VIRTUAL MUSEUMS: FIRST RESULTS OF A SURVEY ON METHODS AND TOOLS

Sylaiou S.[1], Liarokapis F.[2], Sechidis L.[1], Patias P.[1], Georgoula O.[1]
[1] Aristotle University of Thessaloniki, Greece
sylaiou@photo.topo.auth.gr , lazikas@photo.topo.auth.gr , patias@topo.auth.gr . olge@topo.auth.gr
[2]City University, London, U.K - fotisl@soi.city.ac.uk

KEY WORDS: Cultural Heritage, Virtual Museum, Virtual Reality, Augmented Reality, Web3D

ABSTRACT

Museums are interested in digitizing their collections in order not only to preserve the cultural information, but also to make it available to the wide public in an attractive manner. Emerging technologies, such as VR, AR and Web3D are widely used for creating virtual museum exhibitions in a museum environment through informative kiosks and on the World Wide Web. This paper makes a survey in the field and explores the various kinds of virtual museums, their advantages and limitations by presenting old and new methods and tools used for their creation.

1 INTRODUCTION

The development of interactive techniques and information technologies' software and hardware, in conjunction with the decreasing of their costs have facilitated their use by a wide range of cultural institutions, such as museums. These new technologies provided solutions for lack of exhibition space, considerable exhibitions' costs and the fragility of some artefacts that museum curators want to prevent their possible damage. The value of the new methods and tools has been recognized and fruitfully exploited by curators for visualizing the cultural context of museum exhibitions (Scali *et al.* 2002), (Web 1). Conferences such as ICHIM *Conferences on Hypermedia and Interactivity in Museums*, which started in 1991 and *Museums and the Web*, which was established in 1997, underline the importance of new technologies to museums. The utility and the potential benefits of emerging technologies like Virtual Reality (VR) (Pletinckx 2000), (Roussou 2001), Augmented Reality (AR) (Brogni *et al.* 1999) and Web technologies (White *et al.* 2004), (Sinclair and Martinez 2001) to museums have been well documented.

Museums changed drastically their way of conveying information about their exhibitions to the wide public. They have started to make use of innovative methods and new communication tools for creating virtual museums that made the content and context of the museum collections more accessible and aesthetically pleasing to the wide public. A virtual museum can be presented either to a CD-ROM, or over the World Wide Web, or even to an intranet in a museum environment. It can be an extension of a physical museum, or it can exist only in a digital form. Sometimes it is a 3D reconstruction of the physical museum, like the exhibition '010101: Art in Technological Times' (Web 2), where in the virtual rooms of the museum exhibition, the visitors can navigate and explore its collections. Alternatively, it may be a completely imaginary environment, in form of various rooms, where the cultural artifacts are placed (Web 3).

This paper will not present the results of a research, because its main aim is to provide the first results of a survey about the current state-of-the-art of virtual museums. It will present virtual museum exhibitions and their characteristics and highlight the potential of virtual museums. The structure of the article is organized as follows: in the first section there is an introduction to the survey about virtual museums. In the second section the emerging methods and tools used by virtual museums are presented. Then, the benefits, which arise from the use of virtual museums by various groups of end-users, are examined. Finally, the conclusions of the paper are provided in the last section.

2 EMERGING METHODS AND TOOLS USED BY VIRTUAL MUSEUMS

Museum curators make use of new technologies for digitizing information about exhibitions' artifacts, as well as for displaying and spreading the cultural information to the wide public in an appealing and effective way. Methods and tools that have emerged as areas of extreme interest make it possible to provide customized interfaces of virtual museum exhibitions in a number of ways. For example, many interaction devices are now available that can be integrated into multi-modal Virtual and Augmented Reality interactive interfaces.

Virtual museum exhibitions can present the digitized information about cultural objects, either in a museum environment (e.g. in touchscreen kiosks), or over the World Wide Web. The first applications in the area were mainly focused on static presentations of texts and photos concerning museums that offered their information through web-sites with a catalogue of texts and photos. Later on, more sophisticated means have appeared and the exhibits were rather dynamic and interactive than static in nature and authoritative (Worden 1997). Thus, these virtual museums provided a more close to reality approach and an enhanced experience to their virtual visitors. In this section, a brief overview of the most characteristic methods and tools currently used for the generation of virtual museum exhibitions are presented.

2.1 Virtual Reality Exhibitions

In a Virtual Reality environment the user gets immersed in an artificial world. Heim says that *weak Virtual Reality* can be characterized by the appearance of a 3D environment on a 2D screen (Figure 1, 2), (Heim 1993).

In opposition to this, *strong Virtual Reality* is the total sensory immersion, which comprises wearing a device like a Head-Mounted Display, or 3D polarizing stereoscopic glasses, or even a glove, in order to create a feeling of control in actual space (ibid). Two indicative example are *Kivotos* (Ark) and *Magic Screen* that are housed in 'Hellenic Cosmos', the Cultural Center of the Foundation of Hellenic World in Greece (Web 5).

Kivotos is a Virtual Reality environment in a room of three meters by three meters, where the walls and the floor act like projection screens and in which visitors participate in a journey by wearing stereoscopic 3D glasses and using a 'magic wand' (Figure 3). The other VR installation, *Magic Screen* is shaped like a table and visitors can engage themselves in similar interactive activities and explore through navigation the virtual environment (Figure 4) (Gaitatzes *et al.* 2001).

Figure 1: VR installation with touchscreen and 3D environment of a Roman villa in a 2D screen (Web 4)

Figure 2: Blending of the reconstructed and the virtual model of the Roman villa (Web 4)

Figure 3, *Kivotos* in the Foundation of the Hellenic World (Gaitatzes *et al.* 2001)

Figure 4: *Magic Screen* in the Foundation of the Hellenic World (Gaitatzes *et al.* 2001)

Another example is the VR installation at the Melbourne Museum in the Science and Life Gallery in Australia called Virtual Room (Web 6), which consists of eight screens and it is a 360°, rearprojected, stereoscopic display system. This environment allows viewers to circumnavigate its perimeter through polarized lenses, enabling a 360° of a 'contained world' (Figure 5), (Web 7). In the Virtual Room two synchronized projectors project two respective views onto the screen, each with a different polarization. The combination of these separate perceptions provides 3D representations of dinosaurs (Web 7).

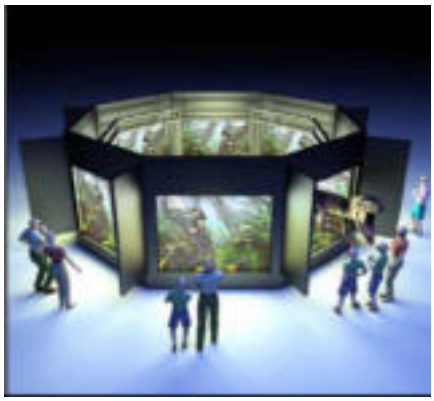

Figure 5: The Virtual Room installation (Source: vroom inc.), (Web 6)

As mentioned earlier, virtual exhibitions can be visualized in the Web browser in form of 3D galleries (Figure 6), but they can also be used as a stand-alone interface (i.e. not within the web browser). In any case, the virtual museum exhibition should be a realistic reconstruction of a real or imaginary museum's gallery and present the 3D models of museum artifacts inside the gallery. In addition, some commercial VR software tools such as WorldUp, WorldToolKit can generate fast and effectively virtual museum environments, but the cost of licensing is considerable high for medium and small-sized museums that represent the majority. For this reason, many experimental VR systems originating both from industry and universities that are focused on specific operations in virtual environments and have the potential to be applied in museums have been developed.

Figure 6: VR Virtual museum exhibition (White et al. 2004)

In these systems, usually the content and layout of the visualized scenes is determined by visualization functionality that 'decides' which artifacts should be presented and how these elements should be composed into one scene. An overview of methods and tools available to the visitors to visualize a virtual museum, have been previously documented (Kwon et al. 2003).

2.2 Augmented and Mixed Reality Exhibitions

In addition to the VR exhibitions, museum visitors caexperience

an enhanced experience by navigating to museum collections (i.e. artifacts), or even by creating museum galleries in an AR environment. The virtual visitors can indicate where the virtual objects should appear in a real scene using either software methods (i.e. computer vision techniques) or specialized sensor devices (i.e. SpaceMouse, InertiaCube, gloves). Through human-computer interaction techniques users can examine thoroughly the virtual artifacts through tactile manipulation of fiducials or sensor devices (i.e. gloves, SpaceMouse). Although the AR exhibition is harder to achieve, it offers more advantages to the participants. In an AR museum exhibition, virtual objects are overplayed upon video frames captured by a camera, giving users an impression that the virtual cultural artefacts actually exist in the real environment. This 'augmentation' of the real-world environment can lead to an intuitive access to the museum information and strengthen the museum exhibition's impact to the virtual visitors (Figure 7).

Figure 7: A digital replica of a Maori whalebone club in AR (Courtesy of the Canterbury Museum, Christchurch, New Zealand), (Woods *et al.* 2001)

One of the earliest examples of an interactive virtual exhibition is an automated tour guide system that uses AR techniques (Bederson 1995) and can superimpose meaningful audio on the world based on the location of the user. An advantage of this prototype is that it can enrich visitor's experiences without interfering with their social interactions. Another important work is the Meta-Museum guide system (Mase *et al.*, 1997), which is based on AR and artificial intelligence technologies. The Meta-Museum provides a communication environment between the real world and cyberspace that maximizes the utilization of museum's archives and knowledge base.

Finally, the ARCO project (White *et al.* 2004), (Liarokapis *et al.* 2004) provides customised tools for virtual museum environments, ranging from digitisation of museum collections to a tangible visualisation of both museum galleries and artefacts. The tangible interface allows the user to visualise virtual museums in Web3D, VR and AR environments simultaneously. Museum visitors can interact intuitively with the displayed objects using a combination of natural interactions and sensors (i.e. SpaceMouse) (Figure 8).

A major benefit of an AR-based interface is that carefully designed applications can provide novel and intuitive interaction themselves without the need for expensive input devices. Participants in AR learning environments can interact physically, in a way that cannot be obtained in a virtual environment. For example, there are many available devices that can be integrated into multi-modal Virtual and Augmented Reality interactive interfaces. Combined VR and AR application offer the possibility to examine the artifacts of the virtual museum exhibition in more detail. For example, the visitors can explore the virtual museum exhibition through a VRML browser in the context of other multimedia data on a web page and then switch to an AR environment, in order to manipulate, rotate or increase the size of the artifact. In these cases, virtual artifacts are integrated into the physical environment (Figure 8).

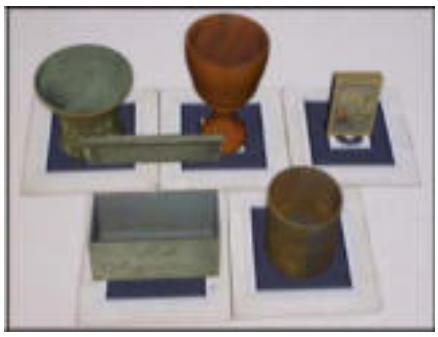

Figure 8: AR Virtual museum exhibition (Web 3, Liarokapis *et al.*, 2004)

Finally, there are also Mixed Reality museum exhibitions that refer to an environment, where virtual and real objects coexist in the same place (Azuma 1997) with visual representation of real and virtual space (Hughes et al. 2004). SHAPE (Situating Hybrid Assemblies in Public Environments) project (Hall et al. 2001) has applied MR techniques in a museum environment. It used hybrid reality technology to enhance user's social experience and learning in museum and other exhibition environments, in relation to cultural artifacts and their context. It proposed the use of a device called the Periscope (now it is called the Augurscope), which is a portable Mixed Reality interface that supports artifacts' visualization and visitor's interaction in a museum environment (Figure 9).

Figure 9: Visitor using Glasstron HMD in the Hunt Museum, Limerick, Ireland (Hall *et al.* 2001)

2.3 Internet technologies and tools

Internet technologies provide the tremendous potential of ubiquitous access to virtual museum environments through the World Wide Web. Furthermore, the broadband Internet connections allow the transfer of rich media files, like digital images, videos, sounds, animations for delivering high-quality presentations of virtual museum exhibitions. Thus, the virtual visitors can have access to virtual museum exhibitions via a PC and an Internet connection anytime and from anywhere.

WEB 3D technologies can create a sophisticated virtual museum environment (i.e. with VRML, X3D) that embeds 3D and Internet technologies, because the Web3D Consortium (Web 8) contains open standards for real-time 3D communication. Web3D methods can transform human-computer interactions and allow the development of new applications that could be the catalyst for launching a virtual museum revolution. This new generation of products can help

not only to integrate museum archives and 3D models of museum artifacts, which are usually created by Computer-Aided Design (CAD) and uploaded in VRML format, which is a reliable and low cost solution, but also to allow remote access over the World Wide Web.
Many museums application based on VRML have been developed for the Web (Sinclair and Martinez 2001), (Gatermann 2000). This is motivated by the fact that some information is best experienced in three dimensionally, such as virtual museums (White et al. 2004), (Liarokapis et al. 2004). However, VRML can be too labor-intensive, time consuming and expensive. Alternative solutions that could address the aforementioned issues can be QuickTime Virtual Reality files and panoramas that allow the animation and provide dynamic and continuous 360° views. Furthermore, hotspots that connect the QTVR and panoramas with other files can be added.

3. BENEFITS OF VIRTUAL MUSEUMS

Targeting communities of virtual museums are the specialists, the students and the tourists (Filippini-Fantoni 2003), (Bowen and Filippini-Fantoni 2004). In order to satisfy the needs of virtual visitors of the different profiles, virtual museum exhibitions can contain great amount and various depth of information.
Museums curators can digitally preserve the artifacts of their collections, provide an appealing and engaging experience to the virtual visitors and disseminate the cultural information. Moreover, virtual museums are beneficial to museum end-users, because they provide significant help to education and entertainment (edutainment). In addition to this, virtual museums facilitate the access to museum exhibitions and provide assistance to the research of students and specialists.

3.1 Benefits for museum curators

3.1.1 Digital preservation: Physical calamities, such as earthquake, fires, floods, as well as man-made disasters, which occur in time of wars and conflicts, often put under threat museum cultural artifacts. Besides this, works of art are often very fragile and vulnerable to climate conditions. Effective ways of safeguarding the cultural artifacts can make use of technological advances, through comparison of different images across time, monitoring their conservation, so as to preserve them digitally and hand them in to future generations. Most of the virtual museum systems are designed so as museum curators with average IT skills can produce quality VR models for virtual exhibitions quickly and accurately. Furthermore, they provide the means for storing and retrieving multimedia data, as well as for visualizing information about the cultural artifacts.

3.1.2 Display: The cultural artifacts that are exhibited in the physical environment of a museum are usually shown in display cases, where only a limited amount of information about them is available. In virtual museum exhibitions, they can be digitized and visualized into an interactive environment. A virtual exhibit can contain information that a physical exhibit in a museum showcase cannot. Thus, museum curators can create a rewarding experience that will offer rich multimedia data about the museums artifacts' context.

3.1.3 Dissemination of museum information: The World Wide Web is widely used by museums for putting their collections online (Web 9), not only because it is very popular (especially amongst young people), but also because it provides a great variety of opportunities to museum curators in terms of museum data dissemination. Virtual museums have taken into account that in order to make the digital information accessible to users all over the world, it needs to be distributed over the World Wide Web. The latter one is a powerful communication tool to the hands of museum curators that can deliver the museum information in a quick and easy-to-use way to potential virtual visitors.

3.2 Benefits for end-users

3.2.1 Access: As it has already been mentioned, virtual visitors, through innovative technologies, are not restricted by the opening hours of a museum and can have an all-day unlimited access to virtual museum exhibitions. Virtual museums can provide access from anywhere and for everyone, even for people with special needs, such as people with visual, acoustic, learning, speech and motor disabilities. The Disability Discrimination Act (DDA) in the UK declares that disabled people have equal rights of 'access to goods, facilities and services' (Web 10). Consequently, cultural institutions, such as museums have to be concerned about how they can provide access to their exhibitions to people with physical impairments. Virtual museums take into account the need for efficient ways of using new technologies, which bring the museum exhibitions to all the end-users' groups and provide to disabled people virtual access to museums (Web 11) that has been emphasized by the Resource Disability Action Plan and has been formed by the Council of Museums, Archives and Libraries.

3.2.2 Learning and entertainment: Most of the virtual museums have been designed by taking into account the constructivist principles of learning through construction and learning through play (Hein 1993) and they involve interaction, experiencing and learning at the same time. In virtual museum exhibitions museum visitors are not passive.
On the contrary, they participate by creating their own exhibitions (Web 12), exploring virtual galleries using walk-throughs, interacting with the 3D exhibits. Moreover, virtual museums allow their visitors to choose the viewpoints they want to see and not the predetermined by the museum curator viewpoints.
Virtual museum exhibitions provide the excitement of displaying the museum artifact 'in the round', by allowing the virtual visitors to view the object from all angles. AR exhibitions can also involve physical interfaces (i.e. marker-cards), which are used as the link between real and virtual worlds. Physical interfaces allow museum visitors to pick up and manipulate virtual cultural objects and see them in their hands within the display system (i.e. flat screen) (Liarokapis et al. 2004).

4. CONCLUSIONS

Virtual museums can respond in various ways to visitors' needs. With the use of VR, AR and Internet technologies, they can provide an entertaining and educational experience. Additionally, they enrich the museum experience by enabling an intuitive interaction with the virtual museum artifacts. The benefits of virtual museums are noteworthy for museum curators and various groups of end-users, like students, specialists and tourists. Virtual museums have the potential to preserve and disseminate the cultural information in an effective and low-cost way through innovative methods and tools. They do not aim at replacing the physical museums, but they act complementary.
Virtual museums that are an engaging medium with great appeal to various visitors' groups can promote the 'real sites' by providing information about museum exhibitions and offer an

enhanced display of museums' artefacts through emerging technologies.

REFERENCES

Azuma R., 1997. A Survey of Augmented Reality. In: Presence: Teleoperators and Virtual Environments, 6 (4), pp. 355-385.

Bederson B.B., 1995. Audio Augmented Reality: A Prototype Automated Tour Guide. In: Proceedings of ACM Human Computer in Computing Systems conference (CHI'95), pp. 210-211.

Bowen J. P. and S. Filippini-Fantoni, 2004. Personalization and the Web from a Museum Perspective. In: Museums and the Web 2004: Selected Papers from an International Conference, Arlington, Virginia, USA, 31 March – 3 April, pp. 63–78.

Brogni A., Avizzano C.A., Evangelista C. and M. Bergamasco, 1999. Technological Approach for Cultural Heritage: Augmented Reality. In: Proceedings of 8th International Workshop on Robot and Human Interaction (RO-MAN '99).

Cosmas J., Itegaki T., Green D. Grabczewski E., Van Gool L., Zalesny A., Vanrintel D., Leberl F., Grabner M., Schindler K., Karner K., Gervautz M., Hynst S., Waelkens M., Pollefeys M., DeGeest R., Sablatnig R. and M. Kampel, 2001. 3D MURALE: A Multimedia System for Archaeology, In: Proceedings of VAST Conference on Virtual Reality, Archaeology, and Cultural Heritage, pp. 297-306.

Filippini-Fantoni, S., 2003. Museums with a personal touch. In: Proceedings of EVA 2003 London Conference, University College London, UK, pp. 25:1-10.

Gaitatzes A., Christopoulos D. and M. Roussou, 2001. Reviving the Past: Cultural Heritage Meets Virtual Reality. In: Proceedings of VAST 2001: Virtual Reality, Archaeology and Cultural Heritage (VAST'01), ACM SIGGRAPH, Glyfada, Greece, pp.103-110.

Gatermann H., 2000. From VRML to Augmented Reality Via Panorama-Integration and EAI-Java. In: Proceedings of Constructing the Digital Space (SiGraDi'2000), pp. 254-256.

Hall T., Ciolfi L., Bannon L., Fraser M., Benford S., Bowers J., Greenhalgh C., Hellstrom S., Izadi S. and H. Schnadelbach, 2001. The Visitor as Virtual Archaeologist: Using Mixed Reality Technology to Enhance Education and Social Interaction in the Museum. In: Proceedings of VAST 2001: Virtual Reality, Archaeology and Cultural Heritage (VAST'01), ACM SIGGRAPH, Glyfada, Greece, pp. 91-96.

Heim M., 1993. The Metaphysics of Virtual Reality, New York: Oxford University Press.

Hein, G., 1993. The significance of constructivism for museum education. In: Museums and the Needs of the People, Jerusalem. Israel ICOM Committee.

Hughes Ch., Smith E., Stapleton Ch. and D. Hughes, 2004. Augmenting Museum Experiences with Mixed Reality. In: Proceedings of Knowledge Sharing and Collaborative Engineering 2004, St. Thomas, US Virgin Islands.

Kwon Y-M., Hwang J-E, Lee T.S., Lee M.J., Suhl J.K. and S. W. Ryu, 2003. Toward the Synchronized Experiences between Real and Virtual Museum. In: Proceedings of the Asia-Pacific Advanced Network 2003, Fukuoka, Japan.

Liarokapis F., Sylaiou S., Basu A., Mourkoussis N., White M. and P.F. Lister, 2004. An Interactive Visualisation Interface for Virtual Museums. In: Proceedings of the 5th International Symposium on Virtual Reality, Archaeology and Cultural Heritage (VAST), Brussels, pp. 47-56.

Mase K., Kadobayashi R. and R. Nakatsu, 1996. Meta-Museum: A Supportive Augmented-Reality Environment for Knowledge Sharing. In: Proceedings of International Conference on Virtual Systems and Multimedia'96 in Gifu (VSMM'96), pp. 107-110.

Pletinckx D., Callebaut D., Killebrew A. and N. Silberman, 2000. Virtual-Reality Heritage Presentation at Ename. In: IEEE *MultiMedia* April-June 2000, 7 (2), pp. 45-48.

Roussou M., 2001. Immersive Interactive Virtual Reality in the Museum. In: Procedings of TiLE (Trends in Leisure Entertainment), June 2001.

Scali G., Segbert M. and B. Morganti, 2002. Multimedia applications for innovation in Cultural Heritage: 25 European trial projects and their accompanying measure TRIS. In: 68th IFLA Council and General Conference August 18-24.

Sinclair P. and K. Martinez, 2001. Adaptive Hypermedia in Augmented Reality. In: Proceedings of the Third Workshop on Adaptive Hypertext and Hypermedia at the Twelfth ACM Conference on Hypertext and Hypermedia, Denmark, August 2001, pp. 217-219.

White M., Mourkoussis N., Darcy J., Petridis P., Liarokapis F., Lister P.F., Walczak K., Wojciechowski R., Cellary W., Chmielewski J., Stawniak M., Wiza W., Patel M., Stevenson J., Manley, J., Giorgini F., Sayd P. and F. Gaspard, 2004. ARCO—An Architecture for Digitization, Management and Presentation of Virtual Exhibitions. In: IEEE Proceedings 22nd International Conference on Computer Graphics, Hersonissos, Crete, June 16-19, pp. 622-625.

Woods E., Billinghurst M., Aldridge G. and B. Garrie, 2000. Augmenting the Science Center and Museum Experience. In: Proceedings of the 2nd international conference on Computer Graphics and Interactive Techniques in Australasia and Southeast Asia (Graphite 2004), 15-18th June, Singapore, 2004, ACM Press, New York, New York, pp. 230 – 236.

Worden S., 1997. Thinking Critically about Virtual Museums. In: Museums and the Web: Selected Papers, Archives and Museum Informatics, Pennysylvania, pp. 93-109.

Web references

Web 1: ORION Report on Scientific / Technological Trends and Platforms, available at http://www.orion-net.org (accessed at 11/05/2005).

Web 2: '010101 Art in Technological Times', available at http://www.sfmoma.org/010101 (accessed at 11/05/2005).

Web 3: ARCO, ARCO Consortium Augmented Representation of Cultural Objects, available at http://www.arco-web.org (accessed at 11/05/2005).

Web 4: R. Kuchar, T. Schairer, Interactive multimedia walkthrough for museum installations, available at http://www.gris.uni-tuebingen.de/projects/villarustica/index.html (accessed at 11/05/2005).

Web 5: Foundation of the Hellenic World, available at http://www.fhw.gr (accessed at 11/05/2005).

Web 6: Virtual Room Project, available at www.vroom.org.au (accessed at 11/05/2005).

Web 7: Kenderdine, S. & Hart, T, 2003. This is not a Peep Show. The Virtual Room at Melbourne Museum (VROOM), International Cultural Heritage Informatics Meeting (ICHIM) 2003, available at http://www.ichim.org/ichim03/PDF/003C.pdf (accessed at 11/05/2005).

Web 8: Web3D Consortium, available at http://www.web3d.org, (accessed at 11/05/2005).

Web 9: Museums in the USA, available at http://www.museumca.org/usa/alpha.html (accessed at 11/05/2005).

Web 10: Disability Discrimination Act 1995, available at http://www.disability.gov.uk/dda/ (accessed at 11/05/2005).

Web 11: Resource Disability Action Plan, available at http//www.mla.gov.uk/documents/dap.pdf (accessed at 11/05/2005).

Web 12: Fine Arts Museums of San Francisco, available at http://www.thinker.org/fam/about/ (accessed at 11/05/2005).