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Challenges of Virtual and Digital Culture

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1. Introduction

An attempt to survey the frontiers of virtual and digital culture can scarcely hope to be more than impressionistic. Within a decade the Internet has grown from under 1 million to over 544 million users. A search for virtual or digital culture yields over one million sites in each case. There are over a million sites for the virtual past,¹ virtual present and virtual future respectively. There are sites on cyber-studies,² cybersociology³ and cyberanthropology⁴ with essays on culture in a virtual world.⁵ There are major sites on archaeology⁶ and new versions of old disciplines such as digital philosophy⁷ and digital communication.⁸ Almost every major discipline has thousands and in some cases millions of sites under the prefixes virtual, digital, or cyber.

The Oxford English Dictionary (OED, 1971 edition)⁹ claims that digital in the sense of finger goes back to 1656 and that interpretation goes back to 1392 (based on an Old French term of 1292).¹⁰ Interpretation in the sense of exegesis goes back to the time of Moses.¹¹ The Oxford English Dictionary, Webster and Dictionary.com¹² list no entries for the term digital interpretation. Under this term the Internet search engine Altavista lists 143,249 entries; Hotbot lists 250,200, Lycos lists 359,800; Google lists 571,000 entries.¹³ The use of virtual and digital exegesis is considerably less (figure 1).

Virtual Culture	1,030,000	Digital Culture	1,240,000
Virtual History	1,580,000	Digital history	2,040,000
Virtual Archaeology	92,600	Digital Archaeology	108,000
Virtual Philosophy	459,000	Digital Philosophy	620,000
Virtual Interpretation	370,000	Digital Interpretation	571,000
Virtual Exegesis	3,860	Digital Exegesis	7,090
Virtual Object	946,000	Digital Object	1,600,000
Virtual Interactive Object ¹⁴	336,000	Digital Interactive Object	366,000
Virtual Cultural Objects	106,000	Digital Cultural Objects	128,000
Virtual Building	414,000	Digital Buildings	593,000
Virtual Monument	86,900	Digital Monument	69,800
Virtual Museum	670,000	Digital Museum	644,000
Virtual Church	430,000	Digital Church	599,000
Virtual Temple	230,000	Digital Temple	226,000
Virtual Sites	1,980,000	Digital Sites	2,680,000
Virtual Landscape	323,000	Digital Landscape	553,000
Virtual Cultural Landscapes	90,400	Digital Cultural Landscapes	26,300
Virtual Tours	802,200	Digital Tours	352,000
Virtual Visits	329,000	Digital Visits	418,000
Virtual Cities	842,000	Digital Cities	904,000
Virtual Countries	984,000	Digital Countries	1,330,000

Figure 1. Virtual and digital disciplines and topics and number of sites listed by Google.¹⁵

The terms virtual and digital are often used loosely as if they interchangeable. The term virtual relates specifically to a non-physical version of objects, which might originally be either physically real or imagined. Digital is a much broader term because it can include both physical and imagined objects and can include both representatives of the original objects as well as their virtual versions. What one can do with a virtual object depends on the medium in which it exists. By contrast, once something is digital it can be translated into any other medium and for any of the senses. Digital objects can be used to make history visible, to restore settings and to display processes.¹⁶ For the purposes of this survey we shall use these categories to review key developments of the past decade, before considering developments in the realms of education and entertainment.

2. To Make History Visible

Prior to interpreting an object we need to see it. The past decade has seen extraordinary developments in this context both with respect to scanning cultural objects and their contexts. We shall examine in turn some developments with respect to books, paintings, cultural objects and then the environments in which they are housed.

Books

In the early 1990's, IBM's Vatican library project¹⁷ was a pioneer in introducing new levels of quality in scanning images of books (figure 2). Another IBM project at the Luther Library at Halle-Wittenberg continued this process and introduced new methods for viewing palimpsest images.¹⁸ Since then there have been many library and cultural applications.¹⁹

Work at the British Library introduced a technique of virtually turning the pages²⁰ of a digital book. The British Library also introduced a new level of quality in publicly available images of some of its treasures including samples from the *Magna Carta*, the *Sforza Hours*, Leonardo da Vinci's *Codex Arundel* and the entire *Gutenberg Bible*.²¹ In March 2002, the Library of Congress announced that they too would produce an online copy of the *Gutenberg Bible* with a much higher level of quality:

As the images are captured, they are automatically transported to an online storage system, so users can see the progress of digitization in real time. Real-time commentary and translation from Latin to English will accompany the job as it is being imaged. So users will be able to click on the word "Genesis" and be taken directly to that section of the Bible.

Viewers will be able to download microscopic details of the age-old text in full-page format. They will be able to zoom in on high-resolution details of single letters. Since each captured image is 757 MB of data, the entire book will total nearly one-half terabyte. The entire process should take about six weeks.²²

If the 15 million books of the Library of Congress were all scanned in at this rate then one would need some 7,500,000 terabytes or 7.5 exabytes for a single library.

<i>Processing step</i>	<i>Uncompressed data(bytes)</i>	<i>Compressed JPEG data (bytes)</i>	<i>Compression factor</i>
Scanned image (2840× 1895)	16,147,368	704,200	22.93
After reduction (1000 × 667)	2,002,964	147,314	13.60
After sharpening	2,002,964	190,546	10.51
(No rotation)			
After color transformation	2,002,964	189,000	10.60
After watermarking	2,002,964	197,098	10.16

Figure 2. Statistics from IBM's Vatican Library project: Number of bytes in the data for the image...after each processing step used to prepare the image for transmission via the Internet. The numbers are given for the raw data, and for the data after JPEG compression.

The scale of the projects has increased dramatically also. The initial phase of the IBM's Vatican library project entailed 20,000 images. In China the e-SKQS project has scanned in the Emperor's library in the form of 79,330 rolls with a total of 700 million characters. The Bibliothèque Nationale's Gallica project entails some 80,000 full-texts.²³ In March 2002 the Joint Information Systems Committee (JISC) reached an agreement to make available full-text copies of 125,000 English books within Britain.²⁴ A project between Carnegie Mellon University and twelve Chinese universities is scanning in a full text version of 1 million books. There are an increasing number of full-text projects some free of charge others, such as the *Patrologia Latinae*, available by subscription.²⁵

Paintings

A decade ago it was usually assumed that objects would be photographed using ordinary cameras and then scanned in digital form. With the advent of 6 Megapixel cameras taking digital pictures directly is becoming an everyday event. Meanwhile, there are a number of specialized cameras developed for high-level (digital) photography of paintings. The IBM camera used in the Vatican Library was originally developed in 1988 for scanning the paintings of Andrew Wyath from Brandywine and was thus known as the Brandywine camera.²⁶

In the early 1990s, the National Research Council of Canada (NRC) developed a high-level laser camera. This was used for conservation purposes²⁷ and for scanning paintings (usually thought of as two-dimensional) as three-dimensional surfaces²⁸ as well as for three-dimensional sculptures.²⁹ This technology is now being marketed by Arius 3-D in the context of virtual objects and museums.³⁰

Another high-end example was the Visual Arts System for Archiving and Retrieval of Images (VASARI) developed at the National Gallery (London) and subsequently used in the Uffizi and the Louvre.³¹ This scanner typically produced images from 100-300 MB per painting. The Uffizi produced very high level images of paintings at 1.4 gigabytes/square meter. The latest experiments entail images of 10,000 x 10,000 pixels. This allows one to follow changes in the surface of paintings, which were impossible previously.³²

Meanwhile a Japanese method called Vector Format for Zooming (VFZ or Vzoom)³³ developed by Nissha Co. (Kyoto) scans high level images at 3 to 5 gigabytes for a single painting.³⁴ In the CRISATEL (IST) project the European techniques are being combined with those of Nissha to develop a high definition scanner (30,000 lines) based on 12,000 pixels line array CCD.³⁵ This is leading to 30 Gigabyte images. Even with good compression techniques such high quality images are re-defining our notions of future requirements with respect to broadband.

Standard Resolution	176k	1372x600
High Resolution	244k	1757x768
Very High Resolution	484k	2342x1024

Figure 3. Resolutions available in on-line images of Leonardo da Vinci's *Annunciation* at the Christus Rex site.³⁶

Cultural Objects

In the early 1990s Apple developed a Quick Time Virtual Reality (QTVR), which provided some of the first effective 360 degree views of environments. This principle was subsequently applied to virtual museums such as the Louvre,³⁷ and even whole cities such as Virtually Vancouver³⁸ and Virtual Bologna.³⁹

A next step was to adapt the same principle to permit one to look at objects from all sides and directions. These objects can be industrial products⁴⁰ or cultural objects. Just how simple is the technique is witnessed by the students from Santa Clara Day School (Pueblo) who have used it for a Quilled horse mask⁴¹ as part of a Virtual Tour of the National Museum of the American Indian Exhibition Creation's Journey.

A professional application of the technique is seen in UNESCO's site on Central Asian Artworks.⁴² High-level versions of the same approach are offered by images produced with the NRC laser scanner.⁴³ New methods are also being developed. A recent action line of the EC (IST III.6)⁴⁴ focused specifically on virtual representation of scientific and cultural objects. A recently completed IST project of the EC: Augmented Representation of Cultural Objects (ARCO) aimed to: "develop a simple, innovative, and robust digital capture and presentation system that will allow curatorial staff to digitize museum's archives through photogrammetry and render them in 3D as virtual objects without damaging the original artifact. ARCO will adopt international standards to facilitate heritage exploitation in the museum and public domain."⁴⁵

In theory, there has been a convergence between information from memory institutions – a term introduced in the fifth framework programme of the European Commission.⁴⁶ Cultural objects are in museums and galleries. Information concerning them is in libraries and archives. These should be combined. While there are hundreds of thousands of sites on memory institutions, ironically one of the few serious attempts thus far to integrate all these resources has been the Cultural Materials Initiative of the Research Libraries Group (RLG).⁴⁷

3. Virtual Buildings and Monuments

The same methods which are changing the way we look at books, paintings and individual cultural objects are also being used with respect to virtual buildings and virtual monuments. Google lists 415,000 and 65,000 sites respectively under these topics. Some of these show great buildings in isolation with hundreds of photos and reconstructions⁴⁸

SRibasCAD, in Portugal, applies these methods to a) virtual interactive objects, b) 3D virtual architecture, c) virtual tourism usually involving the exterior or interior of a given building,⁴⁹ and d) megalithic monuments in archaeology. These are of interest because they combine systematically points on a ground plan plus 360 degree views using Quick TimeVR.⁵⁰ A site on Virtual monuments of Paris⁵¹ extends this approach to an entire city. A European project called Time travel (*Zeitreisen*)⁵² draws attention to 31 sites in terms of themes.

A 3D Virtual Buildings project⁵³ in conjunction with the National Research Council (NRC) of Canada applies these principles to historical buildings in Ottawa for the years 1878, 1910 and the present. Individual buildings can be retrieved using keywords describing their use or the profession of their occupants such as auctioneer, bank, boarding house, or tailor. The models also entail Virtual Reality Modelling Language (VRML) such that users can move around and manipulate the three-dimensional reconstructions.

In rare cases (e.g. 45 –47 Spark Street⁵⁴) both the CAD model and the rendered model have been done by a member of the NRC (John Bonnett). In most cases, (e.g. 65-75 Sparks Street), the CAD model was made by a high school student (Nikita Otlechenko, J.S. Woodsworth Secondary School), and the model was then rendered by a member of the NRC (John Bonnett).⁵⁵ This is an excellent example of how disciplined co-operation between researchers and regular students can lead to high-level results.

Such on-line demonstrations typically range from .5 MB per image to several megabytes. By contrast the major examples of archaeological reconstructions range in size from 50 MB to 5 terabytes.⁵⁶ In short, there is an enormous gap between what is readily available on-line today and what could be available if there were adequate broadband (in the sense of gigabit/terabit connections).

4. Virtual Museums and Sites

A decade ago virtual museums and virtual sites were a novelty. Surveys of the early experiences have been given elsewhere.⁵⁷ Today a search on Google calls up 688,000 examples under virtual museum and 641,000 under digital museum. The standard point of departure for museums remains the ICOM Virtual library museums pages (VLmp) site.⁵⁸ With respect to heritage sites, the UNESCO World Heritage site includes 554 cultural, 144 natural and 23 mixed properties.⁵⁹

Some of the pioneering examples of virtual museums include the Uffizi (Florence),⁶⁰ the Louvre,⁶¹ the National Gallery (London)⁶² and the Metropolitan Museum (New York).⁶³ While these museums remain interesting it is striking that the on-line presence of such art museums in 2002 reflects neither their own internal achievements nor the latest technological possibilities.

Three examples will illustrate this. For instance, the Uffizi has a low resolution Quick Time VR version of Room 15 which contains Leonardo da Vinci's *Annunciation* and an

image of the painting⁶⁴ but far better images of the painting in three different resolutions (figure 3) are available on the Christus Rex site.⁶⁵ Using the VASARI camera the Uffizi has images of 1.4 gigabytes for most of its collection. This offers enormous potentials for research especially in the realm of conservation, which are not being utilized at the moment.

A second example is the National Gallery of London, which has an excellent list of its entire collection by artist name⁶⁶ (although not by title or subject). The site has no map with floor plans, no Quick Time VR or VRML version of the galleries. This is all the more ironic since it was here that the idea of a Micro Gallery was introduced, which provides:

a visual encyclopaedia of the collection, enabling you to explore your individual area of interest whether it is a particular painting, artist, period, subject or genre. A4 colour copies of the Micro Gallery pages can be printed out for a nominal charge.

The Micro Gallery also allows you to assemble and print your own personalised tour of the Gallery. This is a free service, simply click on the tour button when you wish to select a specific painting and add it to your tour. You can print out a free plan showing the location of your selected pictures, which you can take with you around the Gallery.⁶⁷

Technically speaking all of these features could be available on line. They are not. In theory the National Gallery site is accessible in four languages: English, French, Japanese and Italian. But if one chooses French the left column instructions remain in English and if one searches for Léonard de Vinci (using the French spelling) one arrives at Sir Henry Raeburn, 'The Archers', c.1789-90. A search in Italian for Leonardo's *Vergine delle Rocce* (Virgin of the Rocks) produces no hits.

A third example is offered by the Louvre. If one is interested in *Mona Lisa* one is able to find its location within the museum,⁶⁸ one finds a Quick Time Virtual Reality image of the room in which *Mona Lisa* exists which is such a low resolution that one has difficulty recognizing the painting.⁶⁹ If one goes to selected paintings from Italy 13th-15th centuries⁷⁰ one finds neither a description nor an image of the *Mona Lisa*. By contrast if one goes to Google's image search one finds 1610 entries under *La Gioconda* and 3870 entries under *Mona Lisa* including a good quality image (743x1155 pixels) from France.com.⁷¹ Meanwhile the Louvre has produced an excellent CD ROM of its collections and houses the Centre de Recherché et Restauration des Musées de France (C2RMF),⁷² which is one of the leading research institutes of the world. In short there is an enormous discrepancy between what is technically possible and what is practically available in the realm of virtual museums. The Louvre is, however, working on a completely new site with 35,000 exhibits, as part of a virtual 3D tour by 2003. The Louvre will show all the objects in its great collection.⁷³

This discrepancy between the technically possible and things, which are practically available on-line is also evident in the realm of science museums. For example, the Institute and Museum for the History of Science (Florence),⁷⁴ has only one of its rooms

(Room IV Galileo) in Quick Time VR.⁷⁵ The web site contains small images of instruments in the collection. Ironically one needs to go to the website of *Epact*, an electronic catalogue of medieval and renaissance scientific instruments to find high level images from the collection.⁷⁶

One of the great achievements of the Institute was an important exhibition (*Prima di Leonardo*) on the Sienese roots of Leonardo da Vinci's inventions. The on-line site contains isolated fragments of this evidence such as folios from the *De machinis*⁷⁷ by P. Santini (after Taccola) but offers very little idea of the exhibition or its enormous consequences: forcing us to rethink the role of Siena as opposed to Florence in early Renaissance science.

In 1995, the Institute was chosen as one of four examples with respect to the G7's Pilot Project 5: Multimedia Access to World Cultural Heritage. It was chosen for its pioneering work in linking manuscripts with transcriptions and literature in new ways and linking diagrams in manuscripts with physical models, and virtual reconstructions in the form of QuickTime VR. These materials were published as a CD ROM under the title *Mechanical Marvels*.⁷⁸ The web site shows only isolated snippets of relations between manuscript pages and reconstructions of a crank operated pump⁷⁹ or a retractable bridge.⁸⁰

Some idea of the possibilities are suggested by exceptions. The site of an imaginary museum, which does not exist physically, the Museo Virtuel de Artes el Pais (MUVA),⁸¹ offers an example of high level navigation through virtual spaces. The Christus Rex site shows Massaccio's frescoes in the Brancacci Chapel (Florence) and allows one to zoom in on high-resolution details.⁸² The Canadian Museum of Civilization⁸³ allows one to examine objects such as masks or eggs in sequences and thereby gain a better understanding of how an item relates to others in the collection.

In the case of science museums there are also exceptions. The Exploratorium (San Francisco)⁸⁴ the Musée des Arts et métiers (Paris)⁸⁵ and the Deutsches Museum (Munich) especially in its multimedia section⁸⁶ offer interesting examples. The National Museum of Science and Technology Leonardo da Vinci (Milan)⁸⁷ has an excellent section on Leonardo, which relates his sketches to images of physical reconstructions of over 100

Site	Country
San Lorenzo	Panama
Amsterdam	Netherlands
Beijing	China
Angkor	Cambodia
Historic Centre of Naples	Italy
Great Pyramid of Giza	Egypt
Pompeii	Italy

Figure 4. Seven virtual tours included in the UNESCO World Heritage Site⁸⁸

devices. It also offers an innovative experiment in a three-dimensional reconstruction of a virtual museum in VRML complete with interactive displays and an accompanying avatar.⁸⁹

One significant development of the past years has been experiments to combine information from different collections. One of the earliest experiments in this context was the photo collection of the Marburg Archive (BildArchiv Foto Marburg),⁹⁰ which combined information from a number of German museums and institutions and now has over one million photographs on-line. With respect to paintings there are projects such as the Euro Gallery.⁹¹ One of the most impressive projects in this context is the Virtual Museum of Canada, which includes materials from 710 member museums and has exhibition materials in three languages (English, French and Spanish).⁹²

5. Virtual Tours

Another significant development of the past five years has been an increasing contextualization of these virtual buildings, monuments, museums and sites in the form of virtual tours. The UNESCO site now includes seven such virtual tours (Figure 4). There is a Virtual Tours Webring,⁹³ which includes 16 sites and a Virtual Tours website which includes over 300 Museums, Exhibits, Points of Special Interest, Virtual Reality and Real-Time journeys.⁹⁴ In addition to museums and galleries these tours entail a virtual tour of the late Timothy Leary's home,⁹⁵ complete with records of his chatroom, his publications, and links to other artists and writers (e.g. Douglas Rushkoff). A virtual reconstruction of a physical space can thus serve as an introduction to the metaphysical spaces of an author.

A site on Virtual tours of Egypt⁹⁶ has a number of cities and places including Cairo, Dendera, Giza, Karnak, Saqqara, Solar Boat and the Ramses Wissa Wassef Art Center. Most of these provide a ground plan with a number of hot spots leading to 360-degree panoramic views using Live Picture. Some sites are effectively the product of an individual such as the Virtual Study Tour by Matiu Carr of the Faculty of Architecture Property Planning and Fine Arts (Auckland, New Zealand) which provides links to both historic (e.g. Hadrianic Baths, Leptis Magna,⁹⁷ Temple Palace of Rameses III at Medinet Habu 1175 BC)⁹⁸ and contemporary locations (e.g. The American Bar by Adolf Loos).⁹⁹ The technologies of companies such as Immersion Studios (Toronto) and De Pinxi (Brussels) are transforming such virtual tours into interactive experiences in movie theatres.

An impressive example of how such isolated efforts can be combined more systematically is provided by the Virtual Tours site of Parks Canada.¹⁰⁰ One begins with a map of the country, clicks on a province such as British Columbia, and then chooses an item such as the Chilkoot Trail National Historic Site.¹⁰¹ This leads to a text, a number of photographs and a video clip of the area.

6. Virtual Visits

Virtual tours typically present official information. By contrast, virtual visits: “represent the visitors' point of view, not necessarily the viewpoint of those responsible for the place visited.”¹⁰² Such tours are typically linked with project-based education. Examples are a virtual visit to the Lowell Mills¹⁰³ and a virtual visit to the Statue of Liberty.¹⁰⁴

7. Virtual Cities

Not surprisingly the increasing contextualization mentioned earlier is leading to virtual cities. Google lists 842,000 sites. Many of these are primarily commercial in scope with links to local business and places of interest for tourism. Some sites such as Virtual Paris by Canal+¹⁰⁵ include cultural dimensions. More intriguing is Virtual Helsinki,¹⁰⁶ which aims to make everyday events with small audiences such as the sermon of a protestant minister or the lecture of a professor lecture available on-line to persons around the world. Connected with this is a virtual museum,¹⁰⁷ which links virtual reconstructions with photographs of actual archaeological evidence. A site on Virtual Rome¹⁰⁸ is part of the Ancient sites Roman network and allows a community of interested persons to interact in the roles of Roman citizens, soldiers etc.

The topic of virtual cities is now also the subject of conferences¹⁰⁹ and entails unexpected applications. For instance, the US Department of Defense has a Virtual cities site¹¹⁰ with reconstructions of the New York,¹¹¹ Los Angeles, Philadelphia Washington and a virtual airport:

The Institute for Defense Analyses has undertaken the challenging task of creating realistic, high resolution, virtual cities to be used for the virtual reality immersive training of both civilian first responders (fire, police, emergency medical and HAZMAT) and the military responders (the National Guard Civil Support Teams) in rehearsing their reactions to weapons of mass destruction incidents or other homeland defense issues.¹¹²

Meanwhile the CyberNet Project¹¹³ uses the metaphor of the city for navigation within the net:

Basically, our model is based around the concept of Center Of Interest (COI), which is a visual part of the 3D world which can be of some interest for the user. For example in a visualization using a town metaphor, a COI can be a house, a district, or all the town. In the model, all the COIs are organized in a hierarchical manner. To navigate the user select[s] a COI and the system moves automatically the user to this COI. There are several manner[s] to select the next COI : relative (using the structuration of the COIs) or absolute (clicking on a 3D object for example), or using special lists. The user[s] have one choice to make: how the translation between the current COI and the next COI should be done. There are 3 options: teleportation, interpolation, or path which moves the user according the visual structure of the current 3D world.¹¹⁴

Such projects are part of an emerging field known as cyber-geography.¹¹⁵ The problem of how topographic information can be used to put objects into context in cultural and natural heritage visualization and animation has also been the subject of study.¹¹⁶

At the research level much more dramatic solutions exist. Already in 1994 Art+Com in the T(erra)-Vision produced a remarkable demonstration which began with satellite images and then zoomed in to the cities of San Francisco and Berlin, ending up within a CAD reconstruction of the company's offices. This demo was itself carried through an ATM connection by satellite from Germany to Japan. In the United States, a project at SRI International, with heavy support from the military, subsequently developed this approach under the name Terra Vision. A Spanish project, called SANTI, applies this same general approach of linking satellite images through Geographical Information Systems (GIS) with virtual reconstructions of towns. This project is several terabytes in size.

The Nuovo MUseo Elettronico (NUME) project focusses specifically on a virtual reality reconstruction of the inner city in Bologna but does so for a millennium from the year 1000 to the present. What makes this project special is that the reconstructions are linked with detailed manuscript records. The website version shows a few screen shots and allows one to navigate using VRML.¹¹⁷ However, this represents but a tiny bit of the full database which is several terabytes in size. Once again there is an enormous discrepancy between what is available via regular Internet today and what could technically be available with a broadband network.

8. Virtual Countries

Google lists 984,000 sites under virtual countries and 1,330,000 sites under Digital Countries. A US site called Virtual countries¹¹⁸ lists seventeen countries including Sweden.com¹¹⁹ Nepal.com¹²⁰ New Zealand.com¹²¹ but not the United States. While largely commercial, these sites have some interesting collections of photographs by visiting tourists. Not directly connected to these sites are other sites with the name of Virtual Sweden,¹²² Virtual Australia¹²³ and Virtual New Zealand.¹²⁴ The latter of these are powered by the WorldXplorer.com software, which allows one to move from a view of the earth to the region, the country and then to parts of the country. Sites such as Virtual Finland¹²⁵ and Virtual Canada have related GIS-like aspects. Sites within e-countries¹²⁶ are again less interesting in this respect.

9. Cultural Landscapes

Virtual museums began as reconstructions of man-made buildings containing cultural objects. The contextualization that has led beyond buildings to sites, cities, and countries has seen also an increasing attention to cultural artifacts within the natural environment.¹²⁷ Hence the Cave at Lascaux¹²⁸ or the Cave of Chauvet Pont d'arc¹²⁹ have become part of a growing number of Petroglyph and rock art sites¹³⁰ and related to efforts at identifying characteristics of a virtual cave.¹³¹

Santiago de Compostela Pilgrim
Via Francigena
Rural Habitat
Silk
Baroque
monastic Influence
Celtic
Mozart
Schickhardt Itineraries
Viking
Hanseatic
Parks and Gardens
European Cities Discoveries
Living Arts and European Identity
Phoenician
Humanism
Wenzel Itinerary
"Legacy of Al-Andalus"
Northern Lights
Popular festivals and rites in Europe
Gypsy

Figure 5. A list of twenty one cultural routes¹³²

This fascination with evidence of man's markings on the walls of caves has spread to study of the cultural landscapes man has created. A project sponsored by the European Commission¹³³ identifies a series of distinct landscapes throughout Europe. Harvard has a Center for the study of Cultural Landscapes.¹³⁴ In Canada¹³⁵ the fascination with cultural landscapes extends to environments in which Indians and aboriginal people lived prior to being visibly altered by man. Under cultural landscapes Google lists 259,000 entries. The realm of digital interpretation has thus spread far beyond individual cultural objects and the museums, which contain them. It has now spread to landscapes and nature itself before the advent of human intervention. Scholars such as Maurizio Forte have identified a number of cognitive qualities of the archaeological landscape: socio-symbolic, geometrical, power hierarchical, visual, artifact, mental, narrative, semiotic, connected inter-connected, natural, spatio-temporal, simulated, virtual dynamic and mindscape.¹³⁶ What might once have seemed a simple technical problem of reconstruction, is increasingly becoming a scholarly problem with many philosophical dimensions.

10. Cultural Routes

Cultural routes are becoming a theme. In Germany a project follows the route connecting Romanesque churches.¹³⁷ In this new world, satellite images of the earth are potentially of great interest. Indeed study of such images led, in 1992, to the rediscovery of the lost

city of Ubar.¹³⁸ The city itself was invisible under the sands but it was found through traces of the ancient trade routes leading to and from the city. In the 1990s, UNESCO devoted an important series of studies to the history of the ancient silk and spice roads.¹³⁹

More recently there is discussion of creating digital silk roads.¹⁴⁰ Meanwhile, in Europe also there has been increasing attention to the importance of cultural routes¹⁴¹ (figure 5). With techniques such as animation, activities on such routes can now be rendered dynamically as has, for instance, been done with maps of the barbarian invasions.¹⁴² What has been done in this respect is miniscule with that which is technically possible.

11. To Restore Settings

The study of cultural objects and their containers has thus led to a study of the places along which objects were spread and knowledge was shared. Many of those places, which were once flourishing centres of world culture (Persepolis, Babylon, Kabul) are now much reduced or in ruins. The quest to make history visible and to create virtual museums thus becomes increasingly connected with a quest to restore settings and in a larger sense with a commitment to virtual archaeology, a topic which has a major website, Archnet,¹⁴³ and no less than 92,600 sites in Google.

A number of these efforts to restore settings are listed in a Virtual Heritage Network,¹⁴⁴ which has, in turn, inspired a separate Italian Virtual Heritage Network.¹⁴⁵ There is also an English site with visualizations and reconstructions.¹⁴⁶ A collection of Ancient sites¹⁴⁷ includes: Alexandria, Athens, Babylon, Machu Pichu, New York, Rome, Tara. In addition there are thousands of sites devoted to reconstructions of individual buildings or complexes. Here the Roman town at Xanthen,¹⁴⁸ the Roman fort at Waldgirmes,¹⁴⁹ the Lion Salt Works (Northwich, Cheshire, UK)¹⁵⁰ and a virtual tour through a reconstructed Dudley Castle¹⁵¹ serve as examples.

Striking about such examples is that they provide credible, sometimes even beautiful reconstructions of a site, which is now in ruins, but typically provide no information either concerning the sources used or the criteria employed in arriving at the result. Needed are new methodologies to link images of structures and their reconstructions with textual information/knowledge concerning them.

Augmented reality is one of the important new tools in the context of restoring settings. This permits one to superimpose upon the physical ruins of a site a virtual reality reconstruction of the original temple or building. One of the most interesting examples in this context is an EU IST project called Archeoguide which has four goals:

- a) Accessing information in context with the exploration of the site through position and orientation tracking.
- b) Personalized and thematic navigation aids in physical and information space through the use of visitor and tour profiles taking into account cultural and linguistic background, age and skills.

- c) Visualization in 3D of missing artefacts and reconstructed parts of damaged sites on Head Mount Displays.
- d) User friendly multi-modal interaction for obtaining information on real and virtual objects through gestures and speech. In addition, tools enabling site administrator to organize the presentation of site information in creative ways will be provided.¹⁵²

The uses of such reconstructions are potentially wide ranging. They can be used for conservation purposes (monitoring changes in the original structures), for tourism, entertainment and for education. Some would claim that such reconstructions have a limited value: that they are useful as introductions. Others see them as ersatz measures for special cases such as the Cave at Lascaux where the interests of conservation preclude the possibility of everyday touristic visits. Others again see such reconstructions as complete substitutes for the originals:

There will soon be a time where a person no longer goes beyond the realms of his own home for experiencing or studying all aspects of any intricate Heritage Structure. Virtual environments of such structures will be easily available and navigable. All the associated information like history, architectural data, archaeological data, culture and also traditional audio will be available at the click of the mouse. There are infinite possibilities of depicting the virtual (different lighting conditions, the structure as it existed (As Was), the present state of the structure (As Is) or future representation of the structure (As It Can Be). Besides marking the beginning of 3-Dimensional documentation of Complex Heritage Structures, this research has extended the limits of human skill (in terms of gathering data and construction of 3D model) and information technology (in terms of hardware limitations and computing power), a symbiosis and confluence of arts and information technology.¹⁵³

In our view it is always preferable to see the original. In some cases it may be ideal to see the original and in addition to have access to reconstructions which make visible aspects one could not see with the naked eye. On the other hand, what is preferable is not always practical. It is clearly not practical to go the original site every time we wish to study it or every time we mention it. For this reason books have proved very useful in the past as electronic images and reconstructions will prove in the future.

12. To Display Processes

The quest to restore objects and settings has led to an increasing interest in using digital media to simulate possible effects of restoration before intervention with respect to the original. In an early example, the NRC camera was used to scan a unique Aboriginal mask in the Canadian Museum of Civilization. The scanned image, with the aid of stereo-lithography was then used to make a precise replica on which conservators were able to test effects of interventions without risk to the original.

In the case of the *Last Supper* (Milan), photographs were typically taken of any given section due to be restored. These photographs were compared with corresponding sections in extant copies. As the restoration took place photographs were made for each level of intervention. Hence there is now an enormous photographic archive whereby a future scholar could reconstruct the whole process of the restoration.

The restoration of Piero della Francesca's *Legend of the True Cross* (Church of San Francesco, Arezzo), financed by the Banca Popolare dell'Etruria e del Lazio, was one of the first large scale restorations where every stage of the process was integrated into a single a database developed by the engineers Chimenti and Menci. The conservators were able to examine a section of the fresco in a high-resolution image, add colour in a simulated intervention and then try alternatives in order to understand the implications of possible interventions. The resulting database of hundreds of gigabytes is well documented in a book¹⁵⁴ and various articles.¹⁵⁵ The material would be ideal for students of conservation and given broadband connection could be made available on-line. Alas, due to local politics this material is not generally available for study.

Archaeology is the only profession, which traditionally destroys the context of its evidence in the process of digging. Methods to capture the excavation process have been the object of increasing study these past years.¹⁵⁶ One website describes ways of animating the excavation.¹⁵⁷ An IST project of the European Commission, 3D Murale, sets out to "measure, reconstruct and visualise archaeological ruins in virtual reality using as a test case the ancient city of Sagalassos in Turkey."¹⁵⁸

The quest to display processes varies enormously in terms of scope and complexity. For instance, a simple but effective site displays dynamically the evolution of alphabets.¹⁵⁹ There are sites which provides a virtual simulation of ship production processes,¹⁶⁰ the cultural impact of virtual processes¹⁶¹ and the cultural processes in Nordic Woodland Communities:

In great parts of the Nordic Countries, woods and woodland management has until recently been the essential basis of human subsistence. The way in which "woodland" was considered to be as well a poor as an unlimited resource deeply influenced Nordic culture in various manners. I. a. it might have given property and inheritance rights another essence than in more "rural" parts of Europe. Furthermore, it might have affected the perception of right and wrong, state and society, wealth and poverty, equality, husbandry and work. Metaphors derived from woodland management were used in the construction of both individual and social identities relating to gender, working status, locality or nation. The project group aspires to study how the concept of "woodland" historically has been employed in various national and local woodland contexts within the Nordic Countries.

It also wishes to develop an experimental milieu where the professional traditions of history, ethnology and other social and human sciences can encounter.¹⁶²

A US site on Louisiana Voices defines Cultural Processes as “Culture and knowledge passed on through folk, popular, or elite cultural modes.” Folk culture is “Culture and knowledge passed on by word of mouth, imitation, and observation. Also known as traditional culture and used as another term for “folklife,” popular culture is “Culture and knowledge passed on through mass media’ while elite culture is “The culture and knowledge handed on, learned, and taught officially through formal institutions such as schools, colleges, museums, conservatories, or governments.”¹⁶³ In this interpretation processes are not just the means by which artefacts are created but also the means by which they are communicated.

While very interesting the above distinction between folk, popular and elite cultural modes does not represent the whole story. One of the significant dimensions of the Internet entails the rise of personal websites, sometimes with the benediction of an employer, often not, which display creative expressions. The sites of the virtual space time travel machine ¹⁶⁴ and of virtual experiences¹⁶⁵ offer two interesting examples.

13. Education and Games

Increasingly there are connections between cultural heritage and entertainment. A search in Google under Virtual Culture Games generates 225,000 hits. Some of these, such as Virtual Reality Notre Dame (VRND) are focused on entertainment.¹⁶⁶ Other such are focused on education. Virtual ukiyo-e¹⁶⁷ offers a simple example. A user is provided with a skeletal version of Hokusai’s *Beneath the wave off Kanagawa* from his *Thirty Six Views of Mount Fuji* and then asked to add seven layers in the correct order. This helps one to understand the stages entailed in making this kind of Japanese print. The range and scope of these educational cultural games varies enormously. For instance, a project in Kilmartin,¹⁶⁸ Scotland entails interactive monuments and Dunadd, a 3-D game with modeling of the Kilmartin valley:

Dunadd fort lies at the geographical centre of the old kingdom of Dal Riata. From late prehistory to the late medieval period, Dunadd was built and occupied by different people. See the changes brought by these people in six different time periods and see what Dunadd may have looked like during these times. Dunadd was at the height of its importance between about AD 400-800, when it was an inauguration site for Dalriadan leaders.¹⁶⁹

Considerably more complex is a project called Virtual Qumran (VQ) which:

will provide information about the Dead Sea Scrolls and the new picture they offer of Jews, Judaism and the origins of Christianity during the formative Second Temple period. This will be an educational resource for high school and college students, teachers, and the general public. The information will be presented in an entertaining format and will include scans of scroll fragments, artifacts, maps, a timeline and pictures with captions.

VQ will be organized as an on-line tour of the caves and archeological site at Qumran that will replace the current Caves Tour. The visitor will be able to enter the caves, buildings and other installations (water cisterns, cemeteries, etc.) where

he or she can learn about the activities conducted there and the people engaged in them.

At the pottery workshop, for example, the visitor will be able to compare the pottery made at Qumran with that from other sites, learn about the life styles and beliefs of different communities and about modern scientific techniques of pottery analysis, including neutron activation of the clay in nuclear reactors. During the visit to the communal hall, the visitor will get a sense of communal meetings, meals, study, and worship, while learning about competing institutions of Second Temple Judaism - including the Jerusalem Temple and the fledgling synagogue.¹⁷⁰

Some of these virtual games help us to understand real games of a given culture. For example a Mayan culture site¹⁷¹ provides us with an electronic version of *Bul, A Mayan Game of Chance*. This site also describes *The Six Tests of Xibalba, How to Write Your Name In Mayan Glyphs* and provides a *The Date Converter*.

The rise of portals means that educational materials also are increasingly accessible through centralised sites. In the mid- 1990s, Canada was one of the first countries to develop a Schoolnet. There is now a European Schoolnet¹⁷² and there are analogous developments all over the world. In the United Kingdom there is a Distributed National Educational Resource (DNER). In Germany, there is now a centralized site for educational online resources¹⁷³ with an enormous number of links. There is also a project to take individual lectures on art history and make them available in a distributed environment.¹⁷⁴ This project in turn will become one of the starting points for a pilot Distributed European Electronic Environment (DEER) within the context of E-Culture Net.

14. Networks

The idea that one can gain by sharing knowledge is probably as old as knowledge itself. It is specifically discussed in the Chinese *Book of Changes (I Ching, c. 1150 BC)*. This principle inspired the academy in the Antiquity and the university in the Middle Ages. In the twentieth century, the Centres of Research and Restoration (1931) which are now combined as the Centre de Recherche et Restauration des Musées de France introduced a new level of sharing research among museums through a centralized research laboratory. The Canadian Heritage Information Network (CHIN, 1972-) introduced the idea that these materials could be shared on-line. Significantly CHIN began as a fully centralized collection and has since evolved into a set of distributed collections linked by centralized authority files.

The rise of numerous individual networks of libraries, museums, archives, universities and all realms of culture has been discussed elsewhere.¹⁷⁵ As early as 1989 UNESCO had a vision to combine all these individual efforts in a Network of Networks, which would combine all the individual efforts in a united vision.¹⁷⁶ Since then there have been hundreds of networks in the cultural domain. A new trend is to link these together. In Japan, there is an Asian Network of Excellence in Digital Silk Roads. Both CHIN and

this Asian network have agreed to work with an emerging European E-Culture Net, which brings together content from memory institutions (museums, libraries and archives) with research institutes and industries in the realms of context and communications. There is now discussion of knowledge life cycles, of production streets linking all aspects of the creative process. E-Culture Net, a new European Network of Centres of Excellence, which is being inaugurated at the Culturtec Conference, will develop these ideas.

15. Conclusions

A survey of the frontiers and challenges of virtual and digital culture brings to light unexpected contrasts and imbalances. A decade ago museums such as the Uffizi, the National Gallery and the Louvre were among the pioneers in the latest technologies. They showed samples from their collections. Today there are efforts at institutions such as the Louvre to put all of their materials on line. This policy has taken the wind out of entrepreneurs such as Bill Gates who had hoped to commercialize access to culture through buying all images thereof.

Nonetheless, an unexpected digital divide has emerged. On the one hand there are public collections, which are on-line, open freely to the public, but often with poor images, typically with partial glimpses of their vast collections and almost invariably with very low-level Internet connections. On this side of the divide a 56K connection is an everyday reality, and ISDN or ADSL pose as “broadband solutions.”

At the other side of the divide is a world of research, which deals with completely different numbers. We have cited examples such as the new Gutenberg Bible project, which scans at 757 MB per image, of detailed Japanese photographs, which contain 5 gigabytes for a single painting, and virtual reality reconstructions of cities and landscapes, which comprise up to 5 terabytes for a single project. Unfortunately the products of this research are not yet online. Access to these will require broadband in a new sense. It will require repositories ranging from petabytes to exobytes, and cultural grids, which we have thus far associated mainly with high energy physics, astronomy and the human genome.

A decade ago most of the challenges lay purely on the technological front. In most cases there simply were no terabyte and petabyte databases and even the first terabyte transmission had yet to be demonstrated. Today the technology exists and the real source of the digital divide is psychological. The broadcast world is happy with the status quo. The telco world is fixated on the new possibilities of mobile connections, which at their best with UMTS take us into the realms of ADSL at present. A new world is almost secretly emerging. In 2000, there were 90 million kilometers of new fibre optic connections.¹⁷⁷ And yet there is, in most parts of the world, no clear vision of how to get fibre optic connections directly into the home or even the school.

The realm of education poses some of the greatest challenges. A half century ago there was no Internet. Most of our parents grew up without computers. In the next fifty years there will be even greater changes. And yet most of our schools and universities still use old-fashioned lectures with blackboards (or whiteboards), without Internet connections.

Teachers are expected to prepare students for a new world of technology while they are not equipped to show students even the best examples of the past decades. Indeed most students' access to high level technology today is typically limited to violent action films and even more violent video games.

With the help of emerging gigabit and terabit networks students around the world could be introduced to art history and culture with wonderful high-level reproductions. They could travel in virtual environments of great historical cities and learn to appreciate the richness of other cultures. With access to such high level reproductions which already exist they could learn to see details invisible to the unaided eye, to see things they could not see even through a traditional visit to a gallery or museum, and learn how the most eloquent expressions of human culture can be conserved such that they can be available for a future generation.

We spend billions annually on weapons and similar sums on broadcasting all the resulting destruction. We ignore the millions who die in poverty and yet express nearly complete hysteria when some 3,000 persons die in an attack on 11 September using the same methods we see daily in our films. If we are truly concerned with the future, surely we should spend some more time, effort and money on peace rather than war, on preserving culture rather than destroying it and teaching our children about the wonderful expressions the human condition has brought forth. We have many treasures all over the world. All of us need to learn more about each other if there is to be true tolerance, which leads to understanding, the only key to real peace.

The past decade has seen an achievement, which is unprecedented in the history of mankind. 544 million persons have begun to use a new technology: the Internet. This amounts to over 8% of the entire population of the earth. No technology has ever spread so quickly. Some have compared the advent of the Internet with the advent of writing and printing in the past. Ironically these great innovations introduced a divide between illiteracy and literacy, which is not per se inherent in the Internet.

The Internet extends to all modes of communication and can thus "translate" a literate text into a verbal speech. Conversely it can record the verbal speech of an illiterate person, "translate" it into digital form and then make it accessible to a literate person as text, to a blind person as a spoken recording or as Braille. Through the Internet a blind illiterate person in the hills of Nepal could theoretically communicate with a deaf Inuit in the Artic wilds. This gives the quest for communication with anyone, anytime, anywhere a considerably deeper meaning.

Once upon a time the barriers to new cultures entailed major explorations of discovery and there were threats to one's life at every turn. Technologies which were physical extensions of man made it much easier to sail, navigate and later fly around the world. The new technologies which are mental, spiritual and meta-physical extensions of man permit us to explore the world in new ways from the comfort of our desktops and mobiles at school, work, at home or as we travel. The old technologies diminished the time to cover distances to far away places. The new technologies have removed many barriers of space and time and confront us with a new paradox. The real challenges of virtual and digital technologies lie not in the logical circuits of infrastructure, machines and gadgets.

They are psycho-logical: they lie in opening our spirits to the magnificent potentials of sharing knowledge from all over the world and being confronted ever anew with discovering that we shall always have much to learn.

Maastricht, Good Friday 2002

Notes

¹ See: <http://137.166.132.18/~dspennem/VIRTPAST/VIRTPAST.HTM>

² See: <http://www.webring.org/hub?ring=cyberstudies&list&page=0>

³ See: <http://www.angelfire.com/ma/Socialworld/Cyberspace.html>

⁴ See: <http://www.fiu.edu/~mizrachs/cyberanthropos.html>

⁵ See: <http://www.fiu.edu/~mizrachs/virtcult.html>

⁶ See: <http://www2.ruf.uni-freiburg.de/provroem/archimin.html#Aquaedukte>

Cf. <http://odur.let.rug.nl/~arge/Themes/>

⁷ See: <http://www.digitalphilosophy.org/>

⁸ Edward Barrett, Edited collections on digital communication include: *Text, ConText*, and *HyperText* (MIT Press, 1988); *The Society of Text* (MIT Press, 1989); *Sociomedia* (MIT Press, 1992), and co-editor of *Contextual Media: Multimedia and Interpretation* (MIT Press, 1995).

⁹ 1971 Edition

¹⁰ The Miriam Webster Dictionary claims that interpretation goes back to the fourteenth century.

See: <http://www.m-w.com/cgi-bin/dictionary>

Cf. Roget: <http://www.thesaurus.com/roget/IV/522.htm>

¹¹ See: <http://www.newadvent.org/cathen/05692b.htm>.

¹² See: <http://www.dictionary.com/search?q=virtualSource>: *The American Heritage® Dictionary of the English Language, Fourth Edition* Copyright © 2000 by Houghton Mifflin Company.

¹³ This was on 15 March 2002.

¹⁴ See: <http://www.sribascad.com/QTVR-Objects/QTVR-Objects-Menu.html>

See: <http://www.synchromedia.co.uk/objects.shtml>

¹⁵ On 20 March 2002.

¹⁶ A new Centre for Digital Interpretation (Falun) lists these as its goals.

¹⁷ F. C. Mintzer, L. E. Boyle, A. N. Cazes, B. S. Christian, S. C. Cox, F. P. Giordano, H. M. Gladney, J. C. Lee, M. L. Kelmanson, A. C. Lirani, K. A. Magerlein, A. M. B. Pavani, and F. Schiattarella, "Toward on-line, worldwide access to Vatican Library materials," *IBM Journal of Research and Development*, Volume 40, Number 2, 1996.

See: <http://www.research.ibm.com/journal/rd/402/mintzer.html>.

It is interesting to note that although this project used IBM technology it was actually financed by the Catholic Community of Rio di Janeiro.

¹⁸ Cf. <http://www-4.ibm.com/software/is/dig-lib/info/lutherpic.html>

¹⁹ See: http://www.research.ibm.com/image_apps/culture.html

Cf. http://www.research.ibm.com/image_apps/index.html

²⁰ See: http://vincent.bl.uk/cgi-bin/html?DB=website&STEMMER=en&WORDS=turning+page+&COLOUR=Olive&STYLE=s&URL=http://www.bl.uk/collections/treasures/digitisation.html#muscat_high_lighter_first_match

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- ²¹ See: <http://prodigi.bl.uk/gutenberg/background.asp>
- ²² See: <http://www.wired.com/news/culture/0,1284,50589,00.html>
- ²³ See: <http://gallica.bnf.fr/>
- ²⁴ See: <http://www.jisc.ac.uk/dner/collections/eebo.html>
- ²⁵ <http://www.csbsju.edu/library/books/online.html>
- ²⁶ By *Stephen S. Hall*, "Libraries without Roofs.COVER STORY: Digital Libraries: Libraries without Roofs, Think Research. See: http://domino.research.ibm.com/comm/wwwr_thinkresearch.nsf/pages/libraries196.html#two
- ²⁷ See: http://www.vit.iit.nrc.ca/Pages_Html/English/NRC%20M&H_tech.html
- ²⁸ See: http://www.vit.iit.nrc.ca/Pages_Html/English/paintings.html
- ²⁹ See: http://www.vit.iit.nrc.ca/Florence_99/Scanner.html
- ³⁰ See: http://www.arius3d.com/dynamic-frameset.html?museum_channel/index.html
- ³¹ See: <http://www.ecs.soton.ac.uk/~km/projs/vasari/>
- ³² Alfred Hermida, BBC News Online, "Digital cameras save artworks," Monday, 11 March, 2002, 08:54 GMT.
See: http://news.bbc.co.uk/hi/english/sci/tech/newsid_1862000/1862234.stm
- ³³ See: <http://www.nissha.co.jp/english/index.html>. This was presented to ICOM-CC, France, 1999, and is being used via Scala to scan Louvre paintings such as Mona Lisa.
- ³⁴ See: www.vfzoom.com
See: <http://www.vfzoom.com/jp/gallery/gion/index.html>
- ³⁵ See: <http://www.crisatel.jussieu.fr>
- ³⁶ See: <http://www.christusrex.org/www2/art/leonardo.htm>
- ³⁷ See: <http://www.louvre.or.jp/louvre/OTVR/anglais/index.htm>
- ³⁸ See: <http://www.virtuallyvancouver.com/>
- ³⁹ See: <http://www.unibo.it/avl/vr/bo/tour/tour.htm>
- ⁴⁰ See: <http://www.apple.com/hardware/gallery/>
- ⁴¹ See: <http://www.conexus.si.edu/VRTour/FrameCJ1.htm>
- ⁴² See: <http://www.unesco.org/webworld/asicent/kazslid.htm>
- ⁴³ See: <http://exn.ca/Stories/1997/05/23/02.asp>
See: http://www.arius3d.com/dynamic-frameset.html?museum_channel/index.html
- ⁴⁴ See: <http://www.cordis.lu/ist/ka3/digicult/en/al316.html>
- ⁴⁵ See: http://www.kti.ae.poznan.pl/ongoing_projects.htm
- ⁴⁶ See: <http://www.covax.org/other/other.htm>
See: <http://www.salzburgresearch.at/fbi/digicult/study.html>
See: <http://www.nara.gov/publications/prologue/hill.html>
See: <http://www.aslib.co.uk/jdoc/2000/jan/03.html>
- ⁴⁷ See: <http://www.rlg.org/culturalres/faq.html>
- ⁴⁸ See: <http://www.greatbuildings.com/types/models/models.html>
- ⁴⁹ See: <http://www.sribascad.com/ArchitecuralVisits/ArchitectureVisits.html>
- ⁵⁰ See: <http://www.sribascad.com/MegalithicMonuments/Megalithic2.html>
- ⁵¹ See: <http://www.parisvr.com/pages/musee/jeu-paume.html>
- ⁵² See: <http://www.zeitreisen-euregio.net>
- ⁵³ See: <http://cfml.iit.nrc.ca/3DVirtualBuildings/Intro2.html>
- ⁵⁴ See: <http://cfml.iit.nrc.ca/3DVirtualBuildings/Qtvr/Ottawa/1878/Sparks/45-47.html>

⁵⁵ See: <http://cfml.iit.nrc.ca/3DVirtualBuildings/Qtvr/Ottawa/1878/Sparks/65-75.html>

⁵⁶ Maurizio Forte, *Archeologia, percorsi virtuali nelle civiltà scomparse*, Milan: Arnoldo Mondadori, 1996.

⁵⁷ See, for instance the author's: "Les répercussions des nouveaux médias," *L'avenir des musées*," Paris: Editions de la Réunion des Musées Nationaux, Musée du Louvre, 2001, pp. 383-395 and "La crescita nel settore dei musei virtuali," *Museo Contro Museo. Le strategie, gli strumenti, i risultati*, [Civiltà Annual Report 2001], Florence: Giunti, 2001, pp. 260-296.

⁵⁸ See: <http://vlmp.museophile.com/>

Under Museums in the USA (<http://www.museumca.org/usa/>) it is bemusing to find the claim that:

The United States has the most developed on-line museum information network of any country in the world. In fact, the number of US museum websites may be greater than combined number of [museum websites in the rest of the world!](#)

Closer inspection reveals that there are 1033 in the entire US list

See: <http://www.museumca.org/usa/alpha.html>). Since there are over 3000 museums listed in Italy alone this claim clearly needs revision.

⁵⁹ See: <http://www.unesco.org/whc/nwhc/pages/sites/main.htm>

⁶⁰ See: <http://musa.uffizi.firenze.it/welcomeE.html>

⁶¹ See: <http://www.louvre.fr/louvrea.htm>

⁶² See: <http://www.nationalgallery.org.uk/plan/default.htm>

⁶³ See: <http://www.metmuseum.org/>

⁶⁴ See: <http://musa.uffizi.firenze.it/Dipinti/leoannuncE15.html>

QTVR: <http://musa.uffizi.firenze.it/QTVR/sala15.mov>

⁶⁵ See: <http://www.christusrex.org/www2/art/leonardo.htm>

⁶⁶ See: <http://www.nationalgallery.org.uk/cgi-bin/WebObjects.dll/CollectionPublisher.woa/wa/artistWorks?searchField=&searchString=&workBatchIndex=0&artistBatchIndex=1&artistName=ANGELICO%2C%20Fra&indexLetter=A>

⁶⁷ See: <http://www.nationalgallery.org.uk/plan/microgallery/default.htm>

⁶⁸ See: <http://www.louvre.fr/louvrea.htm>

⁶⁹ See: <http://www.louvre.fr/louvrea.htm>

⁷⁰ See: <http://www.louvre.fr/louvrea.htm>

⁷¹ See: www.france.com/culture/history/gra/mona.jpg

⁷² See: <http://www.culture.fr/culture/conservation/fr/laborato/lrmf.htm>

⁷³ Reuters, "Louvre hopes Web is picture perfect," March 22, 2002, 10:30 AM PT, News.com.

See: <http://sg.entertainment.lycosasia.com/arts/seen/seenc1/5516.html>

⁷⁴ See: <http://galileo.imss.firenze.it/index.html>

⁷⁵ See: <http://galileo.imss.firenze.it/vr/index.html>

⁷⁶ See: <http://www.mhs.ox.ac.uk/epact/catalogue.asp>

⁷⁷ See: <http://galileo.imss.firenze.it/news/mostra/5/e53mpa13.html>

⁷⁸ See: <http://galileo.imss.firenze.it/news/mostra/ecdrom.html>

⁷⁹ See: <http://galileo.imss.firenze.it/news/mostra/5/e54pom1.html>

⁸⁰ See: <http://galileo.imss.firenze.it/news/mostra/6/e66pre0.html>

⁸¹ See: <http://www3.diarioelpais.com/muva/>
⁸²

<http://www.christusrex.org/www2/art/brancacci.htm#La%20guarigione%20dello%20zoppo>

⁸³ See: <http://www.civilization.ca/collect/bay/bh060et3.html>

⁸⁴ See: <http://www.exploratorium.edu/>

⁸⁵ See: <http://www.arts-et-metiers.net/>

⁸⁶ See: <http://www.deutsches-museum.de/mum/index.htm>

⁸⁷ See: <http://www.museoscienza.org/english/>

⁸⁸ See: <http://www.unesco.org/whc/nwhc/pages/sites/main.htm>

⁸⁹ See: <http://www.museoscienza.org/english/museovr/Default.htm>

⁹⁰ See: <http://www.fotomr.uni-marburg.de/>.

In the realm of scientific instruments the EPACT project was mentioned previously.

⁹¹ See: <http://www.eurogallery.org>

⁹² See: http://www.virtualmuseum.ca/English/index_flash.html

⁹³ See: <http://w.webring.com/webring?ring=virtours:list>

⁹⁴ See: <http://www.virtualfreesites.com/tours.html>

⁹⁵ See: <http://www.leary.com/home/Guide.html>

⁹⁶ See: <http://www.egyptvoyager.com/virtualtours.htm>

⁹⁷ See: http://archpropplan.auckland.ac.nz/virtualtour/hadrians_bath/frigidarium.jpg

⁹⁸ See: http://archpropplan.auckland.ac.nz/virtualtour/rameses/figures/oblique_sack.jpg

⁹⁹ See: http://archpropplan.auckland.ac.nz/virtualtour/karntner_bar/karntner_bari.html

¹⁰⁰ See: http://parkscanada.pch.gc.ca/thesite/virtual_e.cfm

¹⁰¹

See:

<http://parkscanada.pch.gc.ca/thesite/Parks.cfm?SiteID=46&Language=EN&MediaShow=QT3Video&MediaID=4399>

¹⁰² See: <http://www2.wgbh.org/mbcweis/lrc/alri/vv.html>

¹⁰³ See: <http://hub1.worlded.org/docs/lowell/home.htm>

¹⁰⁴

See:

<http://www.hcesc.com/liberty/Virtual%20Visit%20to%20the%20Statue%20of%20Liberty.doc>

¹⁰⁵ See: <http://virtuel.cplus.fr/>

¹⁰⁶ See: http://www.arenanet.fi/menus/helsingin_kaupunki.html

¹⁰⁷ See: <http://www.arenanet.fi/maailmat/virtmuse/english/index2.html>

¹⁰⁸

See:

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