Virtualization, Processing, and Standardization of Knowledge about Bulgarian Cultural, Historical and Natural Heritage for Use in School Education

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Abstract. The report examines an approach to standardized presentation and virtualization of Bulgaria's cultural, historical, and natural heritage sites. Ideas and experience in using this knowledge in the teaching of various subjects in school education are shared.

Keywords: Ontology, Cataloging Cultural Objects (CCO).

1 Introduction

The digitalization of cultural and historical heritage sites and natural landmarks is one of the most important tasks related to preserving, digital distribution and accessibility of this invaluable heritage. A team of UNESCO specialists developed the main methodological guidelines for digitalizing these sites. On this basis, international standards and best practices have been developed and used by many institutions such as UNESCO, ICOM, ICOMOS, ICCROM, IFLA, WWF, IUCN and others. These standards relate to the way data is structured, the content of this data, and the possibilities for sharing, disseminating and using it.

The article proposes an approach to digitalizing Bulgaria's cultural, historical and natural heritage by using the standard Cataloging Cultural Object (CCO). In addition, the idea of combined use of a system of ontologies and databases with CCO-standardized digital objects is proposed. The authors' experience of using this data in school education is also shared.

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2 Standardization in Digitalization of Cultural and Historical Heritage

2.1 Cataloging Cultural Object (CCO) Standardization

In recent years, many organizations have been working to create standards for describing and presenting information on cultural and historical sites (Grover et al., 2022). These standards not only help to keep the information in a logical sequence but also to present the data effectively. Cataloging Cultural Object (CCO) is a standard that focuses on data description - defines the order, syntax and format for storing and presenting the information. CCO covers almost any type of information needed to represent different objects (work type). Each object belongs to a type. Its specific characteristics and the corresponding images must be described and documented. This large amount of data needs to be managed to be easy to present and share.

Bulgaria is a country with a rich history and remarkable nature. To structure the information, we created a classification of Bulgaria's cultural, historical and natural sites according to the Law on Cultural Heritage of the Republic of Bulgaria and the UNESCO World Heritage Convention (UNESCO,1972).

In essence, the CCO is a standard for describing and documenting cultural and historical sites, including works of art, architecture, cultural artifacts, paintings, sculptures, manuscripts, photographs and archaeological sites, and their reproductions such as museums and libraries, art galleries, etc. It is not intended to describe natural landmarks. It's a challenge for us to check whether it is possible to digitize these objects by using the CCO standard. Using UNESCO's definitions and normative documents, we created a classification structure of natural sites (Fig. 1.).

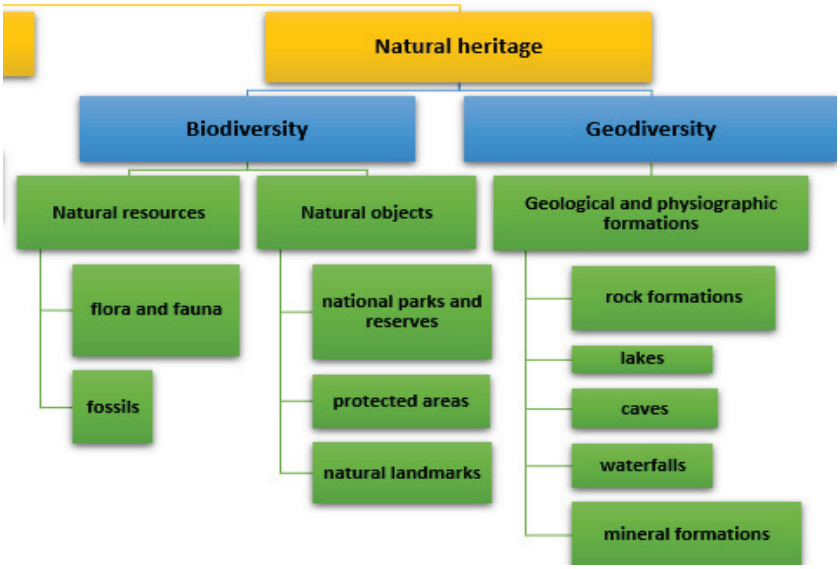

Fig. 1. Part of the proposed classification structure of the national landmarks

2.2 CCO Standardization of Knowledge in Ontology

The use of ontologies to present cultural and historical heritage knowledge has proven effective (Dekova, 2020), (Tibaut, et al., 2022). Our team from DeLC Laboratory of Plovdiv University develop a network of ontologies, which we have called CHH-OntoNet (Cultural and Historical Heritage-Ontology Network), as a knowledge base for cultural and historical sites in Bulgaria. Through CHH-OntoNet, the modeled tourist guide (Stoyanova-Doycheva, et al., 2020) generates virtual or real tourist routes according to the set criteria of the tourist. The ontologies have been developed by the Cataloging Cultural Objects (CCO) standard, which contributes to the easy and convenient dissemination and sharing of data between different organizations and institutions.

The ontology BulgarianLiteratureAndHistory, for example, digitizes knowledge about one of the first high schools in Bulgaria established by Naiden Gerov in 1850 in Plovdiv - today's Humanitarian High School "St. St. Cyril and Methodius" (Grancharova-Hristova, et al., 2021). Its graduates are notable Bulgarians who have left a lasting mark on our history - Ivan Vazov, Dimcho Debelyanov, Peyo Yavorov, Pencho Slaveykov, Petko R. Slaveykov, Vasil Levski, Lyuben Karavelov, Todor Kableshkov, Stoyan Zaimov, Zlatyu Boyadzhiev, Prof. Asen Zlatarov, Maestro Georgi Atanasov, and many others. (Fig. 2).

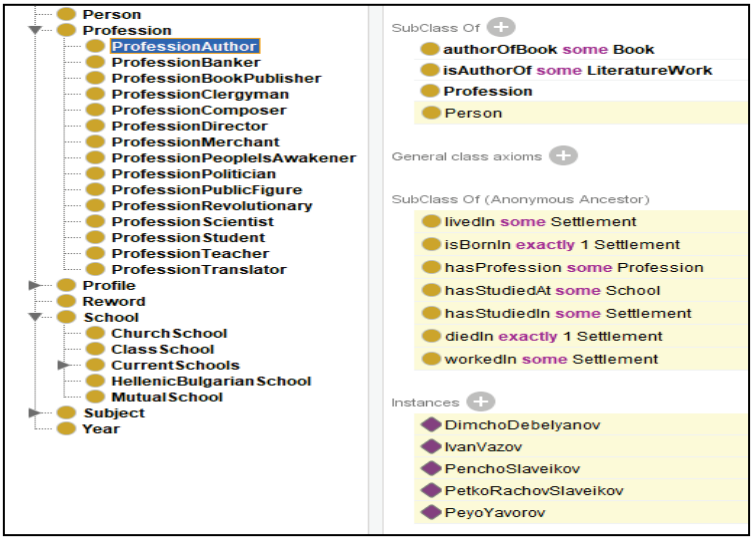

Fig. 2. Part of the class hierarchy in BulgarianLiteratureAndHistoryOntology

2.3 CCO Standardization of Data in DB

Ontologies are a kind of semantic representation of knowledge and are very suitable for development, but the process of their creation is time-consuming and too slow. An alternative is to use databases. Over the years in the DeLC Laboratory of Plovdiv University, many relational databases have been created, which store information about

various historical, geographical, and natural landmarks in our country and which are part of the work of our team on the BECC and BULCHINO projects (Govedarova, et al., 2008), (Trendafilova, 2007). Each of the available databases has a different structure. For example, the Thracian treasure database maintains information about the treasure, where it was found, and what material it is made from; the design of Icons DB contains information about artists, restorers, materials, etc. To be able to reuse all the collected data, it is necessary to develop a unified structure of a common database based on the CCO standard. The next challenging task is establishing a CCO-compatible standard database structure and transferring the information gathered over the years into the new unified and standardized database. The newly created database complies with the requirements for describing cultural and historical sites in the CCO standard. As already noted, CCO is not intended to digitize natural heritage, which significantly complicates the description of these objects in the CCO standard.

The transfer of information from the old databases to the new one is done through separate scripts. The new database contains 28 tables, which are connected in a standard structure according to the requirements of the CCO standard. For example, Fig. 3 presents the existing structure of the DB for the lakes, and a small part of the standard structure of the unified database is visualized.

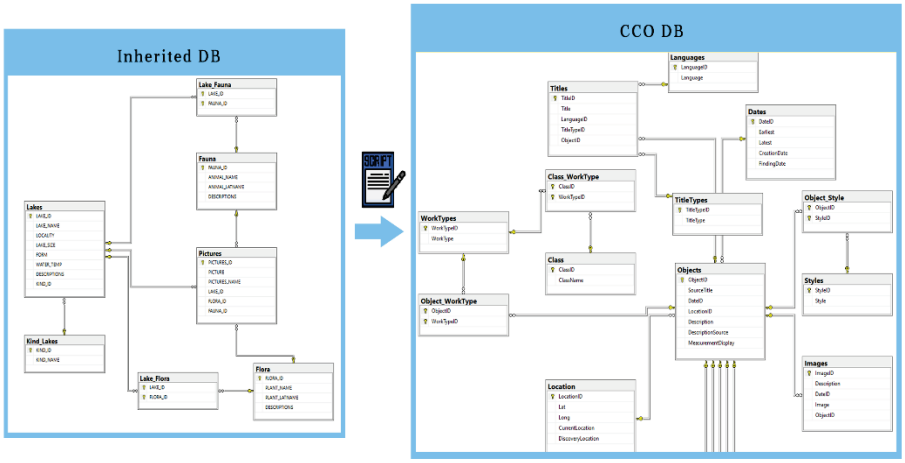

Fig. 3. Lakes database and unified database structures

2.4 Combined Approach to Digitalization of Sites

In the last few years, the team of the DeLC Laboratory of Plovdiv University has been developing a reference architecture of cyber-physical and social space - ViPS. The purpose is to adapt to different application areas - agriculture, tourism, education, and others (Stoyanov, at al., 2020), (Glushkova, et al., 2019). The main component of the ViPS architecture is the Digital Libraries, which store the necessary information related to the respective application area. A prototype of a ViPS adaptation for school education called BLISS (Todorov, et al., 2019) has been developed, which is essentially a multi-

agent system and supports and extends the individual ViPS components, including the Digital Libraries with CHH-OntoNet and CCO DB. Several groups of agents operate in the space, providing different types of services. Personal assistants (PAs) interact with users, and operative assistants provide the necessary personalized services when communicating with individual PAs.

It was already mentioned that the information about the cultural-historical sites and natural landmarks could be stored in CCO-based ontologies or DB. Furthermore, it is possible to describe the same object in both standardized structures. For this purpose, a meta-ontology was developed, based on the created hierarchical structure of cultural-historical and natural landmarks, which maintains information on where to look for the requested information - in ontologies, in databases, or both (Fig. 4).

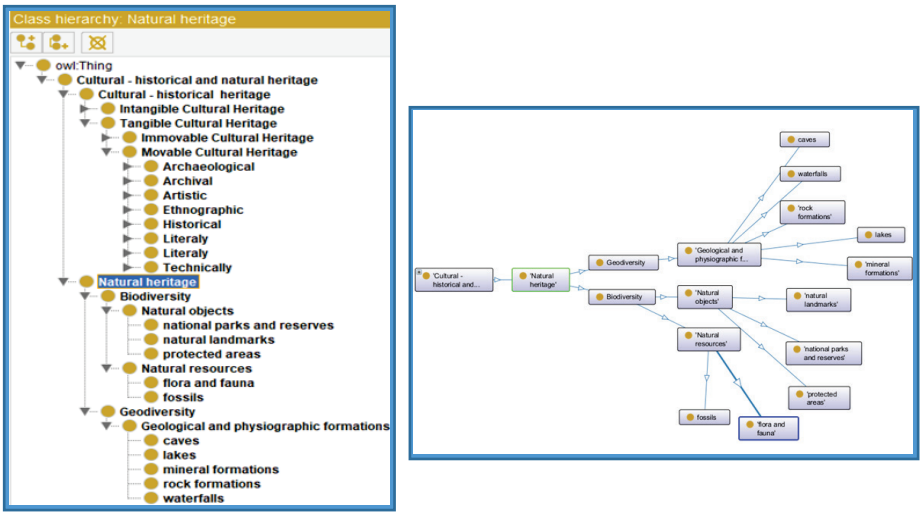

Fig. 4. Part of the developed meta-ontology

For the realization of this service, an operative agent MOA (Meta Ontology Agent) is being developed, which according to the information from the meta-ontology for the location of the requested information, communicates with two other specialized agents:

- KGA_O (Knowledge Generation Agent from Ontology) - to retrieve information available in ontologies and
- KGA_DB (Knowledge Generation Agent from DB) - to extract information from the CCO-standardized database.

The information obtained from the database or ontologies is sent to another agent RGA (Route Generation Agent), which ensures the operation of the specialized ViPS component - Route Generator. The interaction between the agents is presented in Fig.5.

A unified template based on the CCO standard is used for the digital presentation of the individual objects. Standardization makes it possible to combine information from CHH-OntoNet and CCO DB, processing it in a unified way and visualize it to the end-user by their PA.

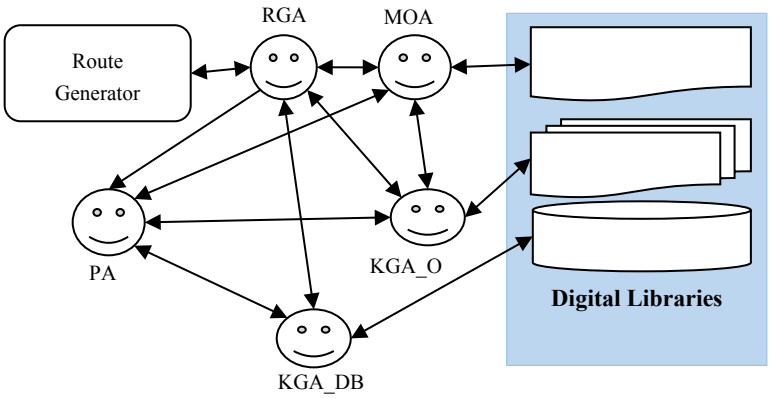

Fig. 5. Multi-Agents communications and architecture

3 Approach to Application this Approach in Secondary School Education

The information structured in a standardized form, which is part of the Digital Libraries of the educational environment, can be applied in the teaching in the secondary school for classwork, project work, game-based training, generation of test questions, etc.

Proven practice in the schools is to use the information presented in a visualized manner. It is effective for school subjects like history, geography, biology, etc. The use of virtual tours can realize the didactic goals. Virtual tours can also be used in students' self-preparation. Let's assume that the lesson's topic is connected with the ancient history of the city of Plovdiv. Let's look at the following sample scenario: Students through their PA express their desire to generate a virtual tour of Plovdiv and send a request to MOA. After searching into the meta-ontology, it found that this information was maintained by the CCO DB and in CHH-OntoNet and sent the request to the two agents - KGA_DB and KGA_O. These agents find the required information and return the collection of discovered objects. According to the CCO standard, each of them is presented in a unified template. Then, MOA submits this collection to the agent RGA for generating the route of the virtual tour in communication with the specialized Route Generator Module. Finally, the generated virtual tour is passed to the PA for visualization.

3.1 CCA Modeling of the Sample Scenario

The Calculus of the Context-aware Ambients (CCA) (Siewe, et al., 2011) is a paradigm for modeling the aspects of the physical world (city, university, agriculture, etc.). The essential part of the CCA modeling is specific building blocks called “ambients”. They are used for modeling physical and virtual objects with their characteristics and could be adapted to various applied areas (domains). In CCA, ambients are defined as identities used to describe an object or component – process, device, location, etc. The ambients have names and locations. There are three possible relationships between two

ambients (parent, child and sibling). Ambients can exchange messages with each other. In the CCA notation, we use the symbol "::" to describe the interaction between sibling ambients; "↑" and "↓" are symbols of parent-child interaction; "<,>" means sending a message and "(,)" means receiving a message. In terms of the CCA paradigm, the main processes of the given scenario (already described above) are shown on Fig. 6.

$$P_{PA} \cong \left(MOA ::< PA_i, ancient\_Plovdiv, needVirtExc > .0 \mid MOA :: (VirtualExcursion).0\right)$$

$$P_{MOA} \cong \begin{pmatrix} PA :: (PAi, ancient\_Plovdiv, needVirtExc).KGA\_DB ::< PA_i, ancient\_Plovdiv > . \\ KGA\_O ::< PAi, ancient\_Plovdiv > .0 \mid \\ KGA\_DB :: (PAi, ListObjects\_DB).KGA\_O :: (PAi, ListObjects\_O). \\ RGA ::< PAi, ListObjects\_DB, ListObjects\_O > .0 \mid \\ RGA :: (VirtualRoute).PA ::< VirtualRoute > .0 \end{pmatrix}$$

$$P_{KGA\_DB} \cong \left(MOA :: (PAi, ancient\_Plovdiv).MOA ::< PAi, ListObjects\_DB > .0\right)$$

$$P_{KGA\_O} \cong \left(MOA :: (PAi, ancient\_Plovdiv).MOA ::< PAi, ListObjects\_O > .0\right)$$

$$P_{RGA} \cong \begin{pmatrix} MOA :: (PAi, ListObjects\_DB, ListObjects\_O). \\ MOA ::< VirtualExcursion > .0 \end{pmatrix}$$

Fig. 6. Main CCA processes of the described CCA scenario

3.2 Testing and Verification of the Sample CCA Scenario

The modeling of the CCA scenarios could be realized with the help of the ccaPL programming language (a computer-readable version of the CCA). It has a specific syntax. The programming of the CCA scenario should be implemented in a plain text file using an ordinary text editor, which requires exceptional CCA knowledge from a person who models the scenario. This significantly complicates the developing process, and because of this, we decided to develop a specialized visual CCA Editor (Glushkova, et al., 2021). This will help us to realize the simulation, testing, and verification of the different scenarios from various applied areas along with the creation of the ambients and communication between them (Fig.7).

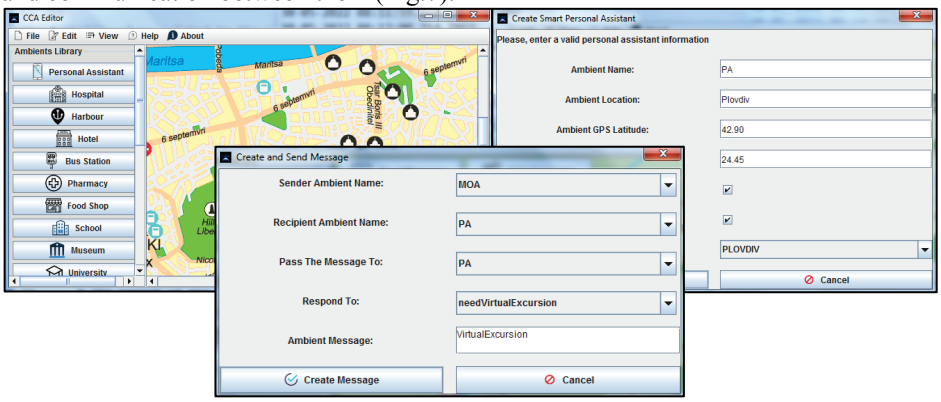

Fig. 7. Generation of CCA model of scenario by CCA Editor

The CCA scenario simulation, testing and verification could be done using the ccaPL interpreter. To be able to do that, it's required to open the terminal. This could be achieved using the CCA Editor. The "Open Terminal" option needs to be chosen from the "File" dropdown menu or uses the keyboard combination (shortcut) "Ctrl + T". Currently, the interpretation and visualization of the sample CCA scenarios are being realized with the help of the command-line interface (Fig. 8). An animator is planned to be developed and implemented. It'll allow us to visualize the collaborations and interactions between the different ambients during testing and simulation of the CCA scenarios of various applied areas.

Fig. 8. Results of the executed CCA scenario

Along with the implemented CCA model, a brand new mobile application for organizing virtual excursions is developed, and the interface of the one prototype version is visualized on Fig. 9.

Fig. 9. Interface for organizing virtual excursions

Similar to the presented scenario, the combined approach for digitalization and presentation of knowledge from ontologies and databases can be used in other learning situations such as: generating presentations or learning resources on specific topics; creating Question Games; games with object recognition by image or text description; generating test questions (Stoyanova-Doycheva, et al., 2021), working on projects, etc. All of this is greatly facilitated by the use of the CCO standard and the use of unified visualization templates.

4 Conclusions

The presented combined approach for digitalization of CCO-standardized cultural-historical and natural sites of Bulgaria allows for their wide use for achieving various goals - for information, for use in tourist guides, and secondary school education.

The development of a multi-agent system is a complex task. The proposed CCA modeling allows the baseline scenarios to be tested and verified in the period before the start of the system development.

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