

Multimedia Digital Library as a Constructive Block in Ecosystems for Digital Cultural Assets

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Abstract. Libraries have always been a valuable source of knowledge. The technology evolution transformed the traditional libraries into digital ones which arose the need of efficient serve of the huge amount of information that now exists in the form of digitized content. The focus of the monographic study “Multimedia Digital Library: Constructive Block in Ecosystems for Digital Cultural Assets. Basic Functionality and Services” is on the search of innovations especially in areas and subareas relevant to digital library data management and processing—innovative and creative tools for approaching cultural assets, applications and services for better access and exploiting of the rich and diverse digital cultural heritage in a sustainable way, intelligent curation, creative use/re-use and remix, reinterpretation, study, understanding, analysis, personalization, adaptation, semantics, etc. The research deals with important issues of handling data directly, affecting the economy (as presented by creative and re-creative industry), the public sector (cultural institutions—museums, libraries, galleries, etc.), education, and society as a whole.

Keywords: Cultural Heritage, Data Management, Data Processing, Data visualization, Digital Culture, Digital libraries, e-Learning, Services, Ecosystems for Digital Cultural Assets

1 Introduction

During the first decade of the 21st century, information technologies reached levels of development, which allowed new ways to conserve, display and spread out our rich history and the national art and cultural heritage (CH). Contemporary technological solutions such as smart and digital content management systems, virtual museums, galleries and the Internet provided a way to reach, use and preserve this wealth at any time, everywhere and by anyone. Big ecosystems for digital cultural assets using Cloud technologies are created or are in process of active development aiming to store, manage and provide ubiquitously the great diversity of heritage resources. These ecosystems virtually assemble various digital collections, archives, virtual museums, digital libraries (DLs) and cultural heritage sites facilitating the access, reuse and exploitation of digital cultural resources meeting real user needs. The resources are being indexed and semantically annotated in order to be reached in the fastest and easiest way possible; special functionalities and services are being supported for creation of objects and for

extracting new data for the existing ones; mechanisms are being provided for automatic update of digital objects and collections; means and services are being created which allow various applications and creative usage (including e-learning, advertising, e-tourism, etc.). Systems feature flexibility and decentralization and the access to resources and services is mostly direct or through web-based portals.

Following are some key research questions, raised during the design and the development of these systems:

- How to help the user in exploring the information resources about the chosen domain by offering the most suitable topic-related materials and services: provisioning of suitable and necessary services (improved searching and grouping of resources, creative resource usage), providing automatic simultaneous access to the resources of more than a single system (digital library, repository, archive), flexibility regarding the order of the suggested information objects, resource recommendation, object reuse, analysis and generation of resources, etc.?
- How to describe the selected resources in a given context and to determine the conditions and use cases – cognitive or educational goals, analysis, creative use, etc.?
- How to help the user not just to view, but to also gain knowledge?
- How to provide knowledge in the most suitable way and form?
- How to adapt the offered information content for each individual user or group in order to achieve their goals and tasks?
- How to choose the most suitable resources for a specific situation and the method of introduction to the domain, which is subject to research, etc.?

The difficulties in solving these research issues are related to the lack of common model and working solutions regarding the basic and the extended functionality, and synchronizing the solutions with the existing standards and regulations in the area; analysis, understanding and better interpretation of digital cultural content; context-dependent use of digital cultural resources; increase and generalisation of visitor experience, contextual techniques for personalising visitor experience, etc.

The current research activities of the Institute of Mathematics and Informatics at the Bulgarian Academy of Sciences include the study and applications of new methods and tools for the creation, integration and development of innovative ecosystems for digital cultural assets and their constructive blocks - digital content management systems (viz. mainly digital libraries, virtual museum, digital cultural collections). The focus is in researching and exploitation of new or emerging technologies for the development of innovative products, tools, applications and services for the creative digital content production, usage and management. The aim is to transform cultural heritage into digital units, which integration and reuse through research-led methods will have high commercial potential for cultural institutions, tourism, creative and media industries.

There are lots of challenges while working on the given task: a necessity for clear definition of the user's needs of some specific functionality; the presentation of information content in the most suitable way for the chosen user types, the content's ability to be easily found and reached; assuring reusability of the resources in specific context and situation; adapting resources; searching for flexible conceptual solutions, which are

easily transferable and implementable via new technological means; synchronization with established standards and specifications, etc.

These questions suggest deep research and analysis of the different components of the system – content, user needs, offered services and its applications. The following are of great importance:

- Building of a straightforward model/specification of the activities that the system will serve;
- Developing and introducing proper functionalities for ensuring flexible access to the resources;
- Analysis of the context in which the resources will be used (including educational one) and searching for methodological approaches and techniques for improving the access to the resources to meet the user needs to the highest extent.

2 Innovative Ecosystems for Digital Cultural Assets

The paradigm of ecosystems for digital cultural assets (also called digital cultural ecosystems) appears to respond to the growing willingness to share the wealth of cultural resources and continuous research and study of cultural treasures. The European activities in this field are promoted and supported by the Horizon 2020 programme of EC H2020-EU.3.6.3. - Reflective societies - cultural heritage and European identity in the priority REFLECTIVE-6-2015 - Innovation ecosystems of digital cultural assets. The following research and innovation projects are successfully evaluated and are starting in 2016: I-Media-Cities - Innovative e-environment for Research on Cities and the Media (I-Media-Cities, 2016), ARCHES - Accessible Resources for Cultural Heritage EcoSystems (ARCHES, 2016), CROSSCULT - Empowering Reuse of Digital Cultural Heritage in Context-aware Crosscuts of European History (CROSSCULT, 2016), and ArchAIDE - Archaeological Automatic Interpretation and Documentation of cEramics (ArchAIDE, 2016). Activities under these projects aim to:

- “stimulate new research perspectives for the humanities and social science communities, promote further the use of digital cultural heritage allowing its reinterpretation towards the development of a new shared culture in Europe.
- provide innovative and creative methods for approaching cultural assets and generate applications and services to access and exploit the rich and diverse European digital cultural heritage in a sustainable way.
- foster collaboration between those with primary expertise in the interpretation of cultural data and researchers with complementary expertise in digital and interactive frameworks”, Horizon 2020 Programme of EC (REFLECTIVE-6-2015, 2015).

Horizon 2020 call REFLECTIVE-6-2015 supports and promotes access to and rescue of digital cultural heritage resources (available in scientific collections, archives, museums, libraries and cultural heritage sites) as part of research and innovation. Projects should enable new models and demonstrations of the analysis, interpretation and understanding of Europe's cultural and intellectual history and/or capitalising on state

of the art technologies (e.g. mobile and wearable devices), bring cultural content to new audiences in novel ways, through the development of new environments, applications, tools, and services for digital cultural resources in scientific collections, archives, museums, libraries and cultural heritage sites. The developed technologies or services should be generated in the context of humanities research perspectives (identity, culture, questions of place, historical and cultural knowledge) and/or facilitate the access, reuse and exploitation of digital cultural resources meeting real user needs.

Bulgarian academics have demonstrated considerable interest in this area in recent years. The main efforts are concentrated in applied aspects, especially for increasing the presence of digital artefacts and collections of the Bulgarian cultural and historical heritage in the global information space. Besides, work is done towards developing ICT tools and systems for digital presentation and preservation of cultural heritage artefacts. There is also intensified interest in fundamental research (priority areas of Informatics, ICT and Cultural Heritage of the *Strategy for the Development of Science in Bulgaria till 2020*, *Innovation Strategy for Intelligent Specialisation*, Horizon 2020, etc.) in areas/subareas relevant to data processing, access control, intelligent supervision, security, semantics, etc.

Authors' key assumption is that improved use, research and delivery of knowledge and collections related to cultural and historical heritage and the overall structuring of a digital culture ecosystem software environment by a referential model will help addressing some of the problems with handling large volumes of digital cultural data and objects, as well as their dynamic interaction in the system. Current problems will be overcome, such as data loss due to lack of uniform structures; lack of uniform interpretation; insufficient attractiveness of presentation; lack of unified access to many different digital repositories of cultural and historical heritage; poorly adaptive and customizable presentation of objects; difficulties in context-based use; etc. Furthermore, technology transfer to the technical and social sciences and the humanities, as well as the innovations in these areas, will be greatly encouraged.

Moreover, the research community has to deal with important issues of handling data directly affecting the economy (as represented by creative and recreational industry), the public sector (cultural institutions—museums, libraries, galleries, etc.), education, public processes, human resources, etc.

3 Digital Libraries in the Digital Cultural Ecosystems

The innovative ecosystems for digital cultural assets virtually assemble various digital collections, archives, virtual museums, digital libraries and cultural heritage sites in order to facilitate the access to their resources, bringing cultural content to new audiences in novel ways.

In the nature, an ecosystem is an area where organisms interact with one other as well as with the non-living parts of the environment. In the digital cultural ecosystem, various “digital organisms” (viz. collections, archives, virtual museums, digital libraries, cultural heritage site, etc.) also interact with one other as well as with the living part of the environment (viz. users). A digital cultural ecosystem can be huge, covering one

country or a region (similarly to a large forest or lake in the nature), but it can be small, such as a virtual museum or a private collection of artefacts (the nature analogues, a puddle of water or only a tree). “Digital organisms” work through their services and tools to satisfy and interact with their users.

We determine digital libraries as key constructive blocks in the ecosystems for digital cultural assets, which demonstrate appropriate services and tools of re-using and repurposing digital assets, paving the way for wider exploitation of cultural resources and boosting innovation. We accept them as “virtual plants” with diverse purposes and functions in the digital ecosystem.

In the past digital libraries were isolated and monolithic systems limited to access to content of a single provider. The development of the technologies during the last years provides new functionalities and advanced services to contemporary digital libraries transforming their static complex structures to environment with a dynamic federation of functional units. This change resulted from the needs of the market, the emergence of new technologies, and especially from the request for stricter use of the existing resources and adapting DLs content and services to the needs of different user groups.

Digital libraries could provide powerful and efficient functionalities for content management (acquisition, storage, indexing, access, and maintenance), manifold metadata for content enrichment, and structuring, as well as services for effective content search, access, annotation, filtering, and dissemination. The DL content and services are determined by acquisition (collection development), organization, and access policies tailored to the users the DL is intended to serve. The following basic characteristics of digital libraries could be specified:

- Ability to share information;
- New forms and formats for information presentation;
- Easy information update;
- Accessibility from anywhere, at any time;
- Services available for searching, selecting, grouping and presenting digital information, extracted from a number of locations. Contemporary methods and tools for digital information protection and preservation;
- Ability to use different types of computer equipment and software;
- No limitations related to the size of content to be presented.

As constructive blocks of the ecosystems for digital cultural assets, DLs demonstrate also advanced solutions for:

- Intelligent content curation;
- Context-based content usage, automatic contextualization and identification of content;
- DL usage for research, e-learning/e-training, applied games/gamification, animation/simulations, mobile applications, etc.;
- Personalization, user experience design and aesthetics;
- Real-time adaptable and interactive visualization, end user centric visualization;
- Linked data and semantic analytics;
- Multimodal interfaces providing improved user’s experience, etc.

The DL contemporary vision is related to the development of tools and services for innovative usage and better user interaction with their digital cultural assets. Thus, DLs will allow the content reinterpretation, study, understanding and analysis, creative use/re-use and remix (for new art projects, incl. documentaries and performance) and exploitation towards the development of a new shared and linked digital heritage culture for new knowledge around cultural heritage.

The focus of this study are the basic functionality and services in multimedia digital libraries in specific CH domains, as demonstrations of solutions for optimized content management and usage.

4 Book Overview

The monographic study “Multimedia Digital Library: Constructive Block in Eco-systems for Digital Cultural Assets. Basic Functionality and Services” (Paneva-Marinova, Goynov, & Luchev, *Multimedia digital library: Constructive block in ecosystems for digital cultural assets. Basic functionality and services*, 2017) is developed by a team from the Institute of Mathematics and Informatics, Bulgarian Academy of Sciences (IMI—BAS) and presents its scientific research and developments at the innovation ecosystems of digital cultural assets, digital library management systems, tools and services. It is a result of several national and international projects, such as: 1) Research project “Concepts and Models for Innovation Ecosystems of Digital Cultural Assets” (Contract № DN02/06/15.12.2016 between IMI—BAS and the National Science Fund of Bulgaria (2016–2018) (CultEcoSys-Project, 2017); 2) Research project “Digital cultural heritage “North+”: documenting, preserving and providing access to the cultural heritage in libraries, museums, archives and galleries in North and Central Bulgaria”, awarded by grant within Programme BG08 “Cultural heritage and contemporary arts” co-funded by EEA FM (2015-2017), Coordinator: Regional Public Library “P. R. Slaveykov”, Veliko Tarnovo, Partners: IMI—BAS and others; 3) Joint research project “Development of software systems for multimedia and language technologies” (2015-2017) between IMI—BAS and Institute for Computer Science and Control at the Hungarian Academy of Sciences; 4) Joint research project “Digital libraries implementation in culture and education” (2016-2018) between IMI—BAS and Latvian Academy of Sciences, Latvia Culture college at the Latvian Academy of Culture; 5) CIP-ICT-PSP.2009.2.4 Project „EuDML – European digital mathematical library”, EU Competitiveness and Innovation Framework Programme, ICT Policy Support Programme (2010–2013); 6) Research project “Development of digital libraries and information portal with virtual exposition “Bulgarian folklore heritage””, Contract №IO-03-03 between IMI—BAS and the National Science Fund of Bulgaria (2006–2012); 7) Research project “Digital libraries with multimedia content and its application in Bulgarian cultural heritage”, Contract №8 between the IMI—BAS, and the State Agency for Information Technologies and Communications (2005–2006).

The presented systems and their services aim to provide flexible and effective access and multimedia presentation of the cultural heritage artefacts and collections, maintain-

ing different forms and format of the digitized information content and rich functionality for interaction. The developments are a result of long-standing interests and work in the technological developments in information systems, knowledge processing and content management systems as constructive components of an innovative ecosystem for digital cultural assets. Long-term research activities aims at creating innovative solutions and building new models, methods and tools for improved use, research and delivery of content in the digital culture ecosystem. We assemble multimedia digital libraries and repositories for collaborative use in specific cultural heritage context, maintaining their semantic/services/users interoperability and creating new functionality for dynamic aggregation of the resources, access improvement, personalization, intelligent curation of content, content protection, innovative technology-enhanced learning, etc. The investigations are directed towards the development of distributed tools for aggregating heterogeneous content and ensuring the compatibility for pan-European access to rich digitized collections of Bulgarian cultural heritage.

This book is a result of collective work of software designers and developers, researchers, CH domain specialists, content managers, etc. from the IMI—BAS and its partners.

Chapter 1 of this book discusses the paradigm of the innovative ecosystems for digital cultural assets, which virtually assemble various digital collections, archives, virtual museums, digital libraries and cultural heritage sites in order to facilitate the access, reuse and exploitation of their digital cultural resources. Special attention is paid to digital libraries as key constructive blocks in the ecosystem for digital cultural assets. Chapter 2 presents the specifics of the concrete CH domain – Orthodox iconographical art, which is the knowledge backbone of the current development. Chapter 2 presents a structure for helping the formal description and documentation of the iconographical art in digital libraries by means of the Semantic web, i.e. ontology of the Orthodox iconographical art. The presented ontology is used for the semantics description and indexing the raw digital content in order to create and maintain reusable digital objects in a digital library (“Virtual encyclopaedia of Bulgarian iconography multimedia digital library”, BIDL, (Pavlova-Draganova, Paneva-Marinova, Pavlov, & Goynov, 2010)) or digital iconographical collections. Chapter 3 briefly describes the overall architecture of digital content management system in a concrete art domain (viz. BIDL), covering the main service panels, repositories and their relationships. A detailed overview of the content creation, selection and preview from the architecture, presenting their functionalities and algorithms are discussed in details. In Chapter 4 a special attention was paid to search and administrative services, trying to cover a wide range of possible solutions such as keyword search, extended keyword search, semantic-based search, complex search, search with result grouping, tracking services, exporting data, etc. The chapter presents these services, their functional specifications and used algorithms. Chapter 5 presents an extension of the current DL functionality for better content observation and knowledge acquisition through advanced content analysis and synthesizing. The main goal is to reach implicit and hidden data, content, rules and facts, dependences and tendencies, valid for the content in the DL repository, to synthesize and summarize the collected data in order to use it in various investigations and learning. DLs power in-

creases significantly when they use mechanisms for ubiquitous sharing of their e-artefacts and they distribute attractive content in the social networks, reflecting community demands and needs. Chapter 6 presents a service for automatic sharing of iconographical artefacts and full collections from BIDL to selected Facebook communities. In this case, the service is used for widely promoting knowledge about East-Christian iconographical art and culture. The main scopes of Chapter 7 is to make a summarizing overview of the basic Web 2.0 DL services, related to readers, authors, administrators. Chapter 8 briefly describes the main standards, which concern digital cultural content, saved in digital libraries. Chapter 9 presents some IMI—BAS's implementations of the digital library management systems for various cultural assets, following main authors publications: (Pavlova-Draganova, Paneva-Marinova, Pavlov, & Goynov, 2010) (Stewart, et al., 2015) (Paneva-Marinova, Pavlov, & Rangochev, 2010) (Bogdanova, Todorov, & Noev, Digitalization and security of "Bulgarian Folklore Heritage" archive, 2010) (Bogdanova, Pavlov, Todorov, & Mateeva, 2006).

5 Conclusions

Europe's cultural, historical and scientific knowledge resources are a unique public asset forming the collective and evolving memory of our diverse societies. Resource discovery, accessibility, usability, interoperability, authenticity, quality and trust by all users of the Information Society are essential requirements for the delivery of digital cultural information and services.

European libraries, archives and museums contain a wealth of information, representing the richness of Europe's history, its cultural diversity and its scientific achievements. The degree of access to this information determines how far people can experience their cultural heritage and benefit from it in their work or studies. By digitising their collections and making them available online, libraries, archives and museums can reach out to the citizens and make it easier for them to access material from the past. The online presence of this material from different cultures and in different languages will make it easier for citizens to appreciate their own culture heritage as well as the heritage of other European countries, and use it for study, work or leisure (MINERVAEUROPE, n.d.).

New ICT technological solutions provides opportunities for:

- Improved access and easy content navigation; adapted display specialized content search, grouping, sorting, intelligent curation of digital cultural, historical and artistic objects;
- Selection and recommendation of information;
- Context-dependent use of digital resources;
- Analysis, understanding and interpretation of the content, etc.

Different tools and services for create, access, exploit, preserve and reuse various forms of cultural assets, and to model, analyse and visualize them in digital cultural ecosystems are the backbone of this analytical study. Several solutions for content man-

agement in were presented. The next step is to preview the extension of this basic functionality – the advanced services for personalized observation and improved users experience in digital cultural ecosystems, mobile access, interoperability between different ingredients in the digital cultural ecosystem, technology-enhanced learning applications, serious games, gamifications, etc.

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