SEMANTIC BASED QUERYING AND RETRIEVING INFORMATION FOR ARTISTIC EXPRESSIONS: THE ART-E-FACT ONTOLOGY

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ABSTRACT

New methodologies and approaches are required nowadays in order to facilitate non-technically trained users to access, browse and retrieve content from relational databases. This paper presents the methodology developed for the scope, definition, real implementation and visualization of a domain ontology for content generation based on cultural databases. This ontology has been implemented within the art-E-fact project to represent conceptually and interconnect data and the associated knowledge stored in distributed cultural heritage databases, so that description, exchange and sharing of this multimedia added-value content can be used in the creation of artistic expressions using the latest developments in the Information and Communication Technologies.

1. INTRODUCTION

Creating art is the genesis of an original impulse of feelings, thoughts, passions, behaviour, etc. Expression is an output of what creators obtain in their internal worlds, through their cultural background and environment, as well as through their technical skills. The huge amount of experiences and the stochastic way of assimilating and mixing them is the kernel of the final expressions that rise out.

So technically speaking, authors, artists or content generators should be aware of this rich internal world which is provided to them through the description ontology. The technical skills of the author aided by tools, which will retrieve content from distributed databases using the metalevel ontology, will rise out in an optimal way following the memory of creating art.

Interoperability between databases has to be provided on both a technical and an informational level. Problems that might arise owing to heterogeneity of the data are already well-known within the distributed database systems community: structural heterogeneity and semantic heterogeneity.

In order to achieve the latter, the meaning of the information that is interchanged has to be understood across the systems. Semantic conflicts occur whenever two contexts do not use the same interpretation of the information. The use of ontologies for the explication of implicit and hidden knowledge is a possible approach to overcome the problem of semantic heterogeneity.

One of the objectives of the art-E-fact project is to develop a generic platform for interactive storytelling in Mixed Reality that allows artists and content generators to create artistic expressions in a cultural context between the virtual and the physical reality. With the means of an Authoring-Tool, artists, users and content generators in general are able to create art stories based upon the content stored in databases. Therefore, to support the authoring process, artists need to have both a very deep understanding of what is going to be authored and how to author it.

The art-E-fact ontology and its visualization model enhance the content stored in the databases, adding a semantic layer above them. This facilitates a general overview of the content available to build art stories and a direct access to the content without having any database system management background.

Section 2 presents a state-of-the-art concerning different aspects related to ontologies. In Section 3, a brief outlook of the art-E-fact project is presented. Sections 4, 5 and 6 deal with different aspects of the art-E-fact ontology, including the scoping and conception of the ontology, the real implementation and the mapping based on the single constraint condition using generic mapping mechanisms. In Section 7, the Content Browser editor is presented. The paper finishes with some conclusions in Section 8.

2. STATE OF THE ART

Already at the middle of the 80s, a big knowledge base on common sense began to be built. However, it is not until the beginning of the 90s when ontologies are more known. It is in this time when DARPA starts its Knowledge Sharing Effort, envisioning a new way in which intelligent systems could be built (10). Since then, considerable progress has been made in developing the conceptual bases needed for building technology that allows knowledge-component reuse and sharing. Ontologies are currently used in agent systems, knowledge management systems and e-commerce platforms.

Originally, the term ontology comes from philosophy (it goes as far back an Artistotle's attempt to classify the things in the world) where it is employed to describe the existence of beings in the world (8). In 1993, Gruber's definition becomes the most referenced on the literature: "an ontology is an explicit specification of a conceptualization" (6,7). Conceptualization refers to an abstract model of phenomena in the world by having identified the relevant concepts of those phenomena. Explicit means that the type of concepts used and the constraints on their use are explicitly defined. Formal refers to the fact that the ontology should be machine readable, which excludes natural language. Shared reflects the notion that an ontology captures consensual knowledge, that is, it is not private to some individual, but accepted by a group.

Tools for building ontologies usually provide a graphical user interface that allows ontologists to create ontologies without using directly a specific ontology specification language. Some tools such as Protégé, Chimaera or FCA-Merge have been created for merging and integrating ontologies.

Recently, many ontology languages have been developed in the context of the World Wide Web: RDF, RDF Schema, SHOE, XOL, OML, OWL, OIL and DML+OIL (5). Their syntax is based on XML, which has been widely adopted as a 'standard' language for exchanging information on the web. From all these languages, RDF and RDF Schema cannot be considered as ontology specification languages per se, but as general languages for the description of metadata in the web.

Ontologies can be used for many different purposes (2). The literature on knowledge representation contains research on the use of ontologies for data-interchange, for data-integration, for data-querying or for data-visualization. In general, visualization of information can be seen as a two-step process. In a first step, information is transformed into some intermediate semantic structure. This structure organises the raw information into a meaningful structure. In a second step, this semantic structure is used as the basis for a visual representation.

One of the most widely seen tools for graph visualizations of RDF metadata is IsAViz (11), built on AT&T's Graphviz graph visualization software. In addition to producing the graphs, it is a stand alone application for browsing and authoring RDF documents. Finally, the Spectacle system creates an Exploration Context out of information sources, providing users a convenient way to find and explore information (16). The system can create hypertext interfaces, containing selected content, design and an appropriate navigation structure, based on the semantics of the information, and present the information using graphical visualization.

3. THE ART-E-FACT PROJECT

The aim of the art-E-fact Project (IST-2001-37924) is to create a generic platform for Interactive Storytelling in Mixed Reality that allows artists to create artistic expressions in an original way within a cultural context between the virtual and the physical reality.

Virtual autonomous characters, multimedia content, physical props and devices, and multimodal human-oriented interactions for artistic expressions are enabled by the means of Interactive Storytelling and Mixed Reality techniques. The target platform is both a new medium for the communication of content and a new form of art. The main objectives of the art-E-fact project are the following:

- to develop a generic platform for Interactive Storytelling in Mixed Reality that allows artists to create artistic expressions in an original way, within a cultural context between the virtual and the physical reality,
- to use the platform to build a compelling Mixed Reality installation that facilitates the access to a knowledge base of inspiration material of art history reflecting the way humans created art since the last 4000 years,
- to involve artists and the analysis of artistic methods, on from the beginning of the project through all its phases, as well as
- to create a showcase within an interdisciplinary team that can be used for the evaluation of artistic methods, as well as for the diffusion and exploitation of the results, leading to more accessible tools for artistic expression in the future.

Artists can create a Mixed Reality exhibit by using the generic system to shape a specific instance of expression. They make choices of specific interaction devices and physical props to be used for anthropomorphic interactions, as well as corresponding interaction metaphors; they define dialogues with a degree of autonomy and behaviour of virtual characters, and they create multimedia elements to be accessed during run-time.

art-E-fact aims at the provision of Mixed Reality technologies addressing two directions: firstly, to provide a generic platform for the artistic expression that enables interactive exploration of artworks, and secondly, to ease the task of artwork creation by providing standard VRML compatible Virtual Reality framework enhanced with interaction and sensor features.

The art-E-fact platform serves as an experimental platform allowing authors with artistic or humanistic backgrounds to make design decisions that go beyond the state-of-the-art of creation systems for digital media. In summary, it is possible for artists to include anthropomorphic interactions such as gestures or body poses into their design of Mixed Realities.

4. THE ART-E-FACT ONTOLOGY

Since the target of the art-E-fact project is to create stories about artworks and thus, create art, we have to be taught by the experience that has been gained in the last 4000 years of civilization. As noted above, this is not just a conception of the experts performing the scientific diagnosis, but it is also a tool for artists, authors and content generators.

Artists using the ontology have to create stories or experiences concerning one or more selected artworks, including their main features, technical data or historical context. All this information is included within the Cultural Content concept. The domain ontology conception helps them assimilating the internal world of the creator of an artwork, and creating and telling stories.

In order to build the ontology for the art-E-fact project, we have followed the approach proposed in (15). At this point, it should be reminded that building an ontology is necessarily an iterative process.

4.1. Scoping the ontology

Scoping the ontology has been mainly based on two brainstorming sessions with artists and content providers. Having these brainstorming sessions allowed us to produce most of the potentially relevant terms. At this stage, the terms alone represented the concept, thus concealing significant ambiguities and differences of opinion.

A clear issue that arose during these sessions was the terminology differences among different art styles, between the Greek traditional iconography and the traditional European painting schools. The concepts listed during the brainstorming sessions were grouped in areas of work corresponding naturally arising sub-groups. Most of the important concepts and many terms were identified. The main work of building the ontology was then to produce definitions.

4.2. Description of the conception

The scientific diagnosis and documentation of artworks provide artists, authors or content generators with a rich knowledge background with plenty of multidimensional data and metadata. There is a special relation among the metadata, which reveals all the knowledge concerning the artwork obtained from the diagnosis procedure.

The artwork is related to five levels of knowledge, enriched with a set of metadata or descriptors of the data of the diagnosis. All these levels of knowledge or "thematic entities" in the ontology conception are supported by the scientific diagnosis results and the related documentation.

- The entity "Work identification" consists of general historical data, identifying aspects such as subject, title, category, type, dimensions, current location, context, ownership or creator of the artwork,
- The entity "Description" consists of information concerning the descriptive details of the theme and forms of representation, providing a better understanding of the context, such as representation, persons, background, decorative elements, inscriptions or sceneries,
- The entity "Aesthetic appearance" concerns mainly with plastic elements, which provide the appreciation of the style/aesthetic appearance of the artwork, such as the style, manner, composition set-up, colour, drawing style or texture,
- The entity "Technical" includes technical information both revealing the techniques and the materials used in the creation of the artwork, such as support, preparatory layers, underdrawings, painting materials, varnishes or stratigraphy, and also concerning exams of the condition, such as diagnosis or conservation treatments history, and
- The entity "Interpretation" is provided compared or associated with analogous or totally unlike artworks, such as thematic relationships, persons, symbols, styles or techniques.

These main entities and their metadata are supported, documented and provided by the scientific diagnosis, which has been applied to the artworks.

Among the three possible alternatives to define the concepts to build the art-E-fact ontology (top down, bottom up and a combination of both development process), a combined development process has been used. The most representative concepts have been defined first and then they have been specified appropriately in order to get a representation of the knowledge stored in the databases. The art-E-fact domain ontology is composed of 84 concepts and 173 properties.

5. REAL IMPLEMENTATION

When choosing an ontology interface, it should be taken into account not only the ontology editor, but also the exportability capacities of the tool. Studies in the bibliography (3) concerning the evaluation of different ontology tools concluded that Protegé2000 does not require much knowledge of the underlying representation language, and is therefore aimed at non-power users as artists within the art-E-fact project. It is also easy to learn as its interface is straightforward, has a nice interface and can be used for the whole trajectory of building ontologies.

Taking all this into account and some other previous experience using this editor, Protégé 2000 was selected as the development tool for the art-E-fact project. It allows the user building domain ontologies, fulfilling the requirements of the art-E-fact ontology for the Byzantine icons paintings, glass pieces and Fine Arts sculptures; customizing data entry forms and entering data.

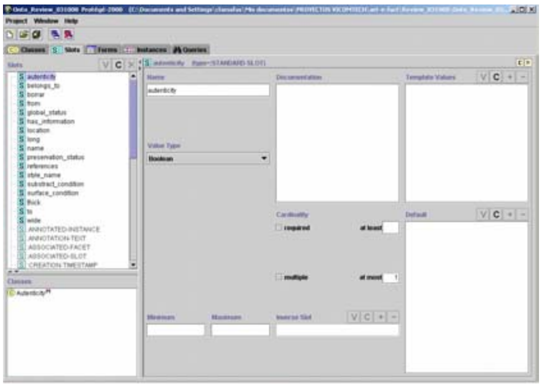

Fig. 1. Implementation of the art-E-fact ontology.

As mentioned before, Protégé 2000 has a very interesting possibility of component-based architecture that enables the system builders to add new functionalities according to their needs by just creating appropriate plug-ins (4). Among all these different choices, Protégé 2000 has the possibility of creating RDF and RDF Schema files that allows ontologists managing the ontology.

The Resource Description Framework file (RDF) is a W3C Recommendation for the formulation of metadata on the WWW (9). It is intended for situations in which information needs to be processed by applications, rather than being only displayed to people (1). RDF provides a common framework for expressing this information so it can be exchanged between applications without loss of meaning.

The basic building block in RDF is a subject-predicate-object triple. That is, a subject S has a predicate (or property) P with value O. However, RDF allows subjects and objects to be interchanged. Thus, any object from one triple can play the role of a subject in another triple. The RDF file is used to store all the instances of the art-E-fact ontology. In our case, this file is empty due to the existence of a solid and well-structured database.

```
<?xml version='1.0' encoding='ISO-8859-1'?>

<rdf:RDF
xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"/>
```

RDF properties also represent relationships between resources. However, RDF provides no mechanisms for describing these properties, nor does it provide any mechanisms for describing the relationships between these properties and other resources. RDF Schema (RDFS) extends the RDF standard with the means to specify domain vocabulary for RDF data and the kinds of objects to which predicates can be applied (13). In the art-E-fact project, the RDFS file includes the structure of the ontology tagged in this markup language, and is used to parse the information to the Cultural Content level.

```
<?xml version='1.0' encoding='ISO-8859-1'?>

<!DOCTYPE rdf:RDF [

<!ENTITY rdf 'http://www.w3.org/1999/02/22-rdf-syntax-ns#'>

<!ENTITY a
'http://protege.stanford.edu/system#'>

<!ENTITY artefact_onto1
'http://protege.stanford.edu/artefact_onto1#'>

<!ENTITY rdfs 'http://www.w3.org/TR/1999/PR-rdf-schema-19990303#'>]>

<rdf:RDF xmlns:rdf="&rdf;"

         xmlns:a="&a;"

xmlns:artefact_onto1="&artefact_onto1;"

         xmlns:rdfs="&rdfs;">

<rdfs:Class
rdf:about="&artefact_onto1;Acquisition_Date"

         rdfs:label="Acquisition_Date">

        <rdfs:subClassOf
rdf:resource="&artefact_onto1;Identification_art_work"/>

</rdfs:Class>

<rdfs:Class rdf:about="&artefact_onto1;Activity"

         rdfs:label="Activity">

        <rdfs:subClassOf
rdf:resource="&artefact_onto1;Biography"/>

</rdfs:Class>
```

Once the ontology has been built and the RDFS file automatically generated in Protégé 2000, all this information is stored in such a way that it is easily managed, queried and retrieved. Artists are able to get the relations among the concepts and properties of the ontology, and to inference the Content databases.

Therefore, what is clearly required is a query language that is sensitive to the semantic of the RDF Schema primitives. Sesame is an architecture that allows persistent storage of RDF data and schema information and subsequent querying of that information (12).

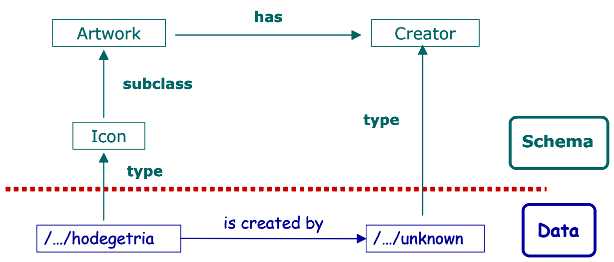

Fig. 2. An example of a RDF Schema for the art-E-fact ontology, defining vocabulary and a class hierarchy.

Sesame is an RDF-Schema based Repository and Querying facility. It is a platform independent support for main-memory storage, inferencing and retrieval. For persistent storage of RDF data, Sesame needs a scalable repository. Naturally, a Data Base Management System (DBMS) comes to mind, as there have been used for decades for storing large quantities of data. However, Sesame introduces a separate layer (Repository Abstraction Layer) which makes it possible to implement Sesame on top of a wide variety of repositories without changing any of other components of Sesame. The introduction of this layer makes Sesame into a generic architecture for RDF/S storage and querying.

Sesame also supports the query of a relational database (the database where the ontology N-triples is stored) by using RQL querying language. The RQL (Resource Query Language) is a query language for RDF and RDF Schema, loosely based on the syntax of SQL. One of the most powerful characteristics of the RQL is that it addresses RDF Schema semantics in the language itself. Class-instance relationships, class-property subsumption, domain-range and such are all addressed and inferred by specific language constructs. This query on the ontology's database is done using Sesame, since it has an RQL query engine that can be used to evaluate RQL queries.

Thus, the information about the art-E-fact ontology is saved in a relational database, using the Sesame Administrator to parse it from the ontology editor to the database. The query on the content database provided by the cultural partners of the project is done using the SQL (Structured Query Language) query language on the basis of the information retrieved from the ontology's database.

6. MAPPING THE ART-E-FACT DATABASE USING THE SINGLE CONSTRAINT MAPPING METHODOLOGY

The general interest of integrating heterogeneous information from distributed systems put ontologies into the context. They cannot be perceived as standalone models of the world, but should therefore rather be seen as the glue that puts together information of various kinds. Consequently, the relation of an ontology to its environment plays an essential role in information integration. In this paper, we use the term mapping to refer to the connection of the ontology with the database.

6.1. The single constraint condition

One necessary and sufficient condition for the database to be mapped through the ontology is that there must be a field in one of the tables within the structure of the database (called herby "DB entry point") that has access to all of the fields of the tables that compose the dataset.

In this way, it is possible to guarantee that once this field is correctly identified, queries to retrieve information from each of the fields in every table of the database are allowed.

6.2. The database architecture

The main idea concerning the design of the architecture of the Artworks Database (AWDB) system corresponds to the conception of the ontology. In this architecture, the main levels of knowledge are treated as main "thematic entities" for the database. The entity of the identification work is the table "ITEM" (DB entry point) and all the tables are related to this table. There can never be a table with no connection to at least one or more tables, since that would automatically mean that there is some data that is not reachable by the querying engine.

6.3. The mapping

The most obvious application of mapping is to relate ontologies to the real contents of an information source. The art-E-fact ontology is related to cultural content provided by the cultural partners within the project. Among the different approaches used to establish the connection between ontologies and information databases, a definition of terms has been chosen.

It is not enough to reproduce the database schema in order to make the semantics of terms clear. Thus, definitions of the ontology do not match to the structure of the database. These are only linked to information by the term that is defined. The ontology is not a "mirror" of the structure of the database. Moreover, it should act as a "semantic index" representing the data and information stored in the database. Therefore, a class on the ontology can not be identified with a table in the database.

The mapping has been made at the property level, so that a property in the ontology represents a field on a table of the database. To map the database through the ontology in Protegé2000, properties can be divided into two different groups:

- Properties made up by "Class" and "Instance". As this group is used to define relations between concepts, the associated properties cannot be used for the mapping since they only show information about the structure of the ontology; and
- Properties made up by "Literals" (e.g. string, boolean, float, etc.) This second group can store information about the information stored in the database, e.g. the name of a person, so it is used to take part on the mapping.

The properties of each Class of the ontology must be mapped to a field of the database. As the aim of the mapping is to facilitate access to the database, one property of a Class can point at two different fields on the database. However, one field could not point at two different classes, since it may cause some conflicts when trying to retrieve data from the database.

In order to access the content through the ontology, we have designed a "middle" ontology that records the information of the structure of the database, the database itself and the relations between both. In this way, artists can access the data avoiding the complex and rough task of managing databases.

7. THE CONTENT BROWSER

One of the main requirements for the art-E-fact project is the implementation of user-friendly interaction interfaces. Artists and content generators as target group of this platform should be provided with some kind of user-friendly environment while developing the art experience.

The Content Browser displays the ontology information graphically in order to support artists to easily navigate and browse through the concepts. Moreover, it provides them with information about the concepts and other related issues concerning the ontology. The Browser is particularly useful to artists who are not familiar with concept searching and want to browse the information resources in a user-friendly way.

The displayed concepts are obtained querying the ontology. If the artist requires the concrete content associated to any of the concepts displayed in the Content Browser, another query is done, this time, on the content database. In such a way, the artist gets the information requested with the precise content to build the story.

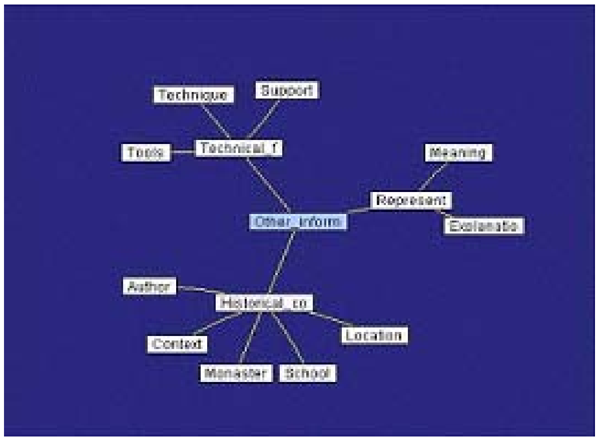

Fig. 3. View of the Content Browser.

The Content Browser enhances the content stored in the database adding a conceptual hierarchical layer above based on two possible approaches: hyperbolic tree or Windows-like folder trees. Besides, the Content Browser provides the following functionalities:

- Visual exploration and support of the ontology and the content for the authoring process; and
- Access to the content of the databases.

Searching a large information space such as the one of the art-E-fact project requires more than a technical infrastructure to query available resources. The sheer volume of results will overwhelm authors and artists, who often might not even know what to ask for. To address these common information disclosure problems, the art-E-fact Content Browser includes an intelligent interface that guides artists when exploring the information space and presents the query results in a structured way.

We have used a prototype of a user interface called the "Content Browser", which has been reused as a background provision from the WIDE project (12). It gives users the ability to navigate a collection of documents using knowledge-based techniques, while hiding much of the complexity of the back-end, such as the existence of multiple data sources or any ontology mapping.

The editor has three different areas: the area for the selection of the desired artwork on the left side, the browser itself in the middle area and the area of documents in the bottom side of the screen. Artists can navigate through the cultural content visualizing concepts and relations. For each concept, artists can search for information associated to that concept using semantic techniques for querying relational databases in a transparent way. In the low part of the screen, artists are provided with the paths or URLs of the concrete content stored in the database for the selected artwork.

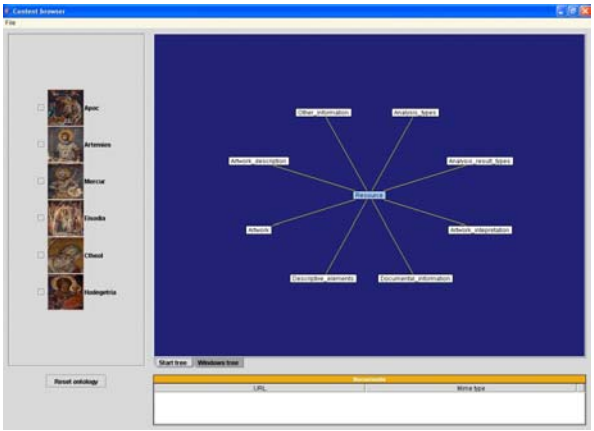

Fig. 4. Screenshot of the Content Browser editor.

8. CONCLUSIONS

The art-E-fact project aims at developing a generic platform for interactive storytelling in Mixed Reality that allows artists to create artistic expressions in an original way. This platform should facilitate the access to knowledge databases which content will be used as an inspirational material for them.

The domain ontology that has been implemented within the art-E-fact project gives artists a general overview of the content stored in the Cultural Content database without having to deal with a rough structure of a database. Moreover, graphical interfaces for the presentation of the ontology provide access to this content in a user friendly way.

Regarding to the work implemented, first of all, the reasons for the building a domain ontology within the art-E-fact project have been explained. Moreover, the type and the role of the ontology have also been justified.

A great emphasis has been put on the description of the methodological approach for the building of the ontology. It must be mentioned that this work has been done in close collaboration with other partners of the consortium. This methodological approach is generic enough so that it could be transferred to other applications.

Concerning building the ontology, the selection of the developing tools for the ontology and the use of other emerging semantic web technologies such as Sesame and RQL query language for the ontology inferencing process have been described.

Finally, the description of the Content Browser tool is provided. As it has been mentioned before, the ontology not only shows a general overview of the database, but it must give user-friendly access to the content of the database. This graphical interface helps the artists in the navigation through the concepts, allows automatic queries to the content database and retrieves the information required by the artists. These queries are done through an embedded inference logic that makes this platform generic.

As a conclusion, it must be mentioned that the developed platform is generic. Were there changes on the domain, including different databases, only changes in the new database and the ontology should be required, following the methodological approach that has already been developed and implemented.

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