Ontology-Based Access to Multimedia Cultural Heritage Collections - The REACH Project

C. Doulaverakis, Y. Kompatsiaris and M. G. Strintzis

***Abstract* — In this paper, an approach for providing unified access to heterogeneous distributed cultural heritage collections is presented. The proposed approach is developed within the framework of the REACH Greek National Project with the overall aim to provide a web portal enabling access to different databases of cultural content with emphasis on multimedia material. In order to achieve this, the project employs ontology-based representation of cultural content, multimedia content-based search algorithms, hybrid ontology and content-based access and user-friendly search interfaces. This fusion approach provides users with resources for building queries of multimedia repositories sequentially using multiple individual search tools, and performs higher quality searching. In the current stage of development, real content such as inscriptions and coins from the Greco-Roman time period, has successfully been incorporated in the system.**

***Keywords* — Multimedia retrieval, museum collections, ontology, semantic retrieval**

I. INTRODUCTION

ONE of the fields of applications which will benefit from the recent advances in *Multimedia Content Search and Retrieval* and *Semantic Web Technologies* is the area of Cultural Heritage Information Management. This field involves the development of applications and systems for the efficient processing, storage, retrieval and exploitation of material taken from the records of foundations and institutes like museums, antiquities and art collections. Such collections in many cases include a large set of multimedia content with rich metadata. Several systems which provide access to cultural heritage collections already exist, such as Artefacts Canada and MuseumFinland[1]. However these systems other than semantic based retrieval, do not provide any form of multimedia based searching.

In this paper, an ontology-based approach for providing unified access to distributed cultural heritage collections is presented. It is part of the REACH project, which deals with the development of new forms of access to multimedia cultural heritage material. The main focus is the organization of the content in an ontological structure and the development of a central web portal with advanced searching capabilities (including hybrid ontology - multimedia content-based search) for accessing the underlying information. The paper is organized as follows: In Section II a brief description of the project is given, while Section III describes CIDOC-CRM, the core ontology used, and the mapping between the latter and the provided content. In Section IV the searching functionalities of the currently implemented web portal is described and presented. Finally, in Section V conclusions and future work are mentioned.

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II. THE REACH PROJECT

The objective of the project is to develop an ontology-based representation in order to provide enhanced unified access to heterogeneous distributed cultural heritage digital databases. The system to be developed will integrate Greek databases of cultural content offering unified access and efficient methods of search and navigation of content to users, while enabling commercial exploitation. The complete system will be composed of the following subsystems: (i) a cultural heritage web portal for unified access to the information and services, (ii) digitalization system for the efficient digitalization of artwork and collections, (iii) an ontology to describe and organize cultural heritage content, (iv) multimedia content-based as well as ontological-based search engine to offer advanced choices of searching methods, (v) e-Commerce section for the commercial exploitation of the portal. The paper will focus on subsystems (iii) and (iv).

The main content provider for the project is the Centre for Greek and Roman Antiquity (KERA) offering a large collection of inscriptions and coins from the Greco-Roman time period, accompanied with detailed documentation.

III. CORE ONTOLOGY

The purpose of the core ontology is to provide a global model able to integrate information (metadata) originating from different sources. The integration process involves efficient mapping of the available metadata to the concepts and relations of the core ontology, so only one knowledge base has to be used for the development of cross-domain tools and services. While the area of cultural heritage combines very heterogeneous sources of information and

material, one of the requirements of the project was that the ontology to be used should be as extensible as possible. In order to meet this requirement the CIDOC-CRM (CIDOC-Conceptual Reference Model)[2] ontology, developed by CIDOC, the Museum Documentation Standards Group, was used.

The CIDOC-CRM was developed over the past 8 years by an interdisciplinary working group of the International Committee for Documentation of the International Council of Museums (CIDOC/ICOM) and is in the process of standardization by the ISO Committee. The latest version, 4.0, consists of 80 classes and 132 properties. It is available in RDFS and other formats.

Currently a mapping of the available database from KERA to the CIDOC-CRM was achieved. The CRM provides a way to integrate in appropriate classes, all data that are essential in characterizing a cultural item. However no straightforward way for this kind of work has been described. For this task, the ontology was thoroughly studied and we ended up with a mapping structure that was found to best describe the available content in the CIDOC-CRM. An example involving the inscriptions metadata is given in Fig. 1.

As ontology administration tool, the Sesame[3] platform was selected as it provides a set of useful services. The most important to mention are the ability to store the ontology in a relational database which can then be queried like a normal ontology, an API for the development of applications to interact with the ontology and a powerful query engine and query language, *SeRQL*, which is based on the well-known RDF query language, *RQL*[4].

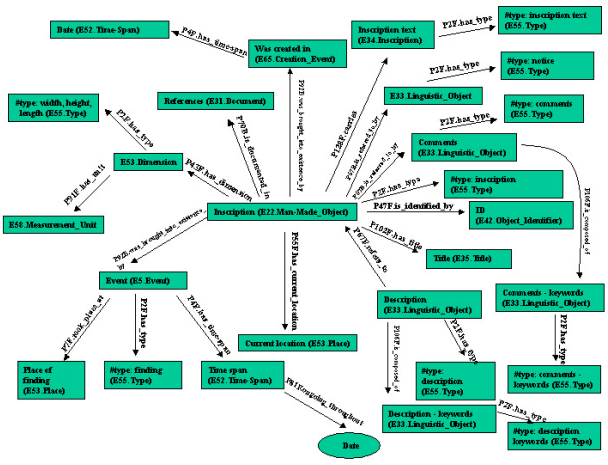

Fig. 1. Mapping of the inscriptions to the CIDOC-CRM concepts and relations

IV. SEARCHING THROUGH THE COLLECTIONS

The web portal will provide advanced searching capabilities to users. The requirement is that users will be able to use a variety of searching functionalities so that access to the underlying information will be easier and more effective. These functionalities namely include ontology-based search, content-based visual search and a novel hybrid ontology-visual search. A more detailed description of the three searching mechanisms follows.

A. *Ontology-based search*

The ontology-based search will give the opportunity to the users to take advantage of the ontological data structure and look for specific information. The search can be conducted using two different methods. With the first method, predefined concepts will be available as links in the web interface (such as *"search based on location, date, etc."*). A tree-like interface gives an illustrative example of the structure of the underlying knowledge. By using this method the user can select a concept to start the search process. Using this approach a user could for example select the *"Search by location"* option and a grouping of the entries in the ontology based on location is displayed. As a second step the user selects the desired place and the corresponding results are displayed. This approach is useful for visitors to the web portal to easily browse through the ontology and review the content. An example of this functionality is displayed in Fig. 2.

(a)

(b)

Fig. 2. Ontology based search, a) Users can select one of the predefined concepts, b) final result set after selecting *"Search by location"* for the inscriptions entry

Using the second search method, the user has the option to type in keywords in a text field. The ontology is queried

and the objects that were found to contain the keywords in their metadata are displayed in the result set. This allows the users to have access to the ontology content by not restricting their searching criteria to a single field.

B. *Content-based visual search*

In addition to the ontology-based search which exploits textual metadata, the web portal will also provide a content-based search functionality to exploit visual similarity. By utilizing this option, users will be able to perform a visual search by taking advantage of the multimedia content (images, video, 3D representations). The user will be able to provide an image, video or 3D model as input query to the system. Based on the extracted descriptors of the query and the stored content descriptors, the system will perform a content-based search and relevant results will be retrieved.

The aim of using a content based search functionality is to provide the means for efficient access to similar objects based on examples provided by the system or the user. An example of a result set using content based retrieval is shown in Fig. 3.

Fig. 3. Content-based search results using the upper left coin as query image

The analysis for images involves segmenting into meaningful regions using an approach described in [5]. MPEG-7 descriptors are then extracted from these regions as well from the whole image, thus ending up with coarse (global) and fine (region-based) descriptions for each image. To implement descriptor extraction and matching, the MPEG-7 XM [6] software is used which realizes the MPEG-7 descriptors and provides a set of functionalities useful for retrieval, as described with more detail in [7].

For video analysis, the same process as in image analysis is followed with the difference that prior to image segmentation, shot segmentation and keyframe extraction algorithms are utilized on the video sequence. The analysis is then performed on the keyframes themselves. During retrieval, the whole video shot is thought to be described by it's keyframe.

Finally, for 3D content analysis an approach similar to [8] where a generalized 3D Radon transform is used for extracting feature vectors and dimensionality reduction techniques are employed on the latter. During retrieval the Euclidian distance of the vectors is calculated.

C. *Hybrid search*

The hybrid search will provide a novel retrieval method where both visual and ontology search will be employed. This novel method will automatically or with minimal user intervention combine different type search results and will handle sequential search like finding some images or videos with ontology-based search and then continuing the search with content-based search.

Most importantly, this module will generate new queries transparent to the user in order to retrieve more results, combine them and present them to the user. For example, starting from ontology-based search, this module automatically generates content-based queries based on the first ranked results and finally integrates all results to be presented to the user. The outcome of this method will be a more complete result set which is not restricted to one search method only.

Fig. 4. Search results using the hybrid searching functionality.

An example of this novel functionality is illustrated in Fig. 4 where a content based search is performed as in the example in Fig. 3 but on the right column additional results are displayed where they were generated by performing a query to the ontology based on metadata taken from the first results (specifically for this example, the collections that the coins are part of).

V. Conclusions

The organization and means to access cultural heritage collections described using an ontological structure within the framework of the REACH project have been presented. A core ontology is used for structuring

semantic content descriptions, thus providing enhanced semantic-based information access to the collections and efficient and effective retrieval. A search engine has been implemented which incorporates three main functionalities. These include ontology-based semantic search, content-based search and a novel hybrid search where the former two methods are combined to provide a more complete result set. The first experimental results are promising showing good exploitation of the underlying knowledge and satisfactory retrieval results when searching through the collections.

Future work includes integrating additional cultural content and respectively enriching the ontology infrastructure, the integration of a rule-based recommendation engine so as to improve semantic retrieval and the development of a more sophisticated algorithm for use in the hybrid search system for providing a more relevant additional result set.

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