TOWARDS A TEMPLATE-BASED GENERATION OF VIRTUAL 3D MUSEUM ENVIRONMENTS

D. Biella and W. Luther
Institute of Informatics and Cognitive Sciences,University of Duisburg-Essen, Lotharstr. 65, Duisburg, Germany

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Abstract: This paper focuses on the question of how metadata and existing metadata standards can be used for the administration, layout, storage, retrieval and visualization of Web-based virtual 3D museum environments. We present enhanced metadata concepts that encompass the infrastructure of a virtual museum or laboratory using stationary or mobile interfaces to communicate with information sources or interact with artifacts.

1 INTRODUCTION

In recent papers, we have presented Web-based virtual 3D museum environments featuring photo-realistic 3D models, nondeterministic simulations and special user interaction (Biella, 2006; Biella & Luther, 2007, 2008). We have also addressed the question of whether 3D or 2D virtual environments are preferable, depending on the type of exhibits involved. How to create virtual 2D exhibitions is discussed in (Nesland et al., 2005). Concepts and design aspects of virtual exhibition systems using XML-based conceptual hypermedia document models are addressed in (Foo, 2008).

The research presented in this paper focuses on the question how metadata and existing metadata standards can be used for the administration, layout, storage, retrieval and visualization of such environments.

First, we provide a definition of the virtual museum and discuss the concept of a virtual museum as an informal learning environment. Then, we highlight the theoretical aspect of metadata and its potential functions in an application context. Next, various existing metadata standards are introduced and compared with regard their capabilities for 3D virtual museum environments. Finally, we focus on the ARCO metadata standard AMS, present a case study in which it has been used to describe a virtual museum and highlight the strengths and weaknesses of AMS when it is used to create virtual exhibitions in specific environments providing meaningful user interactions.

2 VIRTUAL MUSEUM

In this paper, we focus on virtual museums. We follow the definition given by McKenzie, Sola and Keene that defines a “virtual museum” as “an organized collection of electronic artifacts and information resources—virtually anything which can be digitized” (McKenzie, 1997), which “uses as the means its collections, related information, knowledgeable people, and the museum itself with its galleries and displays of objects” (Keene, 1997).

According to Sola, the “traditional museum piece, an item, a three-dimensional fact, is only a datum among a complex of museum information, of a message. We do not have museums because of the objects they contain but because of the concepts that these objects help to convey.“ (Sola, 1997)

In summary, we regard a virtual museum environment as a combination of replicated or “born digital” exhibits, ideas and concepts. Furthermore, ideas and concepts can be conveyed through means of interaction with objects. Although this approach is commonly used in “hands-on” museums, there are few virtual museums that follow this approach.

Despite the properties given above, a virtual museum is expected to support the following features:

- Modification of exhibits with regard to position, form and content, even with the aim of creating new, enhanced instances of a cultural object,
- Interaction with exhibits via adequate interfaces,
- Reversibility to the original state after a user’s interaction, and
- Simulation of a kind defined by a discrete or continuous process model.

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We want to cite predominant forms of interaction supported by various cultural object types (cf. Table 1).

Table 1: Object and interaction types.

Object type	Interaction type
Geometric object	Moving, modifying the form, cloning
Visual object	Watching from a different viewpoint, modifying appearance
Dynamic object	Launching the dynamic process via a concept keyboard (Baloian et al., 2007)
Room or lighting	Being a part of the installation
Experiment	Parameterizing and executing
Historical object	Documenting the historical context, creating extensions

It is noteworthy that reversibility is much easier to accomplish in virtual simulations than in reality and that it offers the opportunity to learn and understand concepts by modifying objects regardless of their physical accessibility or monetary or cultural value. The concept of a museum as an informal learning environment using metadata for the description of room-based layout, dynamic exhibit models and interaction design is shown in Figure 1.

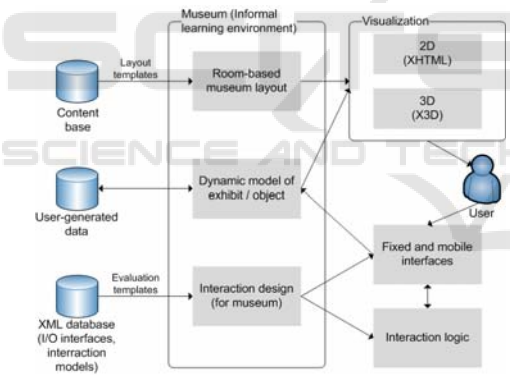

Figure 1: Concept of a virtual museum.

3 ENLARGED METADATA SCHEMA

A metadata standard is chosen or developed based on a list of requirements or required functions. This standard must be able to describe the smallest information units, which are usually objects or groups. Gilliland-Swetland introduced the notions of intrinsic and extrinsic metadata, which relate, respectively, to the content and context of the information object. Intrinsic data are associated with the characteristics of the object, and extrinsic data with contextual parameters. The following metadata categories are mentioned (Gilliland-Swetland, 2000): *Administrative Metadata (AM), Descriptive Metadata (DM), Preservation Metadata (PM), Technical Metadata (TM),* and *Use Metadata (UM).*

Although the ARCO data model (cp. Section 4) provides a metadata standard that can be applied in general museum contexts, the visualization tools seem to be proprietary add-on applications that present items in augmented reality environments. We found only partial counterparts to parameterized exhibition rooms, presentation forms, X-VRML templates or interaction patterns in the AMS (Patel et al., 2005) (Walczak et al., 2006).

Even if the ARCO standard used some of the categories introduced above, it did not distinguish between intrinsic and extrinsic data and follows the three-tier classification CO-AO-RO. Neither proposal explicitly supports sophisticated virtual museum generation, typical room arrangements or illumination concepts, dynamically changing objects or user-object interaction following a certain action and interaction logic. Powerful metadata schemes should support graphical tools to generate and modify architectural designs that define exhibition rooms including the ambient infrastructure, like libraries, video viewing or information desks. Using parameterized room templates and predefined presentation and interaction styles, the exhibition design process can be accelerated by using a standardized search engine, a repository containing the cultural object data based on a complete metadata schema. Parameters and data could be introduced using script languages or a graphical user interface (GUI) with enhanced object search, editing and preview functionalities.

We would like to emphasize the necessity that a valuable metadata concept should encompass the infrastructure of a virtual museum or laboratory with stationary or mobile interfaces to communicate with the information sources or to interact with the artifacts. This can be done via information terminals and sensitive touch screens or silent digital companions. The goal of our ongoing research is to determine to what extent the interaction logic can be automatically generated via template-based tools together with the virtual learning and experimenting environment and the human-machine interfaces.

Whereas the interaction logic is characterized within the *use metadata* and serves to launch operations that change the situation of a virtual object, the *technical metadata* describe the underlying action logic. This metadata scheme could also be inspired by certain elements of the actual learning object metadata (LOM) standard, such as interactivity type, intended end user role and entries to measure occupation time.

In augmenting the proposed ARCO metadata standard, *administrative and descriptive metadata* should encompass all the environment information (e.g.: exhibition objects, room installation, geometry and appearance attributes, illumination models). *Preservation metadata* define constraints and consistency checks to allow reversibility and preserve authenticity and integrity when users are interacting with virtual objects. *Technical metadata* should contain the creation and dynamization of (virtual) replicas and are related to the creation of user groups and access rights. *Use metadata* circumscribe the range of user activities, including virtual object creation and manipulation and types of expressivity.

The enlarged metadata standard makes a clear distinction between intrinsic and extrinsic metadata and completes the topics artifact selection, digital acquisition, storage/collection management, model refinement and exhibition building and can be implemented via an extension of a VRML model.

4 COMPARISON OF EXISTING METADATA STANDARDS

The metadata standards Dublin Core, CIDOC-CRM, VRA Core and ARCO have been compared based on their 3D data capability.

The Dublin Core Metadata Initiative (DCMI) is concerned with the development of metadata standards for the description of resources with a focus on interoperability between heterogeneous document management systems. Default DC metadata elements can be used in the description of artifacts and resources in museums. However, interaction or simulation models and extrinsic hierarchies cannot be described.

The Comité international pour la documentation Conceptual Reference Model (CIDOC CRM) is an ISO standard for the formal semantic description of cultural heritage information. In addition to DC, it can describe the temporal and spatial properties of an object-related event. CRM is limited in terms of multimedia content description but is well suited for physical objects, rather than for virtual objects.

Visual Resources Association (VRA) focuses on the metadata classification for both physical and virtual visual information objects. VRA Core's level of detail in object descriptions is similar to that of CIDOC CRM and offers many relation types for modeling relations between exhibits and between a museum and its rooms. It has limited capacities for "born-digital" 3D objects.

The ARCO project sought to develop a single standard that was also suitable for virtual 3D objects and their workflow (modeling, modification and visualization). It concretizes the notion of an information object by defining the abstract class cultural object (CO), the physical artifact, and by deriving two nonabstract instances, the acquired object (AO) and the refined object (RO). The digital representation of the CO (as AO or RO) is the Media Object (MO). Examples of MOs include 3D models and images of various MIME types.

The ARCO metadata element set (AMS) is an extension (partly based on DC, CIDOC-CRM) that defines six metadata types for ARCO objects: *Resource discovery metadata*, *Presentation Metadata*, *Curatorial and Descriptive Metadata*, *Technical Metadata*, *Themed Metadata and Administrative Metadata.*

The major advantages of the ARCO standard are the ability to manage native 3D and to store chronological information. The results of the analysis of ARCO's features with regard to certain metadata types are provided in Table 2.

Table 2: Support of certain metadata types in the ARCO metadata standard.

Type	Existing or partly existing feature	Missing feature
AM	Acquisition, rights, location, digitization, metadata creation	
DM	Creation (production date or period, location, creator, contribution), source, type (material), geometry and appearance, components, accession, actual location, field collection	Modification by users, No environment description
PM		Consistency
TM	Object metadata concerning virtual/ digital manifestation, MIME-type, media object instance in database, data type and format extent, person effort to produce, rights, skill level	
UM	Type-specific metadata, size, resolution panorama, compression, color depth, dimension, textures, modeler software, language, animation, algorithm, manipulation	Only 3ds Max, VRML & Dynamic modeling, No user impact, no interaction model, algorithm only for rescaling

The ARCO metadata standard—despite some minor exceptions—meets all the demands made by Gilliland-Swetland. Nonetheless, some functions are mapped to different metadata types (e.g.: rights). For this reason, we have chosen this standard to design 3D virtual museums and laboratories based on room templates, exhibit-specific navigation and interaction techniques.

5 FEASIBILITY STUDY

The feasibility of our concept was demonstrated by using an existing implementation of an African Grassland museum (Mafo, 2007) that includes an entrance hall and a separate hall for exhibits on the topic of daily life (cf. Figures 2 and 3). The system architecture consists of a PHP-capable Web server, a MySQL database server and Altova XML Spy and a Web browser as the client-sided interfaces. The object descriptions are stored in the database. Data is read and written through an ODBC connection. The Web-based metadata and object visualization front-end lists several objects in a selection list. When an object is clicked, it is visualized, and several metadata can be displayed (Figure 4).

Figure 2: Grassland museum (3D entrance hall).

Figure 3: Grassland museum ("Daily Life" hall).

Figure 4: Metadata visualization (Entrance hall).

6 CONCLUSIONS

We have presented workflow-based system architecture for the administration and visualization of metadata for 3D virtual museums. Several metadata standards have been evaluated. ARCO is the preferred standard due to its high degree of completeness with regard to different metadata types and its ability to handle 3D content. A case study has proven the feasibility of this concept, an empirical validation of the enhanced metadata standard is planned.

Another focus of our future work concerns the inclusion of conversational agents in analogy to existing solutions for real museums (Kopp et al., 2005) and agent descriptions in metadata standards.

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