Creating 3-D virtual learning environments

Fabrizio Giorgini, PhD, Fabrizio Cardinali, Michele Dicerto, Andrea Lorenzon
Giunti Interactive Labs
Sestri Levante(Ge), Italy
Tel.: +39018542123, Fax: +39018543347
E-mail: f.giorgini@giuntilabs.it, Web: http://www.giuntilabs.it

Abstract:
We describe a system for the creation of 3-D virtual learning enviroments exploiting the media objects which are accumulated into a digital repository comprising 3D models of digitalized museum artefacts, images, videos and sound clips, textual descriptions as well as a comprehensive set of metadata based on the IMS meta-data specification.
We illustrate how we model a Cultural Learning Object (CLO) and how our system generates packages of the created 3-D virtual learning enviroments of CLOs according to the ADL SCORM 1.2 specifications. We also investigate the importance of using standards enabling the creation of learning scenarios and their exploitation into a Learning Management System.

1. Introduction

Museums, galleries and other cultural heritage institutions hold vast amounts of digital multimedia representations of their collections and metadata which can be exploited to create rich and rewarding learning experiences.
This offers researchers and technologists a growing series of challenges, particularly as the range of multimedia representations is expanding to include, for example, a wider variety of imaging modalities, 3-D models and digital videos and the technologies available for exploitation are evolving rapidly, notably in the area of 3D digitalization and virtual representation.
This paper provides a brief progress report on a research and development project designed to meet one of these new challenges, especially in the area of exploitation of multimedia information in the context of virtual learning environments.
The project, SCULPTEUR [1], involves five major European galleries, the Uffizi in Florence, the National Gallery and the Victoria and Albert Museum in London, the Musee de Cherbourg and the Centre de Recherche et de Restauration des Musees de France (C2RMF) which is the Louvre related art restoration centre. Technical partners include Giunti Interactive Labs (the coordinator), University of Southampton (UK), IT Innovation (UK), Centrica (IT) and GET-ENST (FR).
One of the goals of SCULPTEUR is to exploit the knowledge base developed in the project, mainly 2D/3D images and cultural information, to create virtual learning spaces where the user can enjoy reconstructions of museums' rooms, 3-D models of cultural artefacts and experience educational material associated with the virtual objects.

In section 2 we describe some of the specific needs of the end-users, the starting point of our work. Sections 3 discusses issues relating to the use of standards to improve the efficiency of e-learning systems. Section 4 presents the developed application for the creation of 3-D virtual learning environemnts. Conclusions are illustrated in section 5.

2. Identifying User Needs

Questionnaires to gather museums requirements and motivations was the starting point for our work. Museums' answers were useful to identify new museums' needs, particularly in relation to their increasing number of 3-D digital representations of their artefacts.

The motivation for digital capture of museum artefacts was an important factor in determining the functionalities that the application needed to address. For example, we discovered that the major reason for digitising was not the preservation, but to provide easier and increased access to the cultural object.
Other museums' requests concerned the ability to manipulate the generated 3-D models (zoom, rotation, translation), to create and compose scenes and virtual exhibitions, to associate educational material to each object of the virtual scene and to provide mechanisms for browsing the learning material and interacting with the virtual world.
Last but not least, museums asked for the possibility of tracking end-users' activities (what have been experienced and assessment results) and define different learning paths according to the different end-user's actions.
All these requirements and others relating to the usability of the application (intended for non IT experts like curators, museum educators...), imposed substantial demands on the architecture and functionality required in the new system.

3. Use of standard in e-learning

Educational issues have been one of the underlying motivation for our research being conducted in the framework of the SCULPTEUR project.
Within the areas of digital collections, issues relating to accessibility, re-usability and interoperability are paramount in harnessing the potential of distributed resources – whether for educational or other applications. All of these aspects are under-pinned by the development of technical and metadata standards, which facilitate search, retrieval, evaluation and sharing of information resources.
Several unrelated and independent initiatives have been involved in the development of standards, theory and models for learning materials, two of the most prominent are the IMS Global Learning Consortium (IMS) [2] and ADL Shareable Content Object Reference Model (SCORM) [3]; it is encouraging that standardisation efforts are now beginning to merge with the IEEE Learning Object Metadata (LOM) [4] acting as the basis on which to simplify discovery, management and exchange of learning resources over the Web [5].
Re-usability, in particular, is of relevance to the development of learning materials, which are prime targets for multiple uses in differing educational contexts. For this reason, the concept of a *Learning Object (LO)* has emerged. According to the IEEE LOM standard, a LO is "*any entity, digital or non-digital, that may be used for learning, education or training*" [4]. In our context, a LO is the virtual environment containing the 2- D and 3-D models of artefacts and the educational material associated with the objects of the scene.
The adoption of standards allows differing e-learning systems to define their LOs, so that they can be exchanged. This is particularly important in the cultural heritage sector, where contents can be distributed on the network and represented in different formats, making them difficult to find, access, present and maintain. The SCORM and the IMS aim to describe how learning objects can be packaged making them sharable and interoperable. The SCORM is a set of specifications for developing, packaging and delivering educational and training materials. SCORM's Content Aggregation Model (see Figure 1a) defines how learning objects can be identified and described, aggregated into a course - or portion of a course - and moved between systems. It uses IMS Content Packaging [6] (Figure 1b) to assemble contents and IMS Meta-data [7] to tag learning resources.
The purpose of the SCORM Run-time Environment is to provide a means for interoperability between learning contents and systems for e-learning.

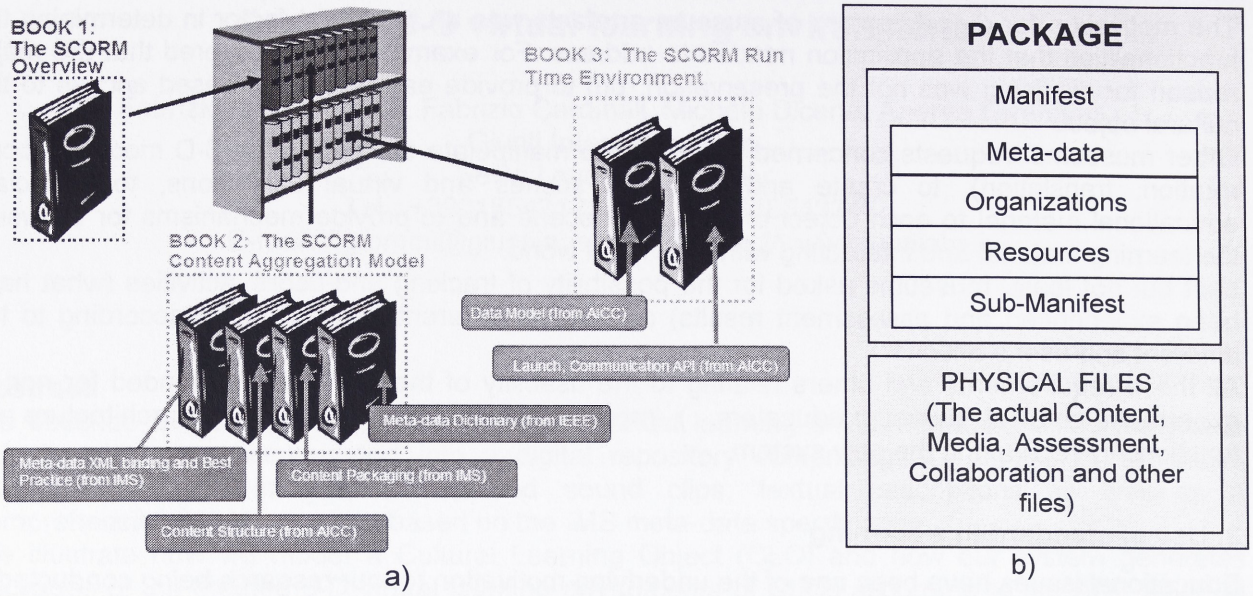

Figure 1: a)The SCORM model and b) the IMS Package

4. Creating 3-D virtual learning environment

Recently, we have been investigating the purposing of 3-D digital museum artefacts for use in virtual reality learning contexts. Evidence in the education and learning domain suggests that interaction and exploration enforces learning objectives and improves knowledge retention [8,9]. This concept remains valid also for the education in the cultural heritage sector.

With this in mind, we have designed and developed an application that assists curators, instructional designers and educators to build interactive virtual environments of 3-D Cultural Learning Objects (CLOs).

The creation of such virtual learning environment can be seen as a sequence of steps, from the description of the CLO, to the definition of learning paths, passing through the positioning of the objects in the virtual space (Figure 2). The authoring process ends with the definition of the conditions governing the presentation order of the CLOs to the end-user. After that the "ball" passes to the Learning Management System (LMS) which renders the CLOs, interprets the end-user's actions and decides which are the CLOs available to the end-user.

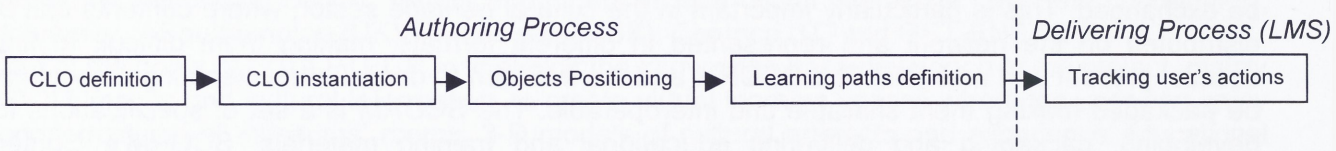

Figure 2: Process dealing with the creation and delivery of the virtual learning environment

4.1 CLO definition and instantiation

The first step of the authoring process is the definition of the CLOs. As explained earlier in section 3, the term Learning Object generally applies to educational materials. A LO is any digital resource that can be reused to support learning designed and created in small chunks for the purpose of maximizing the number of learning situations in which the resource can be utilized.

To maximize the potential for re-use, multimedia objects (primary resources like images, audio, video, animations and 3-D models, which normally do not have any added-value in terms of educational contexts) are assembled into 3-dimensional Cultural Learning Objects according to the logical model illustrated in the next figure.

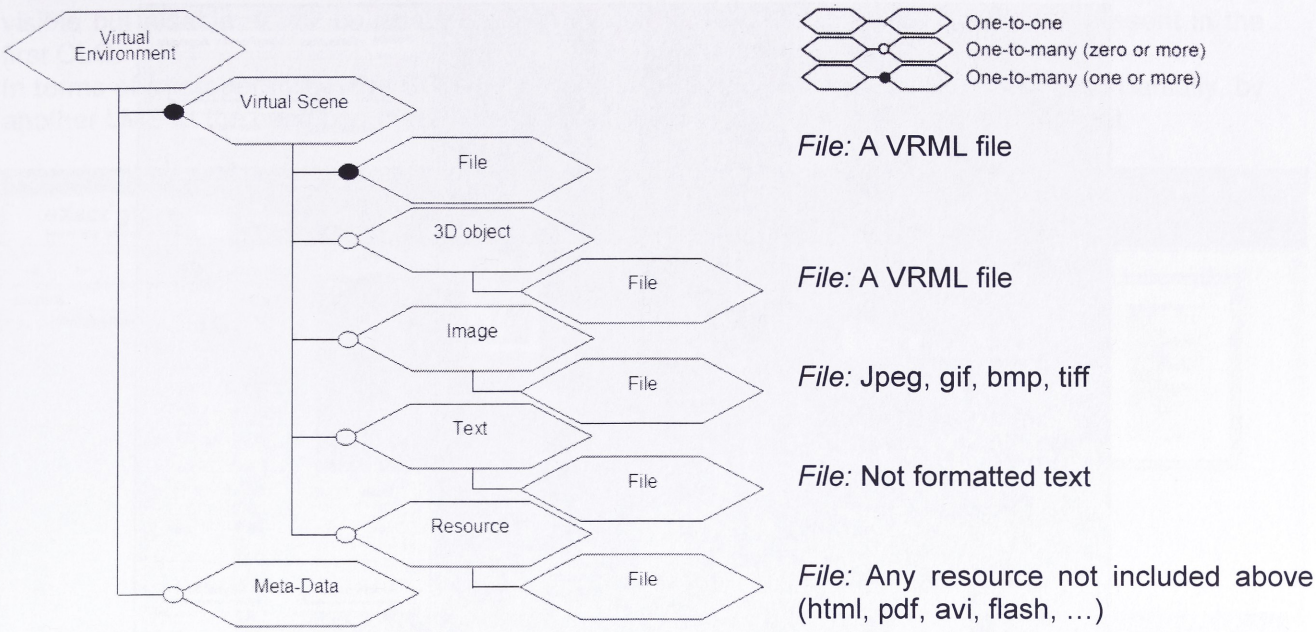

Figure 3: Cultral Learning Object model

The model is quite flexible and allows authors to define simple virtual learning environment as well as very complex scenarios composed of several objects, images and educational material. IMS Meta-data 1.2 may be used to describe the CLO.
Once the structure is defined, the CLO model is instantiated with physical resources: VRML, jpeg, html, pdf, ...

4.2 Objects Positioning

Despite of generic CAD systems, the developed application provides authors, also non-expert users, with an intuitive and easy to use graphical user interface to position (translate, rotate or zoom) the media objects of the CLO model in the virtual environment (see Figure 4).
Other facilities also allow to define view points for a faster navigation of the virtual space and to attach sensors (cylindric or spheric) to the 3-D objects offering different visual perspectives of the same object.
John Manley, Chief Executive of Sussex Past/Sussex Archaeological Society Bull House (UK), says *'objects in them once had real lives and, for example, were meant to be handled, or worn, or drunk from, or contained something, or displayed on walls in homes etc, often in the immediate locality; ofetn in the museum we remove the objects from those local contexts, which gave them meaning, and then lock them in glass display cases'.*
3-D reconstructions and virtual spaces definitely liberates the cultural objects from the museum glass case where they normally are "imprisoned".
The developed technology allows to display, remotely or in-gallery, objects in the round, link objects with other objects and local places (i.e. where they were found) and aims to enhance the sensual experience of the physicality of real objects.

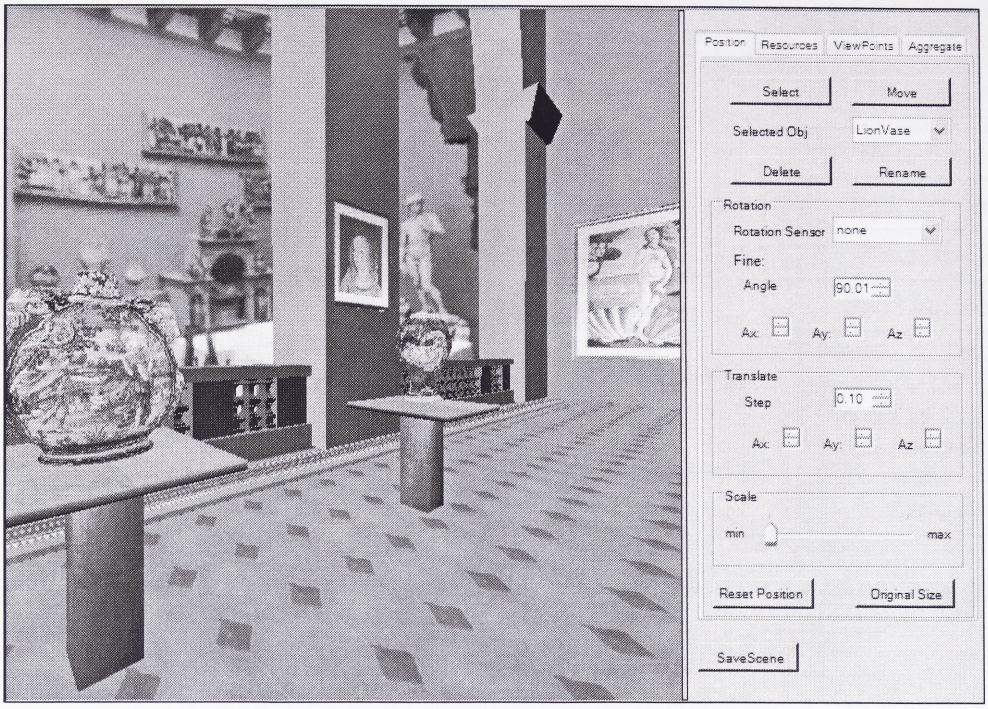

Figure 4: The GUI of the authoring tool

4.3 Creating learning paths

In the context of cultural education, each CLO can be seen as a different learning path. Learning paths can be presented to the end-user all together, like a flat table of contents, or in a sequence that depends on the result of evaluation sessions. As this second possibility seems to be more attractive and productive, the developed application also gives the possibility to embed test sessions in the virtual scene; the evaluation sessions, based on IMS QTI [10] tests (true/false, multiple choice questions, image hot-spot) can be assigned to each of the virtual objects of the scene and can be used to effect the presentation order of the learning paths.

When the end-user navigates the virtual environment he/she will be asked to answer to the tests. The LMS captures and evaluates the end-user's answers and can redirect the end-user to new virtual paths in accord with the correctness of the answers. Imagine the following scenario: the end-user is navigating the virtual room of some of the most popular pantings of the XIV Century. Next room presents some beautiful paintings and sculptures of XV Century. In order to access to the next virtual exhibition the end-user has to pass a simple test which proves he/she really experienced the works of art of the XIV Century before moving ahead.

When the authoring process is complete, the developed application generats an HTML file containing the VRML file of the virtual learning enviroments and the JavaScript support for communication with the SCORM Application Program Interface (API). The JavaScript will be used to communicate all end-users' actions (what has been seen, the score of QTI tests, ...) to the LMS. On the base of this information, the LMS decides, during the rendering, the order of virtual contents.

Finally, metadata, ordering of contents, HTML and external resources are packaged according to the SCORM 1.2 specifications. The genetared SCORM package is a single package interchange format (PIF) file, a zip file which contains the imsmanifest.xml in the root directory linked to files necessary for the virtual learning environement to run. The LMS unzips the package, reads the imsmanifest and extracts and visualizes the first CLO. Figure 5 reports an example of a created SCORM package visualized by the Learn eXact LMS [11]. In the figure, the CLO is shown in the upper window while the educational material (in the example the biography of Leonardo Da Vinci) is shown in the lower part. The list of CLO is located on the left: in the list, the second CLO is

visible but disable. It will be enabled when the end-user passes the test sessions present in the first CLO.
In terms of interoperability, the SCORM package can be exchanged and re-used, also partially, by another LMS at the condition that the receiving LMS is SCORM specifications compliant.

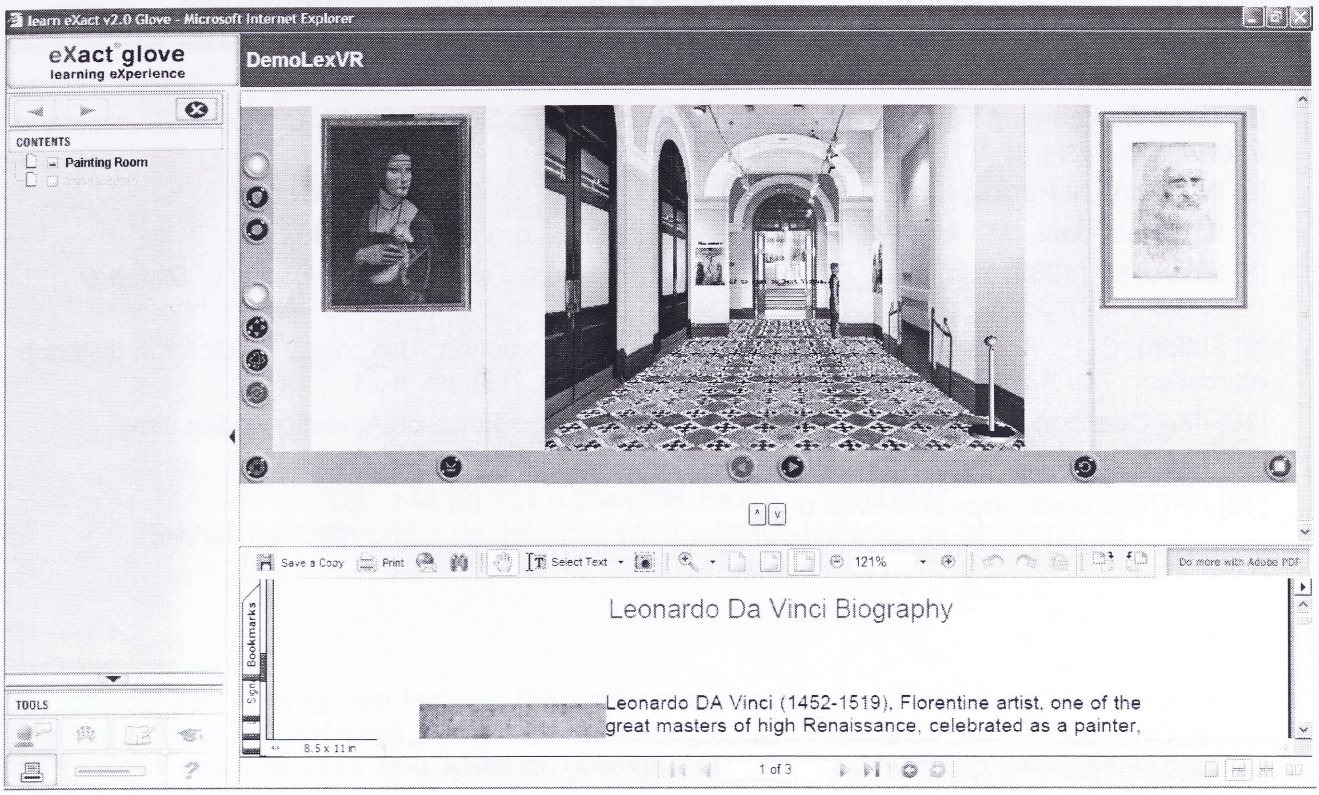

Figure 5: The CLO visualized by the Learn eXact LMS

5. Conclusions

We have demonstrated that the basic facilities of the implemented application allow museum professionals to exploit their repository of primary multimedia cultural objects to create effective learning scenarios particularly appealing to children and the younger generation of museum visitors. The multimedia objects may be imported in the presented application for the creation of complex cultural learning objects which can be used in a variety of virtual learning environments.
We have also demonstrated how standards improve the interoperability and exchange of educational material also in CH sector.
We have found that the quality and quantity of resource discovery are quite important in the re-use and re-purposing of primary multimedia objects. Of course, the digitised quality of primary resources is also a major issue when creating them for multiple learning purposes (researchers require higher quality than the one necessary for pupils). In addition, digital rights management and copyright are equally pertinent aspects, which will influence the extent of sharing and re-use of defined CLOs.

6. Acknowledgments

We are grateful to the ARCO Consortium [12] for some VRML models provided.

7. References

[1] SCULPTEUR project, http://www.sculpteurweb.org

[2] IMS Instructional Management System, IMS Global Learning Consortium, http://www.imsproject.org

[3] ADL-SCORM, http://www.adlnet.org/index.cfm?fuseaction=scormabt

[4] IEEE LTSC LOM, http://ltsc.ieee.org/wg12/

[5] Duval E., Learning Technology Standardization: Making Sense of it All, *Computer Science and Information Systems* 1(1), Feb. 2004

[6] IMS Content Package, http://www.imsglobal.org/content/packaging/index.cfm

[7] IMS Meta-data, IMS Meta-data, http://www.imsglobal .org/metadata/index.cfm

[8] Moore, M. (1989). Editorial: Three types of interaction. *The American Journal of Distance Education*, 3(2), pp. 1-7

[9] Fulford, C. P., & Zhang, S. (1993). Perceptions of interaction: The critical predictor in distance education. *The American Journal of Distance Education*, 7(3), pp. 8-21.

[10] IMS Question and Test Interoperability, http://www.imsglobal.org/question/index.cfm

[11] Learn eXact, www.learnexact.com

[12] ARCO project, www.arco-web.org