

The Orthodox Icons Collection of the Regional Historical Museum—Burgas: A Digital Library for Iconographic Objects

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Abstract. In an attempt to answer the needs for wider accessibility of the orthodox icons collection of the Regional Historical Museum—Burgas (RHM—Burgas), a team from the Institute of Mathematics and Informatics has developed and applied a multimedia digital library “Virtual Collection of Icons”. This development aims at adequate and complex presenting, documenting, cataloguing and preserving of orthodox icons through the use of modern technologies. Section 2 and 3 briefly describes a methodology for evaluation the need of introduction this innovation in RHM-Burgas, the innovative solution’s degree of viability and the economic impact. Section 4 presents the developed digital library, passing from the semantic description of the iconographic art content to the library architecture and functionality. In the last section are described some conclusions and aspects for future work.

Keywords: Multimedia Digital Library, Virtual Museum Collections, Functionality, Services, Evaluation of Applicability, Evaluation of Necessity, Evaluation of Economic Effect.

1 Introduction

Meeting the requirements and needs of information society in the 21st century is a key activity for contemporary museums. In Bulgaria this process is very long and difficult due to the large gap between the areas of culture and information technology. World practice has shown that the results from the combination of knowledge and efforts of specialists from these two areas can change the public understanding of its values and perception. In this sense, the documentation of the movable cultural heritage from the Burgas region and its preservation in the best accessible form can only be done through digitization.

For this purpose, the Regional History Museum Burgas (RHM-Burgas) is actively seeking opportunities and has entered into partnerships with proven specialists in information technologies from the Burgas Free University (BFU) and the Institute of Informatics and Mathematics Academy of Sciences (IMI-BAS).

In 2014, thanks to project № BG161P003-1.2.02-0022-C0001 “Implementation of new office for transfer of innovation technologies in business organisations of the South-East Region of Republic Bulgaria” with beneficiary Burgas Free University, co-financed by the Operative Programme “Development of the Competitiveness of the Bulgarian Economy” 2007–2013¹, RHM-Burgas started the implementation of technological innovation associated with the creation of a digital library collection of icons stored in the Historical exposition of the museum. The project financed the transfer of technology solutions for creation, integration and development of multimedia digital libraries with applications in cultural heritage developed in the Institute of Mathematics and Informatics at the Bulgarian Academy of Sciences (IMI—BAS). The purpose of the transferred technology is to provide adequate and comprehensive presentation, documentation, cataloguing and preservation of the museum’s iconographic collection. It will provide a user-friendly platform for the presentation of information from the inventory records, which ensures a more effective and stable work process aiming long-term preservation of the information for posterity.

This paper describes the methodologies for evaluation of the applicability, necessity and economic effect of the innovation’s implementation in RHM-Burgas. The results of the analysis are presented briefly. The next section of this paper describes the main results of a marketing research in the field of high technology. A methodological approach was developed, considering the specifics of the Bulgarian museums as potential users of the multimedia digital libraries for presentation and preservation of historical and cultural heritage.

The last section of the article presents the Digital Library “Virtual Collection of Icons” (DL-VCI) developed for RHM-Burgas (<http://www.burgasmuseums.bg/bidl/>), passing from the semantic description of the iconographic art content to the library architecture and functionality. A special attention is paid to content creation, preview, search and administrative services, trying to cover a wide range of possible solutions. Moreover, the semantic content description requires the specification of a unique descriptive scheme for iconographical art content, covering the rich semantic, identification and technical features of the iconographical objects.

2 Methodologies for Evaluation of Applicability, Necessity and Economic Effect

The evaluation of technological innovation is based on a methodology developed for the study of: the degree of viability of an innovation; the needs of RHM-Burgas for

¹ Website of the Office for transfer of innovation technologies in business organizations of the South-East Region of Republic Bulgaria: <http://www.bfu.bg/bg/organizatsionna-struktura/ofis-za-tehnologichen-transfer>

introducing of technological solutions and assessing the economic impact of the introduction of these innovative solutions [12, 14].

2.1 Studying the extent of applicability

The first method aims to investigate the relevance of the offered innovation in a particular organisation. It has a practical and applied nature and indicates specific procedures adapted in accordance with the characteristics of the organisation—subject to evaluation. The relevance of the innovation has been established through a selected system of indicators concerning various aspects of the museum work. Data obtained through a conducted survey, documentary analysis, statistical and economic data at sectoral and national level, as well as results from previous studies, served as output base. The selection of this innovation is also preceded by a study of alternatives. The advantages of the preferred innovation are that it will comply with the Bulgarian legislation in the museum field, supports a Bulgarian interface and is fully consistent with the needs of museum workers. The estimated timeline for the introduction of this particular innovation in RHM-Burgas is six months. After its introduction it is expected to increase revenues from sales of provided service at the rate of 20% compared to the prior comparable period. In terms of physical security for working with innovation at the time of the survey no vulnerabilities have been found.

2.2 Studying the museum's need of the technological solution at hand

This methodology aims to assess the organization's need of the technology. It consists of the following steps: collection of information through questionnaire, analysis of the metrics, final assessment and conclusion on the magnitude of the summary indicator "Organisation necessity of the specific technology implementation", which is calculated as a weighted average of individual indicators. The idea of using statistical indicators is to get an objective conclusion on the organization's need for technological modernization by assessing the various aspects of its activity. The final conclusion was based precisely on this score.

The questionnaire includes two parts related to: general data and values for a set of indicators for the organisation's activities for 3 years before the time of assessment. For each relevant indicator the expert team calculated the percentage deviation of the actual reference value or the change (%) in value in 2013 compared to 2011 (upon absence of a suitable reference value). The purpose of this descriptive analysis is to assess the dynamics in direction of improvement or deterioration of the relevant parameters. For RHM-Burgas, because of the scarcity of available statistical data for the sector, as reference values there are used mainly expected values after the introduction of technology set by the museum management, and in some cases averaged values from the Bulgarian economy. The comparative analysis suggests that RHM-Burgas has a significant need to increase resource productivity. The next stage is to determine the expert assessment (from -10 to +10 on predefined criteria), weight and weighted expert evaluation of each indicator. The assignment of ranks (see Table 1) is

justified by the SWOT analysis, as weights are calculated by linear ranking. The results are illustrated in Table 1.

Table 1. Analysis results

Rank	Title of indicator	Expert evaluation	Weight	Weighted Average Mark
(1)	(2)	(3)	(4)	(5)
1	Workforce productivity	-10	0.143	-1.429
2	Labour intensity	-10	0.132	-1.319
3	Change in productivity	-10	0.121	-1.209
4	Quality of product	-4	0.110	-0.440
5	Organisation assessment of the need for this technology adoption	-10	0.099	-0.989
6	Assessment of the current technological level	-8	0.088	-0.703
7	Deviation from the technological level of the competitors	10	0.077	0.769
8	Newly introduced fixed assets	10	0.066	0.659
9	Turnover from new and improved products	-10	0.055	-0.549
10	Produced quantity	-10	0.044	-0.440
11	Sales revenue	-10	0.033	-0.330
12	Change in productivity— Change in labour costs	8	0.022	0.176
13	Value of the tangible fixed assets	0	0.011	0.000
Weighted average of the “Necessity of the organisation to introduce the technology”			$\Sigma = 1$	-5.802

The average weighted mark for “Necessity of the organisation to introduce the technology” is -5.802, which falls in the range (-10, -5). In accordance with its scale

this gives grounds to conclude that RHM-Burgas has a great need to introduce the technology in question.

2.3 Assessment of the economic impact by the introduction of this innovative solution

The main idea of the third methodology is to compare and analyse the values of a set of indicators related to key aspects of the organisation’s activity before and after the introduction of the innovation. The starting point to this method is the information compiled by the respondents through two forms—a checklist and a questionnaire. The checklist contains 33 questions with open and closed answers. Closed answer questions are set to dichotomous responses (growth/decline; yes/no). Answers like “I do not know.” or “I do not expect change.” are avoided in order to gather information only on those aspects of the activities which are expected to be affected by the new technology. The questionnaire includes 26 indicators of the economic activity. Most of them require data from the official documentation of the organisation such as statement of income, manpower lists etc. Several indicators suggest an evaluation by the 5-likert scale.

Table 2 presents the expected benefits, grouped in 5 categories: manufacturing effects, financial accounting effects, market/trade effects, personnel and secondary effects.

Table 2. Expected benefits grouped in 5 categories

Regional Historical Museum—Burgas
<p>Production effects</p> <p>Significant growth in labour productivity—the speed of finding and use of information increases dozens of times.</p> <p>Decline in service time of one customer</p> <p>Improvement of the provided service quality and the technical parameters of the product: wider access to museum collection, the opportunity to extend the displayed exhibits; reducing harmful effects on exhibits</p> <p>Environmental effects due to reduced use of paper</p> <p>Increase of productivity</p> <p>Standardization of product</p>
<p>Financial accounting effects</p> <p>Increased revenues from entrance fees and fees for services</p> <p>Decline in indirect expenses</p> <p>Decline in the cost of maintenance, conservation and repair</p>
<p>Marketing / trade effects</p> <p>Growth in the number of museum visitors by 30%</p> <p>Expanding the scope and profile of customers to the following groups:</p> <ul style="list-style-type: none"> - Disabled - Companies in the field of tourism - Researchers

- Educational organizations Improving the image of the institution and its awareness – opportunity to provoke interest to other services provided by RHM-Burgas
Manpower Increasing skills and knowledge of the museum workers
Secondary effects Positive effects for the region and the development of tourism; option for internet tourism Social benefits by ensuring equal access to the collections for people with disabilities Support for the research and promotion of Bulgarian culture and heritage

The effectiveness based on performance is calculated as:

$$[(Ef)]_p = (Q_2 - Q_1) / Q_1 * 100 (\%) \quad (1)$$

where Q1 and Q2 are quantity of product produced per unit of time respectively before and after the introduction of the technology. The indicator shows the percentage change in productivity.

Initially the preparation of a statement from the inventory of RHM-Burgas takes one working day (8 hours) with one or two museum specialists. As a result of the digitization it is expected that this same service will be provided in 20–30 minutes, i.e., at least 16 official inventory statements can be prepared in the comparable period. This means that the performance increases 16 times and the efficiency goes up by 1500%. The result is not surprising and it is economically justified in the case of digital processes.

The analysis results show that the effect of the introduction of the innovation in RHM-Burgas is most striking in labor productivity—a more than tenfold decline in the time of statement preparation. The museum is a budget organization that does not seek profit, so financial accounting benefit is paramount to prioritizing the positive effects on direct and indirect users.

Digitization and Internet presence allow not only faster and better access to museum collections, but theoretically expand the potential to reach the global market. As a public organization, the museum expects to achieve side-benefits: promotion of the region and development of electronic tourism, facilitating access for people with disabilities and supporting research.

3 Marketing Research – Results

In order to provide a methodological basis for the conduction of scientifically justified marketing research and to gather reliable information on the attitude of potential users—individuals or organizations of the technological innovation, there was developed a “Methodology for conducting marketing research of contemporary digital technologies in the museum field” [10, 11].

The analysis of the results of the market research of the museums as potential users of a digital media library is based on data from a test study conducted in a sample of

museums in Bulgaria. The sample consists of data from 5 museums; the questionnaire was sent to 12 museums, i.e., the quota of return is 41%. The object of the study were the directors of museums in Bulgaria—regional, historical, archaeological and natural history.

The processed data indicate that 5 of the indicators set in the questionnaire received the highest level of importance—“very important”, 8 of the indicators received degree “very important” and “important”, and only 3 indicators received a prevailing opinion “minor benefit” (40% of the respondents). See Table 3.

Table 3. Results from the marketing research

BENEFITS/ADVANTAGES	Very important	Im- portant	Insignifi- cant
	%	%	%
Digital representation of historical and cultural information.	40.0	60.0	
Enabling flexible access to e-resources and thematic collections.	60.0	40.0	
Open access.	40.0	60.0	
Digital protection and preservation of historical, cultural and scientific heritage.	80.0	20.0	
Aggregation of digital library resources and the establishment of dynamically updated to e-collections.	80.0	20.0	
Large increase of the data durability in the museum funds.	60.0	20.0	20.0
Opportunity for e-learning courses for the employees	60.0	40.00	
Ability to remove unnecessary information and to convert the data format.	20.0	60.0	20.0
Creation of content types and workflows.	20.0	60.0	20.0
Ability to archive (back up)	60.0	40.0	
Connecting of digital libraries with already existing ones, for example, Europeana.	20.0	60.0	20.0
Management of users (employees) and permission levels.		60.0	40.0
Ability to control the content and maintenance of the user interface.	40.0	60.0	
More communications tools and methods for exchange/inclusion of data from other systems.	20.0	40.0	40.0
Web publications—publishing content in a format suitable for viewing from a web browser, mobile device.		60.0	40.0

Dynamic aggregation of resources related to digital libraries for the creation of virtual museums, galleries and exhibitions—portable to other platforms (including GUIDE & HAND) for new application.	40.0	40.0	20.0
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4 Development and Transfer of the Digital Library for Iconographic Objects Technology

Orthodox (East Christian) iconographical art is recognized as one of the most significant areas of the Bulgarian cultural heritage and the main aim of the developers was the creation of a complete web-based environment for registration, documentation, access and exploration of Bulgarian iconographical artefacts and knowledge, providing wide accessibility and popularization of the East-Christian iconographical art works [6].

The research and protection of the rich history, archaeology and still preserved nature of the Burgas region are among the main activities and priorities of the RHM-Burgas. One of the main directions in this regard is related to documenting, cataloguing, preservation and adequate exposure of the icons of the museum fund in hyper-space through the use of modern information and communication technologies. This Internet-based environment becomes a place where iconographical objects of different kinds and origins could be documented, classified, and “exhibited” in order to be widely accessible to both professional researchers and the wide audience. Rare specimens and collections in a risk environment or unstable conditions, etc. are appearing for new e-exposition [13]. The transfer of innovative technologies from IMI-BAS to RHM-Burgas is a good example for cooperation in the area of cultural heritage digitization [12, 15].

In this paper we present the release of a digital library for the orthodox icons collection of RHM-Burgas – Digital Library “Virtual collection of Icons” (DL-VCI, (<http://www.burgasmuseums.bg/bidl/>), passing from the semantic description of the iconographical art content to the DL-VLI architecture and functionalities, offered to the end users. During the DL-VLI development our main objectives are to give the users a tool providing an opportunity to access, observe and compare valuable Orthodox iconographical specimens of RHM-Burgas in their historic context.

The digital library for iconographic icons, developed in IMI-BAS, provides services for registration, documentation, access and exploration of a practically unlimited number of Orthodox iconographical artefacts and knowledge [5, 7] and the end users can use this rich knowledge base through its interactive preview, objects complex search, selection, and grouping. The first release of the digital library for iconographic icons was developed ten years ago during the national project “Digital Libraries with Multimedia Content and its Application in Bulgarian Cultural Heritage” (contract 8/21.07.2005 between the Institute of Mathematics and Informatics, BAS, and the State Agency for Information Technologies and Communications). As

of now, the library has been used in several cross-media, ubiquitous and technology-enhanced learning applications and projects in development [1, 3].

4.1 Domain Ontology for the East Christian Iconographical Art

The domain ontology for the East Christian Iconographical Art, developed by the team of IMI-BAS for the solution of the problem for effective retrieval of the icons, is used for the semantic metadata description and indexing of the iconographical art content. Similar work for determination of semantic classification for the Byzantine icons is done in [9].

Several problems in the formalization of the “Icons” domain appeared. The conceptualization and formal presentation of the iconographical art semantics posed specific challenges for our team of ontologists, art domain specialists and DL content creators, mainly related with: determining the set of separate ontological sub-structures of the iconographical object domain, the iconographic school, the author of iconographic objects, the iconographic character/scene, etc.; determining in a unique way the descriptors of the different types of iconographical objects (icon, wall-painting, miniature, plastic iconographic object, etc.) according to accepted canons of Orthodox painting; reducing the complexity of the structures that describe different aspects of the iconographical object domain (especially for technological specifics, hierarchy of characters, descriptions of scenes, etc.) without loss of important content; presenting relations between classes and constructing their complete network; defining in a unique way the domain rules, axioms, constraints and facts (because of the incompleteness, inaccuracy or subjectivity of the existing information presenting the iconographical art domain); creating standardized and consistent descriptions of iconographical objects following the available standards for cultural heritage content presentation; etc.

The iconographical art world is described by three “thematic entities” (also called levels of knowledge) in the ontological model developed by the team of IMI-BAS. Every one of these entities is enriched with a set of sub-levels, covering a wide range of characteristics. The first one is the “Identification” entity, which consists of general data identifying aspects such as IO title, type, author, clan, iconographic school, period, dimensions, current location and source, and IO object identification notes, author’s clan and biography, and iconographic school description. The second entity covers information concerning the descriptive details of the theme and forms of representation, providing a better understanding of the content. The third entity includes technical information revealing iconographic techniques, base materials, varnishes, gilding, 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. These main entities and their metadata values are supported, documented and provided by the scientific diagnosis, which has been applied to the iconographical objects and collections [8].

Because the goal is to maximize the reusability and portability of the designed ontological model, the iconographical knowledge interpretations are not considered isolated from the standards and specifications in the field of representation of cultural

information. The most significant development is the CIDOC Conceptual Reference Model (CRM), “object-oriented domain ontology” for expressing implicit and explicit concepts in the documentation of cultural heritage. During the creation of the “East Christian iconographical art” ontology we observe the conceptualization approaches of CIDOC CRM ontology. We use part of its concepts and properties in our ontology. We extend another part in order to make it fit the iconography domain. For example, our “Iconographical Object” class is a sub-class of CIDOC CRM E22—Man-Made Object, our “IO Author” is CIDOC CRM E21—Person, our “Clan” is CIDOC CRM E74—Group, etc. The juxtaposing approach and a rich set of examples are included in [2].

To represent efficiently the iconographical annotation framework and to integrate all the existing data representations into a standardized data specification, the “East Christian iconographical art” ontology needs to be represented in a format (language) that do not enforce semantic constraints on iconographic data, but can also facilitate reasoning tasks on this data using semantic query algebra. This motivates the representation of this ontological model in Web Ontology Language (OWL). OWL facilitates greater machine interpretability of Web content than that supported by XML, RDF, and RDF Schema by providing additional vocabulary along with a formal semantics. Knowledge captured from iconographic data using OWL is classified in a rich hierarchy of concepts and their inter-relationships. OWL is compositional and dynamic, relying on notions of classification, reasoning, consistency, retrieval and querying. We investigated the use of OWL for making our ontology using Protege OWL Plug-in.

4.2 The Architecture of the Digital Library “Virtual Collection of Icons”

The architecture of the DL-VLI contains two main service panels: Object data management and Administrative services (see Fig. 1.), joined to a Media Repository and a User Profile Repository.

The Object data management panel refers to the activities related to content creation: add (annotate and semantic indexing), store, edit, preview, delete, group, and manage multimedia digital objects; manage metadata; search, select (filter), access and browse digital objects, collections and their descriptions.

The Administrative services panel mainly provides user data management, data export and tracking services. User data management covers the activities related to registration, data changes, level set, and tracking of the user. The export data services provide the transfer of information packages (for example, packages with DL-VLI objects/collections, user profiles, etc.) compatible with other data base systems. For example, with these services a package with objects could be transported in an XML-based structure for new external use in e-learning or e-commerce applications. The tracking services have two main branches: tracking of objects and tracking of users’ activities. The tracking of objects watches the activities of add, edit, preview, search, delete, selection, and group of objects/collections in order to provide a wide range of statistic data (for frequency of service use, failed requests, etc.) for internal use and generation of inferences about the stability and the flexibility of the work and the

reliability of the environment. The tracking of users' activities monitors user logs, personal data changes, access level changes and user behavior in the DL-VLI.

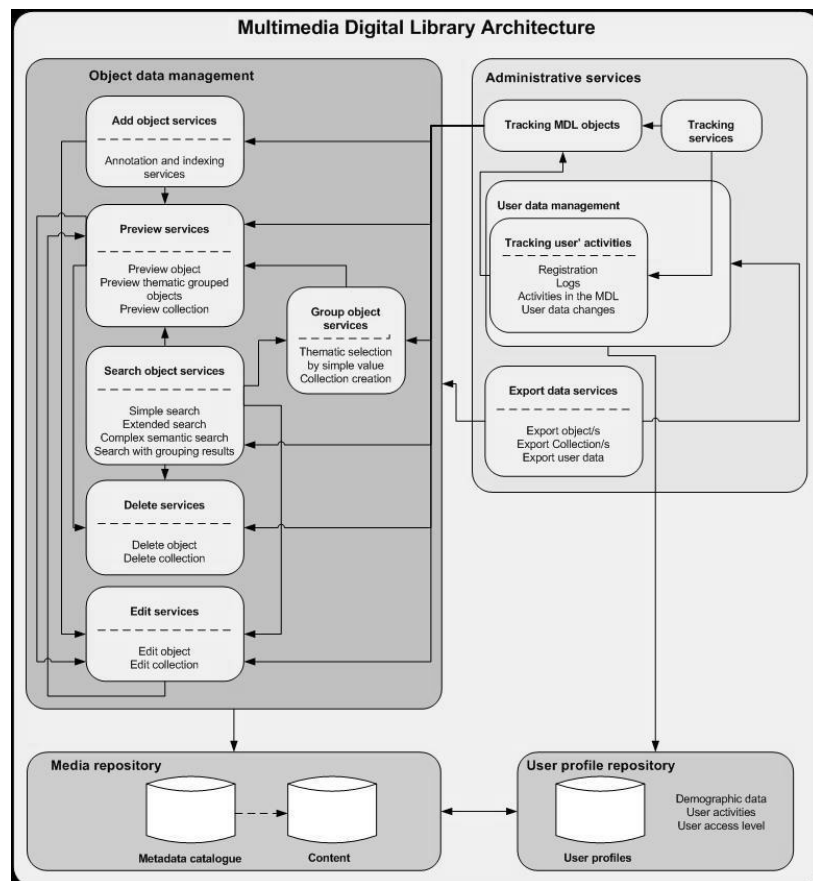


Fig. 1. DL-VLI architecture

For every object all semantic and technical metadata are saved in the Media repository. These metadata are represented in catalogue records that point to the original media file/s associated to every object.

The User profile repository manages all user data and their changes.

4.3 Digital Library “Virtual Collection of Icons” Functionalities

Content Creation

The main part of the content creation process is the annotation and semantic indexing of digital objects in order to add them to the library repositories. The entering of technical and semantic metadata for multimedia digital objects in the Digital Library

“Virtual Collection of Icons” is implemented through different automated annotation and indexing services [4].

The technical metadata, expressed in Dublin Core, are attached to every multimedia object automatically. They cover the general technical information, such as file type and format, identifier, date, provider, publisher, contributor, language, and rights.

An annotation template is implemented for the semantic description of iconographic objects. The template provides several options for easy and fast entering of metadata:

- Autocomplete services (All used (already entered) field values are available in a special panel for reuse.) (see fig. 2).

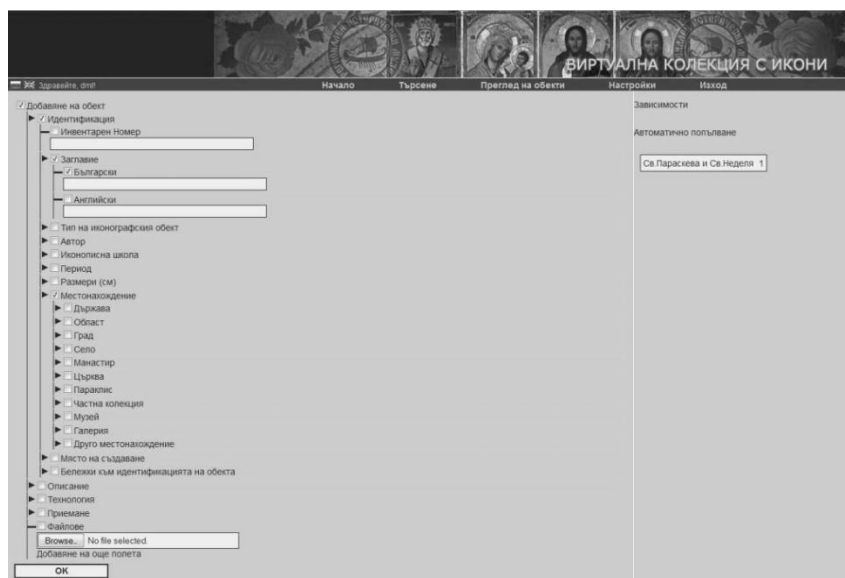


Fig. 2. Part of the annotation template for an iconographical object

- Automated appearance of dependencies coming from the relations of the defined classes' (concepts) in the Ontology of East Christian iconographical art. (All main relations and rules expressed in the iconographical ontological structure are incorporated during the development of the annotation template).
- Bilingual data entering with automated relation between the relevant values in different languages.
- Automated appearance of the number of the used field value, providing regular data tracking.
- A tree-based structure of the annotation template. Only checked fields are displayed for entering metadata;
- Possibility for adding more than one media for one metadata description in order to create rich multimedia digital objects.

- Reuse of an already created annotation for new iconographical objects: the new media object has to replace the older one, the annotation is kept and the new iconographic object appears after saving.
- Automated watermarking of the image and video objects.
- Automated resizing of the image and video objects.
- Automated identification of file formats.
- Automated conversion of the audio, video and text objects to a format suitable for Web-preview.

Content Presentation

In order to satisfy the user's needs, during the development of the content presentation services a profound analysis was made of content selection and preview possibilities. First we had to determine the preview possibilities of a separate iconographical object and its components and after that the preview of grouped objects [4]. Figure 3 depicts the view of separate iconographical object.

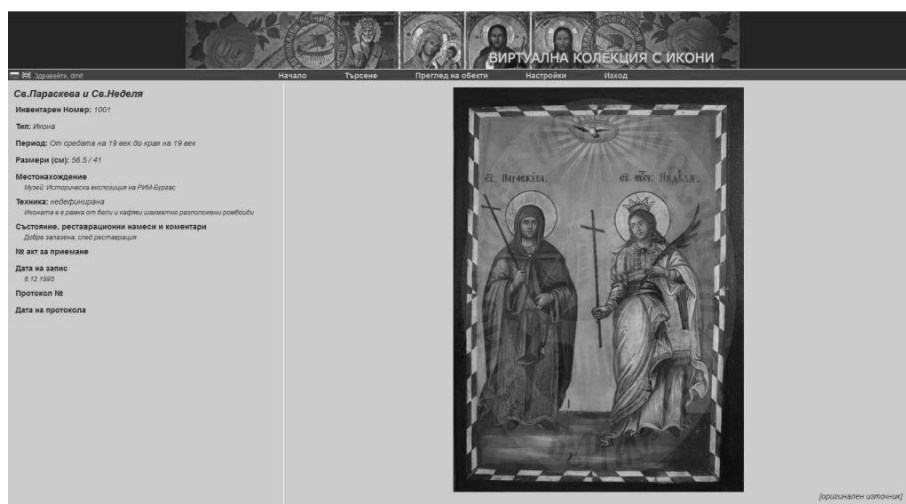


Fig. 3. Saint Paraskeva and Saint Nedelya

The left frame of the preview window shows the description of the iconographical object. In the right frame the media/s object/s is/are situated. There appears a link to the original media source.

The media object shown is stamped through watermarking technique.

The main iconographic ontology classes are selected as object grouping criteria. For example, there can be a preview of the available iconographical objects, grouped according to their title, author, iconographic school, used technique or base material. With another grouping option the user can see separately a list of all the iconographers (authors), and selecting one of them he can see additional biographic information and the collections of their work.

An authorised user can create his private collection of selected objects after search activity. Rich search possibilities are available in order to assist collection creation. The user can write the collection's title and short description. He can also select its status: private or shared with other users. New objects for a collection appear automatically upon entering them.

Content Search

The digital Library “Virtual Collection of Icons” provides a wide range of search services, such as keyword search, extended keyword search, semantic-based search, complex search, and search with grouping results. Their realization was based on querying action to the DL-VLI knowledge base using mainly the structural branches of the “East Christian iconographical art” ontology. Moreover, five types of conditions for the results set are meant:

- “objects having value = V for characteristic C”;
- “objects having value \neq V for characteristic C”;
- “objects having numeric value \geq , \leq , $>$, $<$, or = V for a characteristic C”. In the search templates you can search iconographical objects with a precise date or period;
- “objects having characteristic C”;
- “objects NOT having characteristic C”.

The search services support content request and delivery via index-based search and browse of managed content and its description.

Administrative Services

The Administrative services panel mainly provides user data management, data export, tracking services, and analysis services. The user data management covers the activities related to registration, data changes, level set, and tracking activities of the user. The tracking services have two main branches: tracking of objects, tracking of user' activities. The export data from the administrative services panel provides transfer of information packages (for example, packages with DL-VLI objects/collections, user profiles, etc.) compatible with other systems managing data bases. For example, with these services a package with DL-VLI objects can be transported in a XML-based structure for new external use.

5 Conclusions and Future Work

This paper presents the development of the Digital Library “Virtual Collection of Icons” (<http://www.burgasmuseums.bg/bidl/>) and its application for the iconographical collection of the Regional Historical Museum—Burgas. DL-VCI will facilitate the process of providing RHM-Burgas's services and their quality. The services for electronically provided information will significantly improve the access to one of the significant funds of RHM-Burgas. The digitization of unique iconographic collection

of RHM-Burgas, which is one of the richest in the country, will provide maximal and safe accessibility of the artefacts and will facilitate and enhance the traceability, analysis and study of the history and culture of the Burgas region from antiquity to the present day.

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