented in an easy-to-handle form, which can easily be read by standard GIS tools and conveniently displayed to the end-user. This, may provide an opportunity to find hidden information in the input data [25]. The most complicated is the implementation of the structuring of NL (natural linguistic) texts because this process requires a sufficiently complete formal description of the subset of the language to which they belong. Each text describes a specific subject area (SSA) or a part of it. At the same time, the terms related to the SSA used in the text form its terminology field. The structuring of the text consists of isolating it from this terminology field, particularly the identification of the concepts of the corresponding SSA and their attributes and interconnections.

Any ontological GIS is formed based on a structured representation of the subject area of its application. Structuring is usually based on classes of objects, the properties of which determine the semantics of the subject area. The properties of objects directly allow us to determine the set of relationships between them. Multiple order binary relations are a type of hyperlink with specific properties: acyclicity, partial ordering, and linear ordering, and provide the formation of different classes of GIS objects of taxonomic structures. It should be noted that taxonomic categories are formed based on allocating a specific subset of objects with a common property that characterizes them all. This property may be unique to each object, but by defining a specified class as a complex category, such a property allows to define many binary relations "to be an element of a class" of general concepts of a class. It should be noted that a single property, which is familiar to many concepts of the subject area, can be interpreted as a feature of these concepts or as a criterion for selecting concepts of this class [19].

Constructions that describe the state of the process of problem-solving in the GIS environment can be represented by different terminology: natural language, predictive formulas, equations of different types and types, graphical schemes, etc. The ontological system must have complex means of synchronizing syntactic descriptions of both the objects used and the statements themselves, representing specific states of the problem [19].

2. Material and method

Ontologies were created using tools of Cognitive IT Polyhedron using Ontology Editor. Two types of sheets, XLS to create structure (hierarchy of nodes; in further – structure file) and CSV to add internal information for numeric and semantic data (in further – data file), were uploaded to Ontology Editor to generate hierarchy. After generation, ontologies were uploaded to the store (if it was necessary to use specific functions, they were chosen at the download menu). To store information and share it, google sheets were used, with their further conversion into the .xls and .csv Excel sheets (figure 2). A general view of the ontology library in the proposed Grafeditor is shown in figure 3.

The generated structure is displayed classically as a nodes tree, taking into account the

Figure 2: Google sheet with data.

relationships. An example of displaying information in Grafeditor [9] of the cognitive IT Polyhedron system is presented in figure 4. The structure of the information visualized in the ontological system corresponds to element 1 (figure 4). Element 2 (figure 4) is a visualization part of the ontology structure, which arises due to the presence of media files in the form of included information of the ontology. Included information on the Grafeditor system is represented by element 3 (figure 4). At the top of the display of embedded information is a visualization of node's information, and below – is additional textual or visualization information. For creating ranking, ontologies were used module "Alternative".

2.1. Creation ontologies using module "Alternative"

Module "Alternative" can be used to provide filtering of information [8]. It was necessary to create nodes of a graph filled with semantic data grouped in semantic classes to achieve this. This function was used to create a general ontology of the wastewater treatment system and concrete ontologies of technologies devoted to finding concrete parameters of technologies. To provide this, the sheets were prepared as was shown before.

To create both ontologies, were created three sheets. As was noted before, they were the structure in datasheets, and they were provided with an additional sheet with pictures links for each node. Inputted information in the node was structured by semantic classes located in table rows. Describing node of ontology was determined by cells located in a column. At their intersection was located semantic data related to concrete semantic class and concrete node of the ontology. One node can contain one or more pictures, for example, real-life installation, principles of working, and technological scheme. For building ranking systems, only numerical values and ranking were selected during saving graphs in the database were used.

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+ МЕДИЦИНА
+ SCENARIO
+ Ecology
+ СППР
+ Жемчужинка
+ БЕРЛИН
+ Текущие проекты
+ Класифікатор - задачі
+ Програми
+ TEMPUS
+ Кафедра медичної інформатики
+ Заочні школи МАН
+ Регіональний розвиток
+ НАЦІОНАЛЬНА АКАДЕМІЯ НАУК УКРАЇНИ
+ Банк інтелекту
+ НОРМАТИВНА БАЗА
+ УКРПАТЕНТ
+ МАНЛаб
        + Експедиційні дослідження
        + Дослідження
        + Обладнання
        + Хіміко-біологічна школа
        + Загальна фізика
        + Очищення промислових стоків
        + Визначник грибів
        + Пшениця
        + art
        + Школы
    → Дослідження коливань тіла на пружині (v3)
    → Очищення стічних вод (v3)
    → Підбір лабораторного обладнання (v3)
    → Оборудование НУХТ (v3)
    → Продукти (v3)
+ ХАРЧОВА ПРОМИСЛОВІСТЬ
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Figure 3: General view of the library of ontologies.

3. Results and discussion

3.1. Principles of knowledge systematization

Nowadays, a large amount of information is in an unsorted condition. This phenomenon was associated with the strong growth of humanity's scientific and technological progress.

The information created by a human is a potential "information garbage" in the case of its placement on the Internet without its structurization. Any helpful information placed in a chaotic mode does not bring any use to the user. To reduce the amount of "information garbage,"

Figure 4: An example of displaying information in the Grafeditor system.

it is advisable to sort and classify information [24]. Any information contains several classified features, called "Direction", "Class", "Type", "Subtype", etc. Defining such characteristics allows us to find the information that we need quickly. Such characteristics in the ontological approach indicate semantic characteristics.

For example, ecological research of river Dnieper properties the following semantic characteristics:

- Type of information: Research
- Direction: Ecology
- Class: Hydro ecology
- Subclass: Study of the river

The information sorted on such characteristics allows the researcher to quickly and efficiently find the necessary information in this field of ecology.

One approach to information retrieval is to search for specific information elements. For example, for writing a scientific paper on the diffusion of chloride ions in the river, objects firstly need to find information about the concentration of chlorine ions in different places of the river and the necessary patterns of their deposition. In this case, we are interested in specific data related to a specific characteristic of this substance, and therefore it is advisable to allocate an additional subclass for any of the specific indicators. It seems relevant to provide classification using both GIS and ontology systems [6, 7, 16]. The principle of the complex approach is to embed ontologies in a point on the GIS with the author and the analysis date to take into account the reliability of the result. Using geographical coordinates in a structured ontological form allows us to get the most effective access to information.

Implementing a complex approach will permit creating databases for research in various areas, performed by different researchers and research institutions that store material in a structured form.

3.2. Creation of ontological journals

It is proposed to use ontological journals to systematize research knowledge. Ontological journals are an ontology designed for multifunctional analysis and systematization of information. A feature of the ontological journal is the separation of semantic characteristics in the study (for further structuring). The general view of the ontological journal is presented in figure 5.

Figure 5: General view of the ontological journal.

The peculiarity of the ontological journal is the high level of structuring and visualization of data, the possibility of transition between related nodes, and the search for semantic connections between vertices and their elements. Visualization of scientific data in the form of an ontological journal is presented in figure 6.

Figure 6: Visualization of scientific data in the ontological journal.

The figure shows that large arrays of information obtained during the study are grouped and structured, and the transition to scientific data is quick and clear.

The initial data for the program Grafeditor are descriptions of objects, represented by many of their features. The initial data can be presented as a text file.

For preparing the ontology, it is proposed to use the Excel format tables to construct the ontological tree and nest in the ontological node's information in the ontological journal form (figure 6).

A general view overview of the template for creating a logbook is shown in figure 7. The template for the created ontological log is an Excel file stored in CSV format.

Figure 7: General view of the template for creating an ontological journal.

Figure 7 shows an ontological journal template for water analysis. The main information classes are pH, Cond, Min., Hardness, Cl, SO_4, Pb, Fe_{total}, Fe (II), Fe (III), Cu, corresponding to the indicators: acidity, conductivity, mineralization, chloride content, sulfates, lead, total iron, ferrous iron, ferric iron, and copper. The names of the information classes are abbreviated according to the comparison ontology file. Templates of ontological journals for different types of ecological research have been developed and proposed for use.

A developed ecological map envisages structuring the material according to the criteria of ecological direction – analysis of air, water bodies, soils, elements of the biosphere, etc. Criteria for environmental structuring are presented in the form of layers in ArcGIS. This approach allows the analysis of materials to group the material by the maximum number of study aspects.

The use of obtained data through this method is very relevant in forecasting results. For example, the developed map on ecological studies of quality of soils will allow the scientist to continue research on directions migration or vice versa – the accumulation of chemicals in biological systems. Furthermore, the proposed GIS aims to visualise environmental research by students of extracurricular educational institutions throughout Ukraine. In this case, the data of own research and other researchers conducted in the specified territory are used to carry out preliminary research.

The use of geographic information systems is one of the modern areas of visualization of scientific data, particularly in environmental research. However, the widespread use of GIS leads to the accumulation of large amounts of data on a single map. Therefore, it is essential to develop thematic GIS maps, where information is displayed concerning a specific topic.

To enter the data on the map, it is proposed to use the geo-information system ArcGIS based on the ecological map of the students of the National Center "Junior Academy of Sciences of Ukraine" (JASU). Creating GIS ontology also needs additional inputting geographical coordinates separately in the data file. Obtained graph from XML format is needed to download on a particular GIS server of Cognitive IT Polyhedron, named ArcGIS. To place the ontology on the map, it is necessary to provide the following actions: enter data on the attributes we do need, which we previously set in the data file (figure 8, field which occurs after selecting the location of the analysis on the GIS), Enter a reference for ontology in the "ontology" cell, click the "OK" button.

Figure 8: GIS data input table.

ArcGIS is a geographic platform for an organization that allows to create, manage, and share geographic information and tools through interactive web maps and applications. The advantage of the platform is the ability to implement both in the local network and the cloud environment, providing access from any device: personal computer, web browser, smartphone, or tablet computer.

ArcGIS system is a way of presenting information with graphical visualization of data linked to geographical coordinates. Visualization is carried out based on geographical maps with the ability to create "points" of the objects of analysis. A general view of the GIS is presented in figure 9.

Zooming and control of the map viewing area are performed using "element 1". To control
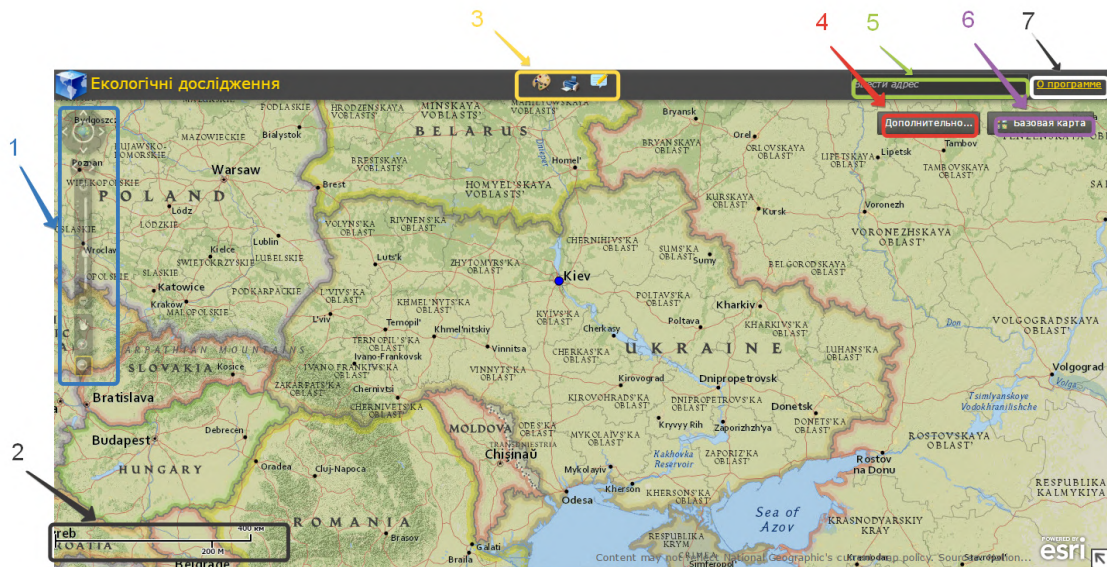
Figure 9: General view of the GIS.

the scale, the following is used: a scale that shows the scale by the ratio of the virtual size to the real one (for example, 1:100,000). Also, the scale can be changed using the tools of increase and decrease (11 and I and respectively).

Control is performed using the "move" tool (EC) on the control panel of the viewing area. In addition, for automatic control, there are orientation arrows on the control panel to move the map work area in different directions.

"Element 2" visualizes the scale of the map; it is a ruler that reflects a constant segment in space (regardless of the change in scale), but the numerical value of the segment changes when the scale changes (for example, 50 km, 100 km).

Map tools are shown in "element 3". The tools include "drawing" (E2), "printing" (9), and "change" (II). Finally, "Element 4" is responsible for displaying the layers on the map. The layers on the map correspond to the types of objects propose to create in filling the map.

Search for a point on the map using "element 5" is carried out. The search can be performed by the names of geographical objects and coordinates. To perform a search, left-click on the address entry area and enter the coordinates or name of the geographical object.

"Element 6" is responsible for the type of map display. Using this element, in particular, change the map type from political to physical.

"Element 7" is designed to display information about the program.

A system has been developed to analyse the data depending on the geographical relevance of information by integrating scientific knowledge with the geographic information system. Furthermore, it is possible to structure the material by systematizing information in ontological graphs and making a transition between GIS and ontological graphs.

Transdisciplinary research has a unique potential in applying an integrated approach to GIS and ontologies. There is a relationship between the natural sciences, which is often essential, but

insufficiently studied. Sometimes it is necessary to conduct research that explains the chemistry of physical processes or when physical laws explain the migration rate of chemicals. The use of GIS technologies allows us to conduct a transdisciplinary preliminary study on the chosen topic by the student of JASU.

Searching for relationships between the states of geospheres on the ecological map is one of the elements of ecological analysis, which is possible with the accumulation of information about the quality of different geospheres. It is necessary to separate semantic categories of the received information presented in the form of ontological journals for further systematization and the possibility of searching for the information and reducing the quantity of "information garbage" in the field of science. The application of the proposed technology will improve the quality of the preliminary research and allow us to choose the highest quality material for its processing in the scientific activity of the student.

3.3. Creation of a system of visualized scientific databases and further potential of its use

The principle of the complex approach consists of embedding ontologies in a point on the GIS map with the indication of the author and time of carrying out the analysis for the account of reliability and result. Placing information concerning geographical coordinates in a structured ontological form allows to get the highest quality access to information.

The development of an integrated approach will allow the creation of research databases in various fields performed by different researchers and research institutions that store material in a structured form.

Structuring based on GIS provides the potential to view related information and search for patterns associated with the coordinates of the location of specific properties of objects. Further development will allow us to accumulate structured information that does not turn into "information garbage".

Such systems are essential for developing environmental expertise and the creation of an environmental safety system. In the future, such systems can be fully used as the primary tool for the functioning of the eco monitoring system with the system of data analysis and forecasting.

4. Conclusions

It is proposed to use an ontological approach for data structuring and GIS for displaying geospatial information and visualizing scientific data, improving the quality of students' research. The structured data gives some advantages additional to simplifying the way of data search such as processing of data (filtering and rank). The template-using approach is proposed to simplify the input process during expeditions. The use of GIS in complex with ontologies is developed and described. The proposed approach was tested in Junior's Academy of Sciences of Ukraine activities related to expedition research on water quality.

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