Educational Application on Top of Digital Library for Cultural Heritage

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Abstract: In the last few years the East-Christian iconographical art works have been digitized providing a large volume of data. The need for effective classification, indexing and retrieval of iconography repositories became the initial motivation of the design and development of a systemized ontological structure for description of iconographical art objects. However, such formal structure could also allow several promising new applications such as learning, cultural heritage advertising, cultural and religious tourism or more specialized applications such as research and analyzing of technology/art, providing inferences for trends and priorities, finding implicit data/content, dependences, tendencies, etc. This paper presents the ontology of the East-Christian iconographical art, developed to provide base content annotation in the Virtual encyclopedia of Bulgarian iconography multimedia digital library. The paper also presents a learning application under this domain ontology implemented during the SINUS project "Semantic Technologies for Web Services and Technology Enhanced Learning".

Key words: Domain Ontology, East-Christian Iconographical Art, Learning Analysis

INTRODUCTION

In an attempt to answer the need for virtual presentation and preservation of the valuable artefacts of the East-Christian iconographical art and particularly of the Bulgarian iconography, a team from the Institute of Mathematics and Informatics, Bulgarian Academy of Sciences developed a multimedia digital library called *Virtual encyclopedia of Bulgarian iconography* (also called Bulgarian iconography digital library, BIDL, http://bidl.cc.bas.bg). The initial aim of the developers was the creation of a web-based environment for registration, documentation, and access and exploration of Bulgarian iconographical artefacts, providing its wide accessibility and popularization. With the library improvement the research and developments point to new applications, such as learning, cultural heritage advertising, cultural and religious tourism, etc. Several specialized tools and services are implemented in the library, aiming to satisfy needs for effective classification, indexing and retrieval of the iconography repository in the new applications.

This paper presents the ontological structure for description of iconographical art objects, also called ontology of the East-Christian iconographical art, implemented in BIDL as a specialized annotation tool. A detail overview of its main classes (concepts), relations and some facts and rules is done. The paper also describes the educational application of this ontology, demonstrating a learning analysis execution on the Bulgarian iconography domain. This application is made during the SINUS project "Semantic Technologies for Web Services and Technology Enhanced Learning", an interdisciplinary research project that demonstrates creative learning-by-doing through active learners' authoring of specific learning materials, using resources delivered through the BIDL. In the paper a short presentation of the Bulgarian iconography digital library is also included.

BULGARIAN ICONOGRAPHY DIGITAL LIBRARY

Until recently, Orthodox (East-Christian) iconographical art had been neglected in the digital documentation and the registry of the art of painting. But the accessibility to this valuable part of mankind's cultural and historical ancestry was enhanced greatly with the appearance of the *Virtual encyclopaedia of the Bulgarian iconography* multimedia digital library in the world virtual space. This Internet-based environment becomes a place where iconographical objects of different kinds and origins were documented, classified, and "exhibited" in order to be widely accessible to both professional researchers and the wide audience. Rare specimens, private collections, icons from difficult-to-access storages, distant churches, chapels, and monasteries, objects in a risk environment or unstable conditions, etc. are appearing for new e-exposition. The library provides services for registration, documentation, access and exploration of a practically unlimited number of

Orthodox iconographical artefacts and knowledge and the end users can use this rich knowledge base through its interactive preview, objects complex search, selection, and group. A complete description of the rich BIDL functionality is made in [6][8][11]. Until now, the library was used in several cross-media, ubiquitous and technology-enhanced learning applications [4][5][7]. At present, media objects and resources from BIDL are used as input data for a learning analysis performed on a special learning layer, developed during the SINUS project. The analysis represents learner authored content/modules, created by using semantically annotated materials from the library, enriched with additional explanations and inferences.

PRESENTATION OF ICONOGRAPHICAL ART SEMANTICS

The initial need for effective retrieval of the icons of East-Christian iconographical art in BIDL motivated the development of the domain ontology for the East-Christian iconographical art. This ontology is used for the semantic metadata description and indexing of the iconographical art content in BIDL. Similar work on classification for the Byzantine icons is done in [13], but it is used for face detection, analysis of the facial characteristics and sacred figure recognition. The new BIDL educational application extends the ontology usage, involving it in learning content authoring process (see the SINUS educational application, described in the next section).

In our ontological model the iconographical art world is described by three "thematic entities" (also called levels of knowledge). Each of these entities is enriched with a set of sub-levels, covering a wide range of characteristics. The first one is the "Identification" entity (see figure 1), which consists of general data identifying aspects of the iconographical object (a sacred image, created on a stone or metal relief, bone, ceramics,

Identification entity of the Ontology of the East-Christian iconographical art

Figure 1: Identification entity of the ontology of the East-Christian iconographical art

glaze, mosaic, wall-painting, art textile, as a miniature on parchment or paper and on a wooden board with tempera paint, IO) such as IO title, type, author, author's clan and biography, iconographic school, period, dimensions, current location and source, and IO object identification notes (for example, distinctive features, possession, inventory number, author's signature, donor inscriptions, etc.), and iconographic school description.

The second entity (see Figure 2) covers information concerning the descriptive details of the theme and forms of representation, providing a better understanding of the content. The main concepts included are: depicted character/s, iconographical scenes, character/s in the scene/s, symbol/s in the scene/s, characters' gestures, characters' vestment, detailed description of the depicted content, etc.

Description entity of the Ontology of the East-Christian iconographical art
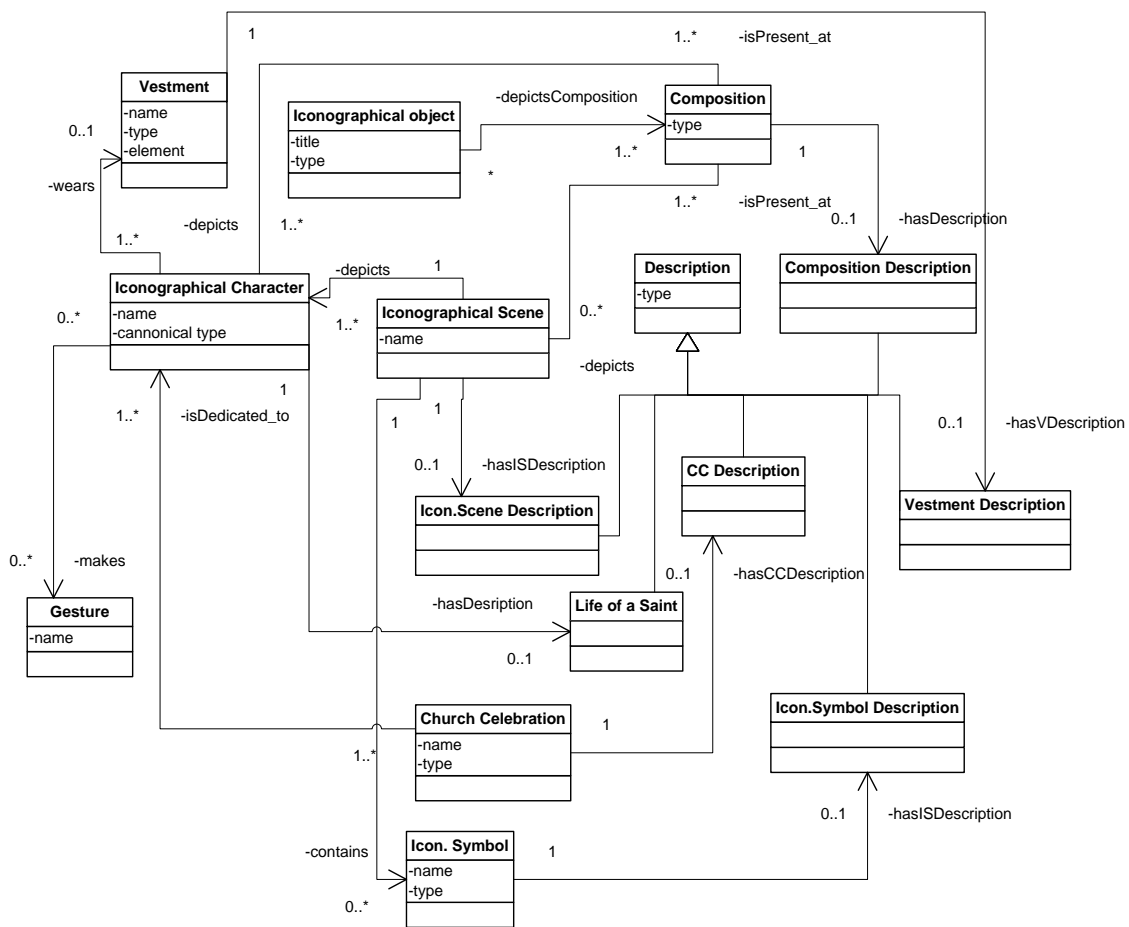
Figure 2: Description entity of the ontology of the East-Christian iconographical art

The third entity includes technical information revealing iconographic techniques, base materials, gildings, repousse covers, etc., used in the creation of the iconographical object/collection, and also concerning examinations of the condition, such as diagnosis or history of the conservation treatment. A wider description of this entity is included in [9].

In the ontology several domain rules and facts are defined. For example, the following statement determines the dependence between the *Author* of an *Iconographic School* and the value of the *Period* in which he worked.

If *Author* isRepresentativeOf *Iconographic School* = A then the *Author* works during *Period* p for the *Iconographic School* A.

For example, if we have an unknown author from Bansko-Razlog iconographic school we could periodize their works (in identity search).

If *Iconographic Scene* = A then *Iconographic Scene* depicts *Iconographical Character* = $\{a_1, a_2, ..., a_n\}$, where $\{a_1, a_2, ..., a_n\}$ is a predefined set.

Similar statements are made for the *Vestment* and *Gesture* of the *Iconographical Character* in the *Iconographic Scene* and the depicted *Iconographical Symbol*. The *Iconographical Character* itself also has similar dependencies with its *Vestments*, *Gestures* and *Iconographical Symbol*. These rules automate the annotation processes in the library. They also give possibilities for inferences about the emphasis, trends, and priorities in the work of an author, an iconographic school or the art during a fixed period.

The rules are defined according the canons of the Orthodox painting described in special technology manuals on icon painting called Ermeniya[1]. The number of these statements in the ontology exceeds 35. In SINUS they are actively used for critical analysis of technology/art, learning analysis (see example in the next section), inferences for trends and priorities in the domain, finding implicit data/content, dependences, tendencies, etc.

The entities and the corresponding metadata values in the ontology are supported and documented by the scientific diagnosis, which has been applied to the domain. The main knowledge sources for the Bulgarian iconography are collections as [2][3][12]. Formal presentation of the ontology is made by OWL and Protégé OWL Plug-in.

THE LEARNING ANALYSIS BASED ON THE ICONOGRAPHICAL ART ONTOLOGY

As mentioned the ontology of East-Christian iconographical art can be used in a wide area of research and analysis in the domain, such as: analysis of the religious meaning of an iconographical image which is the object of research, art analysis of the development of iconographical objects and scenes in the different iconographical schools through time, tracing the iconographical technology development in different iconographical schools and time periods, a technological analysis of a piece of art (base, primer, painting layer, polish, etc.), tracing the current condition and the restoration manipulations, exploring the donor and author signatures, tracing the authentication of an object, etc.

At present, such an analysis with learning aim is performed using the objects and resources of the BIDL in a special learning layer, developed during the SINUS project. A formal use case scenario of this activity is created. It models a technology-enhanced learning on iconographical art domain and is presented in details in [10]. According to this scenario the ontology is used for the annotation, semantic indexing, and search of iconographical artefacts and knowledge included in BIDL, aiming to provide a knowledge base for semantic inferences and proper content selections. The next examples demonstrate a real learning analysis, included in the scenario and played away during the project.

Sample task for the arts critics' team: Make an art critical analysis of the development in time of the iconographic image of Jesus Christ in the various iconographical schools on Bulgarian land.

Steps to be performed:
1. Collect a minimum of 6 iconographical objects containing the image of Jesus Christ in a one-figure composition (Note: The right choice requires selecting iconographical objects with the character or Jesus Christ Pantocrator, or Blessing Christ, or Jesus Christ enthroned, or St. Veronica, etc.).

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[1] "Hidden" books, used by painters to help them follow the technology of the iconography. They trace the sequence of actions to create iconographical objects (main techniques, grounds, pigments, plating techniques, etc., as well as the way they are prepared); the painting in the icon with its specifics and symbols, the way to fix it to the foundation, measures, proportions, prescriptions, etc.

2. Arrange the iconographical objects in groups (i.e. classify them) by school of iconography.
3. If a school of iconography's group contains objects by an eminent author and founder of the school, place these high on the list. Among the objects designated for art critical analysis there should be at least one by a prominent author/school founder, if available.
4. Ensure that the iconographical objects designated for art critical analysis are currently in good condition.
5. Ensure that at least one primitive iconographical object and at least one Renaissance iconographical object are included in the iconographical objects designated for art critical analysis.
6. In writing the art critical analysis compare the selected iconographical objects by contrasting clothing, gesture/s, the character proportions, object/s, the presence of other character/s and/or symbol/s, backgrounds, other element/s (e.g., clouds, etc.) in the iconography of the image of Christ. Look for changes in the iconography of these components, for example, appearance or lack of components (objects, symbols, characters, etc.), changes in the background, clothing, etc., in the selected set of samples.

In the sample task for the arts critics' team the main learning objective of the user is to make concrete analysis in the iconography domain. The subtasks (1-6) show steps (sub-goals) to be executed in this analysis. These steps could be presented as a formula combining one of the "Bloom Taxonomy" verbs [1] with a term (concept) from the ontology of the East-Christian iconographical art. In the SINUS learning platform the **Student** will "execute" the Bloom's verb action on the concept(s) from the ontology of the East-Christian iconographical art. For example, in step 1 the **Student *collects*** iconographical objects presenting Iconographical character = Jesus Christ in a composition type = one-figure. In step 2 the **Student *classifies*** (i.e. *arranges the iconographical objects in groups*) iconographical objects by a certain iconographic school. In step 3 the **Student** has to ***discover-select-show*** iconographical objects by a certain author type, etc. Tracking all the sub-goals clearly shows the place of the taxonomy terms of the East-Christian iconographical art ontology needed for the learning analysis.

The presented learning analysis aims to demonstrate creative learning-by-doing through active learners' authoring of specific learning materials on East-Christian iconography, using multimedia and information resources delivered through BIDL.

CONCLUSIONS AND FUTURE WORK

This article presented an ontological structure of East-Christian iconographical art domain used for formal description and documentation of the iconographical art in digital libraries and elearning analysis realization. By now, hundreds of objects are annotated with this ontology in the BIDL and the learning analysis using its conceptualization framework is performed in a real SINUS eLearning process.

Future work on the East-Christian iconography domain will include the extension of its current formal specification with conceptualization of churches, monasteries, etc. repositories of iconographical artefacts, church plates; ethnographic objects used for idolatry, etc. Thus, the target domain will be completely presented and formalized and will provide tools for profound observations, interdisciplinary research and extended learning analysis.

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