Virtual Museum Exhibition Designer Using Enhanced ARCO Standard

Daniel Biella, Wolfram Luther
University of Duisburg-Essen
ZIM, INKO
47057 Duisburg, Germany
e-mail: {Daniel.Biella,Wolfram.Luther}@uni-due.de

Nelson Baloian
University of Chile
Department of Computer Science (DCC)
Santiago de Chile, Chile
e-mail: nbaloian@dcc.uchile.cl

I. INTRODUCTION

In this paper, we focus on the question of how existing metadata standards can be used and extended for the administration, layout, storage, retrieval and visualization of Web-based virtual 3D museum environments. The new Virtual Museum Exhibition Designer using Enhanced Arco Standard (ViMEDEAS) framework has been developed to support curators and visitors. It unifies features of a recently presented curator tool that allows exhibition planning and includes a functionality for editing existing exhibition layouts and visitors’ museum tours and the Replicave2 framework that generates a Web-based virtual 3D museum defined by various parameters at runtime. The framework uses the Virtual Museum and Cultural Object Exchange Format (VIMCOX), which includes new features such as room design and interactions with exhibits. VIMCOX is sufficiently flexible to gather the administrative, descriptive, technical and use metadata in a way that enables users to search the desired information and to create, display and manipulate virtual instances of artwork and whole exhibitions in a simple and intuitive way.

Keywords-3D Framework; Extended Virtual Museum Metadata Standard; Interaction types; Exhibition and Tour Planning.

Abstract—A new Virtual Museum Exhibition Designer using an Enhanced ARCO Standard (ViMEDEAS) framework has been developed to support curators and visitors. It unifies features of a recently presented curator tool that allows exhibition planning and includes a functionality for editing existing exhibition layouts and visitors’ museum tours and the Replicave2 framework that generates a Web-based virtual 3D museum defined by various parameters at runtime. The framework uses the Virtual Museum and Cultural Object Exchange Format (VIMCOX), which includes new features such as room design and interactions with exhibits. VIMCOX is sufficiently flexible to gather the administrative, descriptive, technical and use metadata in a way that enables users to search the desired information and to create, display and manipulate virtual instances of artwork and whole exhibitions in a simple and intuitive way.

In summary, we regard a VM environment as a combination of (both replicated or “born digital”) exhibits, exhibition space and view of the exterior arrangements, metaphors, ideas and concepts. Furthermore, ideas and concepts can be conveyed through interaction with objects. Although this approach is commonly used in “hands-on” museums, there are few VMs and metadata standards that follow this approach.

In [3], several metadata standards have been evaluated, among them ARCO [4], [5] as the preferred standard due to its high degree of completeness with regard to different metadata types and its ability to handle 3D content. However, there are important features missing that cannot be described with this standard. In a further paper [6] we have proposed extensions to the ARCO standard for the description of room installations, hierarchically structured resources, environmental data, rights management and interaction pattern.

The framework Replicave developed by Biella [7] in 2006 provides a cost-efficient way to create virtual exhibitions by reusing 3D models and generating additional VM content dynamically. The template-based virtual museum consists of an entrance hall, which connects the gallery, different media-rooms and additional interactive experiments [8], [9]. Its successor Replicave2 uses the extensible X3D format and JavaSE to rebuild all features and a Tomcat server environment to present exhibitions online. It has the ability to dynamically generate polygonal room designs, depending on given parameters. A 2D/3D point list can also be used to create nonstandard room shapes; the position of walls and entrances can be defined manually. Replicave2 facilitates the addition of preassembled models (X3D prototypes) like books, tables, chairs, magazines or flowers. It is ongoing work to bring together the features of Replicave2 and ViMEDEAS to enable individual museum and room design. The new software was tested in cooperation with the Museo de Arte Contemporaneo (MAC) at Santiago de Chile [6].

The idea of designing, implementing and deploying applications to enhance visits in a wide range of existing art, culture and science museums and to support visitors and exposition designers with special 3D software and electronic guidebooks with handheld and wireless technologies is not new. In [10] an electronic tour guide for museums based on PDAs is described that delivers a fully interactive 3D Augmented Reality (AR) to a group of visitors. A subsequent paper [11] shows that the use of a full 6-DOF (degrees of freedom) AR to support route guidance and resource appreciation without further environmental instrumentation can be expected within the next few years.

E-Curator [12], a 3D Web-based archive for conservators and curators, studies the impact of 3D documentation on conservation and curatorship. The paper [13] asks how to incorporate mobile technologies in a Web 2.0 manner in cultural heritage management activities and integrates mobile technologies for an ongoing semantic enrichment of multimedia materials in professional discourses. It seeks to
include the media production of non-experts into the multimedia discourses of a professional community. Museums and the Web [14] is the largest international conference devoted to the exploration of on-line art, science and natural and cultural heritage.

The research presented in this paper focuses on the question of how ARCO is to be extended for full X3D support. Extensions are proposed for the description of room installations, hierarchically structured resources, environmental data, rights management and mainly for interactivity types. Existing standards, like DCMI [15], LOM [16], and SPECTRUM [17] are being used. There is ongoing work in implementing a complete schema definition for the new VIMCOX standard [18].

In this paper, we first provide a short overview on the ARCO museum standard and discuss missing elements in its definition and ways of achieving an enlarged VM standard Virtual Museum and Cultural Object Exchange Format. We present a taxonomy of user-exhibit interactions and various interaction types, such as geometric motions, deconstructions and dynamic processes, are highlighted. A final test case describes an ongoing common project together with the Salomon Steinheim institute at Duisburg, which seeks to create a VM hosting the estate of the Jewish sculptor Leopold Fleischhacker [19]. The project plans to design a combination of indoor and outdoor areas in a VM that includes the presentation of the pictorial material and 3D models of tombstones in thematically oriented expositions.

II. AN ENLARGED METADATA SCHEMA

A. Metadata

A metadata standard is chosen or developed based on a list of requirements or required functions [20]. Furthermore, a metadata standard must be able to describe the smallest information units, which are usually objects or groups. Modern museums and exhibitions are quite different and have various concerns including textural, pictorial and sculptural objects. Room installations invite visitors to look at and to interact with such items. Thus modern museum standards like the VICOX standard have to include existing smaller standards that focus on digital text or art collections, hierarchically arranged material with various formats or learning objects. We should also concede that VM cannot be described using classical museum metadata standards developed to describe core records for various works of art and material culture because these standards cannot handle virtual instances of real artwork.

Gilliland-Swetland [21] 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:

- **Descriptive Metadata** are used to describe or identify information resources—cataloguing records, searching facilities, hyperlinked relationships between resources and user annotations. These metadata allow the identification of objects on the basis of their key features over their entire lifecycles and are typically intrinsic.

- **Preservation Metadata** are related to the preservation management of information resources. Documentation of actions preserves physical and digital versions of resources, such as data refreshing and migration.

- **Technical Metadata** are related to how a system functions or metadata behave. They concern hardware, middleware and software documentation, including repositories, interfaces, data types and algorithms used to build and manage virtual objects.

- **Use Metadata** are related to the level and type of use of information resources. Use metadata are, in general, extrinsic and include exhibit records, use and user tracking, content reuse and multiversioning information.

B. ARCO-Standard

The Augmented Representation of Cultural Objects (ARCO) project [4] sought to develop a single standard that was also suitable for virtual 3D objects and their workflow (modeling, modification and visualization). The ARCO model includes the following object classes:

- **Cultural object (CO):** Abstract class representing physical objects.
- **Acquired object (AO):** Non-abstract subclass of CO representing a physical object.
- **Refined object (RO):** Non-abstract subclass of CO representing an improved, modified version of an AO or of another 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.

Although ARCO provides a general metadata standard that can be applied in general museum contexts, ARCO is not yet a general standard for museums such as Categories for the Description of Works of Art (CDWA) [22]. We found only partial counterparts to parameterized exhibition rooms, presentation forms, X-VRML templates or interaction patterns in the ARCO Metadata Element Set as described in Patel et al. [5]. The visualization tools seem to be proprietary add-on applications that present items in augmented reality environments.

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.
C. Metadata standard for virtual museums

Mirroring the properties constituting a VM, powerful metadata schemes support graphical tools to generate and modify architectural designs that define exhibition rooms as well as 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 and a repository containing the cultural object data based on the metadata schema at hand. Parameters and data could be introduced using script languages or a graphical user interface (GUI) with enhanced object search and preview functionalities. With the metadata standard widened, the GUI will include the following features:

- Searching and selecting items from a repository,
- Visualizing the items in a 2D frame as well as from a standard 3D perspective,
- Editing intrinsic and environmental metadata to find items within their local and temporal context,
- Editing the intrinsic and modifying the extrinsic metadata within the limits of the user group in order to rearrange the objects in their context and modify that context, and
- Modifying the use metadata with respect to the users’ activities in the exhibition spaces.

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, for example, the process model or, more formally, the type of automaton with states and transitions.

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 metadata standard VIMCOX, administrative and descriptive metadata should encompass all the environment information, including exhibition objects, object arrangement models, geometry and appearance attributes, as well as illumination models as a part of the room installation and finally the whole museum architecture. This is accomplished by attaching the required information using bidirectional pointers or links.

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 limit the creation and dynamicization 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.

![Figure 1. Museum as an informal learning environment](image)

Intrinsic metadata are, in general, content-based, static and not subject to user modification, whereas extrinsic metadata concern the object’s context and are dynamic and subject to change through user interactions via an XML editor or even by drag and drop in the visualization window (cf. Figure 1).

An exhibition planner would want to place objects within their historical contexts, whereas exhibition users would want to annotate items, create new instances and parameterize experiments. These requirements clearly justify the distinction between intrinsic and extrinsic metadata and the enhancement of the existing ARCO metadata standard.

The enlarged metadata standard completes the topics artifact selection, digital acquisition, storage and collection management, model refinement and exhibition building with aspects like exhibit presentation, user navigation and interaction with static and dynamic items. This can be done via an extension of an X3D model.

The metadata schema should support a hierarchical structure of geometrical objects and their intrinsic and extrinsic parameters. The latter concern the objects’ location in absolute or relative coordinates, coordinate transformation, illumination, viewpoint selection for navigation, and human-exhibit interaction with a static object or a dynamic process. This flexible scene graph structure should also provide wildcards, which can be replaced by virtual objects on the fly.
III. INTERACTION AND DIALOGUE

Despite the properties listed above, a VM is also expected to support the following features:

- Requirements concerning the presentation of exhibits (carrier, wall, room, lighting and so on).
- Interaction with exhibits via adequate interfaces and reversibility to the original state after user interaction.
- Modification of exhibits with regard to position, form and content, even with the aim of creating new enhanced instances of one or more cultural objects.
- Simulation of a kind defined by a discrete or continuous process model.

The virtual resource includes interactive elements, such as 3D interfaces to move, rotate or scale the resource or to trigger a dynamic process modifying the appearance of the object. Visitors have to detect the interactive parts of the resource and match them to the interface and steering mode. A visitor can be visualized as an avatar within the scene and act as such. Thus, user interaction is related to navigation, selection and manipulation.

A. Taxonomy of interactivity types

Interaction features in VIMC0X could also be inspired by certain elements of the actual learning object metadata standard [16], such as interactivity type (cf. Table 1), intended end user role and entries measuring occupation time.

<table>
<thead>
<tr>
<th>Object type</th>
<th>Interactivity type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geometric object</td>
<td>Deconstructing into different parts and reconstructing from its parts</td>
</tr>
<tr>
<td></td>
<td>Moving, rotating, cloning the object or its parts, modifying the form</td>
</tr>
<tr>
<td>Visual object</td>
<td>Watching from a different vantage point, modifying appearance</td>
</tr>
<tr>
<td>Dynamic object</td>
<td>Launching or stopping the dynamic process or influencing it via a concept keyboard</td>
</tr>
<tr>
<td>Room or lighting</td>
<td>Being a part of the installation, modifying the installation and the objects by presence or movement of a person</td>
</tr>
<tr>
<td>Experiment</td>
<td>Parameterizing and executing</td>
</tr>
<tr>
<td>Historical object</td>
<td>Documenting the historical context, creating extensions</td>
</tr>
</tbody>
</table>

Geometric objects can be moved or rotated, superposed, scaled or modified, cloned, or made invisible (cf. Figure 2, [23]). Visual objects can be inspected and scrutinized from different vantages, and the user can modify their position, exposition and appearance. Scene graph-based languages support the deconstruction of an object into its various parts and even its reconstruction in a different way. Lingemann [23] discussed the deconstruction of parts of a house consisting of cutouts of two adjacent fronts and the roof. The artist Leonardo Portus created the artwork in 2007 (cf. Figure 3, [23], [24]).

The interaction logic provides the visitor with a set of rules for interacting with central objects in the experimental setup in correspondence with the theory and research methodology of the experiment.

Dynamic objects or experiments are launched via a control element. In recent papers we have introduced so-called concept keyboards [25]. These are keyboards with a reduced set of keys, on which each key will trigger an action in the context of the task being accomplished by the system. The designer has to create appropriate keyboards consisting of well-arranged key areas combined with expressive icons and audicons, allowing direct interaction with objects or process elements.

In combination with input data fields, input or model parameters can be specified or modified.

New room installations integrate the visitor directly as a part of the artwork or as the conductor of the scene. By moving their arms and/or bodies, visitors can modify objects or control or influence experiments (cf. Figure 4, [6], [23], [26]). As soon as a person is tracked by the camera,
his/her contour is projected on the opposite wall. Within the silhouette, more and more cells appear, and a cell division starts that results in a growing number of cells. The cell movement is linked to the person’s position. When the individual moves out of camera range, the cells begin to die and finally disappear completely.

This experiment uses an interactive canvas, a flat rectangular exhibit with parameterized dimensions, which is placed on the wall to reproduce movies or picture shows.

Via an X3D-MovieTexture object, an animated image sequence can be displayed without the option of direct interaction. As an alternative and to allow user interaction, a JAVA programmed ScriptNode generates a texture sequence used in an appearance node linked with the canvas. A visitor’s position can be evaluated by a proximity sensor and injected into a script to select the modified texture as it is provided in the experiment.

To explain the animated deconstruction, which is part of the category experiment, Lingemann realized a virtual instance of the spring installation created by the artist Pablo Langlois in 1995 [27] and exposed in the MAC. The virtual exhibit is constructed with five textured black cylinders showing human faces. At the lower end, identical springs are fixed with small picture frames. It goes without saying that, in the real museum, the springs could not be extended or manipulated by the visitor.

To create a digital benefit, the user can provoke a damped oscillation of the springs along the vertical axis following the equation $y(t) = 0.5 \exp(-0.1 \ t) \ \sin \ t$ and ending after 20 seconds; the options loop, reverse and HUD control are deactivated, and a click object is selected (cf. Figures 5,7).

The last category consists of replicated historical experiments that invite the user to explore or document the historical context and/or create virtual extensions. Typical examples, such as Tolman’s cognitive maps or Ebbinghaus’ forgetting curve, are described in [7].

### B. Animated and interactive deconstruction

Below, we will explain how the deconstruction and construction of virtual objects is realized. Each modification targets nodes of the scene-graph that describes the entire museum room and contains a subgraph corresponding to the object being modified.

The result of an intervention on a node depends on its type. Shapes are defined in leaf nodes together with their geometry and appearance, transformation and clustering, or sensing to trigger new actions in inner nodes. This comprises the following steps:

- Insertion of new transform and group nodes. Transform nodes influence all objects localized in the corresponding subtree. So we have to group the objects which should be subject to a transformation and isolate them, or restructure the tree by creating new subtrees.
- Insertion of various sensor nodes to detect user actions and trigger navigation and steering.
- Temporary or persistent storing and (later) recalling of deconstruction states.
- Identifying and setting deconstruction states within the X3D scene.
- Interfacing to support deconstruction, storing and reloading.

The main problem for the user is to identify the positioning of the object and its local coordinate system with respect to the world coordinates and to define meaningful operations. In [23] the author presents a viable solution by integrating the Xj3D-API to allow the visualization of X3D scenes with Java. The tree node under consideration can be identified by using an XPath expression and a correctly oriented local coordinate system can be visualized in overlay at the corresponding position (cf. Figure 6).

Figures 7 and 8 depict dialogues that realize the configuration of an animated and an interactive deconstruction.
Here the user defines the animated deconstruction of rotation type with the physical behavior of a damped pendulum, which is applied to an object as a part of a cluster of objects or scene. The animation is started by pressing a button. As an example, one may imagine a chair with one or more rotating legs (cf. Figure 6). The animation flow is determined in advance by defining intermediate positions and time steps, whereas the inbuilt interpolator facility computes the complete animation path. The action is controlled via a Play/Stop button as a superimposed Head-Up Device and a speed slider.

Alternatively, the user implements a step-by-step deconstruction by assigning the shape node and applying the deconstruction type with the convenient parameters.

IV. THE ViMEDEAS CURATOR SOFTWARE

The acquisition of object metadata (such as location, position, and interaction type) is facilitated by a software called the Virtual Museum Exhibition Designer using Enhanced Arco Standard (ViMEDEAS), a curator software tool that was designed [28], [29], [30] for use both on site and on mobile devices. Using virtual content produced in earlier projects, a complete 3D museum room with exhibits is created in X3D, ready to be visualized in an X3D viewer. This software provides a number of functionalities:

- Collection of new data that is capable of describing, managing and representing the metadata of objects that are of cultural value and validated by the aforementioned XML schema.
- Generation of a typical virtual museum, together with exhibits. Various room designs and arrangements can be imported from the new Replicave2 software.
- Interaction with these exhibits inside a VM.
- Provision of a virtual tour through the generated room and support of interaction with the items corresponding to the metadata.
- Collection of data from the tour and publication of the visitor’s walk within the VM, logging the items visited and the visitor’s interactions with them.
- Capturing dimensions of rooms, tableaux or other flat artwork semi-automatically with the aid of photography and a Tablet PC.

The program is designed for curators who would like to create a VM room, to plan an exhibition or to preserve an exhibition design for the archive. Every room has a template that can be generated or imported by the curator. A template contains important metadata concerning the museum room (e.g., length, width, height, entrances). After creating a room template, it is possible to open and instantiate it in the editor and to add virtual exhibits to it.

It is an important issue in our project to allow free placement and adjustment of pieces of art not only on walls but also on the ceiling or in the middle of the room. Pictures harmonize with their passe-partouts and borders and should often be placed in groups or positioned in relation to special alignments. The ViMEDEAS software supports various geometric modifications done by interacting directly with the exhibits and changes in the context, that is, modifying the wall color and light exposition.

Designed rooms, their exhibits, their hierarchical structures and means of interacting with them can be saved in a database. The data is transformed by the software into a webpage that allows the publication of the final room(s) on the internet or on a local computer. The result can be presented to visitors taking a tour through the museum room(s) in a virtual world—even in combination with a real tour.

V. COOPERATION WITH MAC AND STEINHEIM INSTITUTE

During a visit to the University of Chile in January 2010, we digitized seven rooms presenting paintings and sculptures in permanent and temporary exhibitions with the help and support of the MAC (Museo de Arte Contemporaneo) staff. The results are described in [6].

A further test case concerns a joint project with the Solomon Steinheim Institute [19] in Duisburg that seeks to create a virtual museum hosting the estate of the Jewish sculptor Leopold Fleischhacker. During his lifetime, he created more than 250 tombs located in 20 cemeteries in the Rhine-Ruhr area, busts, medallions and insignias, sculp-
Photographs from Fleischhacker connected logically. This is the VIMCOX schema. We are adding historical context of the tombs, which are located in 20 original photos as well as new digital instances of the actual further material concerning the hacker's inheritance and assembling the relevant metadata classifying the collection of heterogeneous VM museum with indoor and outdoor elements, hierarchical room configurations and different types of user artwork interactions, which are defined in a complete XML schema description.

VI. METHODICAL REALIZATION

A. Virtual museum

The ViMEDEAS system was tested in an earlier version during our visit in January 2010 in Santiago de Chile together with our partners in the MAC, where we digitized several rooms, and has since been completed with new features. These features are necessary to complete our heterogeneous VM museum with indoor and outdoor elements, thematic room exhibits or interactive 3D

![Figure 9. Sculpture integrated into a brick building](image)

To plan a complete exhibition concept, we are currently classifying the collection of photographs from Fleischhacker’s inheritance and assembling the relevant metadata in accordance with the VIMCOX schema. We are adding further material concerning the historical context of the original photos as well as new digital instances of the actual tombs, which are located in 20 cemeteries in the Rhine-Ruhr area; busts, medallions and insignias; and sculptures and monuments that were documented and photographed by Fleischhacker. The surviving tombstones and sculptures are often in a new environment; the rest have been irretrievably lost. Within the new VM, the digital instances are placed as virtual reconstructions in a spatio-temporal-cultural context and are accompanied by material from various sources.

These sources include in our case photos, paintings, letters, drawings, maps and descriptions in books and manuscripts. In digitized form, they are stored in a database and hyperlinked to the virtual instances placed in various rooms and floors of the VM following a thematic order to provide additional context-related information and help the visitor to comprehend the digital interpretation.

The references to the historical, cultural or social context define the dimensionality of a virtual museum and the underlying structure of the scene graph containing the shapes, geometry and appearance of the artwork.

B. Formal and conceptual requirements

We have to verify that the enhanced ARCO standard in its new occurrence entitled Virtual Museum and Cultural Object Exchange Format (VIMCOX) is sufficiently flexible to gather the administrative, descriptive, technical and use metadata in such a way that the user can search the desired information simply and intuitively. Additionally, the design of complex room layouts has been simplified. There is no need to pay attention to the physical feasibility of the architecture because the rooms are connected logically. This means that rooms can be nested or linked in such a way that they would overlap in reality. Information about the pieces of art and their contexts can be displayed in various ways, for example, through text panels, information terminals and various media accessible in special media rooms.

C. Replicave2 and dynamic exhibition layout

Replicave2 software provides an exhibition layout based on a spatial metaphorical framework design with navigation schemes. Each artwork category, its corresponding specimens, and the historical context of the art pieces is organized using both a temporal and a conceptual or thematic metaphor. Whereas different historical versions of an item may be located on different floors and are connected through a temporal metaphor, such as an elevator, it is also possible to use a floor as a temporal metaphor linking different rooms in historical order and to use the elevator to give access to different thematically ordered collections.

The framework Replicave was developed by the first author in 2006 [7] and was implemented in PHP and VRML. The intention was to provide a cost-efficient way to create VM exhibitions by reusing 3D models and dynamically generated content [4]. Replicave provides 3D content developers with an initial spatial starting configuration, metaphorical connectors for accessing exhibits or interactive 3D learning objects or experiments, and other optional 3D extensions, such as a multimedia room, a gallery and an avatar selection room.

This concept can be used to create connections between inside and outside areas, where parts of cemeteries would be
realized. Some years ago we developed different VRML-based applications with restricted 3D dimensionality and user mobility using 360 degrees panoramas, 2D textured domes or perspective grids to simulated rooms.

The new framework, Replicave2, uses JavaSE (JDK 1.6) to rebuild all features and a Tomcat6 server environment to generate and deliver exhibitions online. It has the ability to generate rooms dynamically, depending on given parameters. There are three ways to create rooms.

The easiest way is to create cubic/rectangular or polyangular rooms by setting the values for side length (cubic/rectangular/polyangular) or radius (polyangular). Advanced users can also set the height of a room and change all its textures or select an optional platform to be placed directly above the entrance. All rooms can be created with either a normal or a domed ceiling with transparent windows and a variable number of rings. An additional bevel value can be set when creating a cubic/rectangular room to generate conical walls. A 2D/3D point list can also be used to create nonstandard room shapes. In this case, the position of the walls and/or entrances is defined manually. Passive windows with various forms and lighting effects have been preprogrammed.

![Figure 10. View of a cemetery with Fleischhacker’s tombstones](image)

Replicave2 facilitates the addition of pre-assembled models (X3D Prototypes), like books, tables, chairs, magazines or flowers. These models were taken and converted from the existing VRML framework libraries. In most cases, this was accomplished using two simple commands and setting the rotation and translation values. It is also possible to set exterior themes: cloudy/sunny day or night background textures, which can be seen through transparent windows. The gallery is fully configurable via XML configuration files. The colors, texts and images of all placard areas and their corresponding information terminals can be customized. When the gallery file on the server is invoked, the XML configuration file is parsed. Afterwards the polyangular room and its exhibition is calculated and generated depending on the number of nodes found [6].

Each background image (gradient) of a placard area is generated dynamically. In the project we plan to include an atrium, balconies and active windows providing a view of tombs integrated into cemetery landscapes (cf. Figure 10).

Planned features, such as the generation of VMs from data received from a database, are easy to implement since all methods of constructing exhibitions implemented in Replicave2 are accessible for generalizing the room concepts defined in the ViMEDEAS software and allow individualized room hierarchies within a VM.

### D. Definition of interaction patterns

Modern 3D modeling languages facilitate various forms of human-machine interaction and offer the manipulation, deconstruction and reconstruction of cultural objects in their environment. VRML97, X3D and JAVA3D implement the scene graph concept with appropriate node types and edges that allow an object to be inspected from different viewpoints, moved or rescaled, and even modified or morphed in such a way that it is restored to its original state. Objects can even be cloned, grouped and rebuilt in different ways. This helps us to reintegrate conserved sculptures into their old edificial context or vice versa if there is any documentation about the lost work. All these operations are totally unfeasible within a real museum and offer a completely new experience for the visitor and curator, thus helping the art historian to foster cultural heritage.

In this project, it is extremely important to capture the tombs and tombstones in such a way that light and weather effects as well as distracting plants and trees cannot depreciate the quality of the digital instances just when the inscriptions or other artificial texture should be preserved and used for the object and metadata construction.

Our project relies on high-quality digitalization so that metadata will be captured and the virtual items displayed on side using tablet PCs with a GPS module to run the ViMEDEAS software. In this way, the visitor is guided to the interesting tombstones even though this sometimes seems quite complicated because of the overwhelming number of tombs and missing information boards.

### E. Semi-automatic capture tool

In a recent diploma thesis entitled Standardized Capturing of Exhibition Item for Presentation in Virtual Museum Environments (T. Lechtenfeld, [28]), a capture tool for ViMEDEAS was developed that allows users to capture dimensions of rooms, tableaux or other flat artwork semi-automatically with the aid of photography and a Tablet PC. Photogrammetric methods are used to determine the geometric properties of objects from photos. At the beginning, the user has to take lengths and heights from the walls by using an architectural plan or laser distance measuring. Then, he takes a photo of the artwork and the wall on which the artwork hangs. Next, the user marks the corners of the wall and the artwork with a pen. If the size of the wall is known, the software can compute the other distances and the size of the artwork including frame and passe-partout. The program provides an average measuring accuracy of less than one centimeter. This accuracy depends on various factors that were identified and evaluated in the thesis: accuracy in hitting the corner points in the photo, the adjusted focus of the digital camera, the angle and position of the camera, the thickness of the object and, finally, the accuracy of the given room dimension. Adjusted focal length and protruding objects have the strongest influence on the accuracy of the measurements.
To evaluate the ViMEDEAS software and the operability of the new VIMCOX standard we are developing target-group specific questionnaires and tasks. To this end, we will design typical tours with exercises for selected artwork that include adequate interactive operations to modify it together with its context. We will register each user action and evaluate and compare the utterances and completed modifications to derive relevant interaction patterns.

**CURRENT WORK**

Replicave2 is a new X3D-based version of the visualization framework Replicave, which facilitates the addition of pre-assembled rooms and models to a VM. We are currently incorporating this template-based approach into the curator software ViMEDEAS, which was first described in the diploma theses [29] and [30]. Including a high-performance capture tool and suitable mobile hardware, like a tablet PC, will ensure that the entire designing and editing process involved with creating a virtual indoor-outdoor exhibition will be available with the new software.

The proposal of a new metadata standard for museum rooms and objects and a schema definition are important concerns in ongoing work. We are confident of creating an extended metadata standard entitled *Virtual Museum and Cultural Object Exchange Format* to be discussed within the relevant scientific community (cf. Appendix 1).

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**REFERENCES**


Appendix 1. VIMCOX schema overview [18]