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Developments in Virtual Museums

1) Introduction

The term, virtual museum,[1] has two quite distinct meanings: 1) It can mean an electronic version of an existing physical collection. In the interests of clarity we shall call this a digital museum. 2) It can mean an imaginary museum without any necessary physical counterpart. This second meaning has grown partly out of the vision of the French diplomat and author, André Malraux, who introduced the idea of an imaginary museum (*un musée imaginaire*) long before the Internet existed. The practical idea of linking information from various museums in a network was first introduced by the Canadian Heritage Information Network (CHIN) in the 1970s.[2] In Europe, this idea was taken further by the German Bildarchiv Foto Marburg, (which now has 720,000 images on line)[3] and by the French, Network of Art Research Computer Image SystemS in Europe (NARCISSE) project,[4] which includes a number of European institutions. While the online collection at present entails some 100,000 images, NARCISSE has over 20 million images.

At the global level, G7 pilot project five: Multimedia Access to World Cultural Heritage (1995) was intended to place these efforts on a higher plane. Initially (ISAD, Midrand, June 1996), it focussed on new methods to capture, archive, display and navigate. In the absence of concrete funding this had limited success. Nonetheless, it helped to inspire the European Commission's (EC) Memorandum of Understanding (MOU) for Multimedia Access to Europe's Cultural Heritage and subsequently the MEDICI Framework. The initial MOU had 642 signatories. MEDICI had 789 additional signatories.

In the context of the EC, there have also been a number of other steps in the direction of networks[5] including the European Museum Network (EMN); Remote Access to Museum Archives (RAMA); Sharing Cultural Heritage through Multimedia Telematics (AQUARELLE); Museums Over States in Virtual Culture (MOSAIC);

Multimedia European Network of High Quality Image Registration (MENHIR); Virtual Museum International (VISEUM); VAN EYCK and more recently MESMUSES. Within the context of the EC's ACTS, RACE and ESPRIT projects there were parallel efforts in the library and archive world such as Manuscripts and Letters via Integrated Networks in Europe (MALVINE).

A shortcoming of these early projects was that their influence died at the end of the project. It is noteworthy that even the official EC site gives no detailed documentation of the activities let alone the results of these projects. A number of the links are dead. Fortunately this is changing. In order to disseminate more widely both the results of previous work and intentions in the library field, the EC introduced the EXPLOIT project.[6] This has been complemented by CULTIVATE Interactive in the domain of museums and culture.[7]

In addition, there have been attempts at national networks such as the Città Consortium, considered by some to be too strongly driven by commercial interests, and academic networks such as the FORMA consortium led by the Scuola Normale. Discussions concerning national networks are underway at various stages in Austria, the Netherlands, Portugal, Russia, and Spain. Ideally these will be co-ordinated with the emerging vision of a European Research Area (discussed below).

When the initial discussions for the European Museum Network and RAMA began in the early 1990s, it was assumed that European networks would soon be in place. In retrospect, many of these plans were over optimistic. On the surface some failed dramatically. And yet almost imperceptibly the past decade has seen an almost complete transformation in both the meaning and the implications of virtual museums. This essay begins with a review of early experiments. It considers briefly some of the most important international developments, including a trend beyond euro-centrism. Whereas the first museums focussed almost exclusively on producing digital equivalents of physical museums, the last decade has seen a dramatic rise of imaginary museums, which have introduced a number of topics, which would not typically be associated with traditional museums and some of which no physical museum could ever include.

There has also been a recognition that museums are part of a larger reality, now termed memory institutions.[8] Museums typically include objects ranging in size from a lock of hair of an important personage to large objects such as aircraft carriers. The information concerning such objects is typically in libraries and sometimes in archives. Unless we can connect objects in museums with the information about them in libraries and archives we can never appreciate the full implications of the object. Implicit in the idea of linking memory institutions has been a new sense of contextualization, which includes an historical dimension.

Meanwhile, something unexpected has been happening. The frontiers of industry have been transforming the nature of objects. In the past, humans were alive and active, whereas objects were dead and passive. In the past decade, the notion of intelligent objects has begun to transform this relationship. The object is no longer a passive thing: it is now self-aware. This has enormous implications for the museum world ranging from intelligent objects to self-describing landscapes.

2) Early Experiments

One of the earliest experiments in this context was a CD-ROM called The Virtual Museum by Eric Hoffert (then Apple and Banff Centre, 1992), a nephew of Paul Hoffert (Toronto), one of the pioneers in the realm of connected communities. Hoffert's virtual museum "is an interactive, electronic museum where users can move from room to room, and select any exhibit for more detailed examination. The exhibits cover such topics as medicine, plant growth, the environment and astronomy."[9]

By 1994, the British National Gallery (London) had produced a Microgallery, which demonstrated that one could effectively show all the paintings of one's collection in electronic form. This idea has spread to museums such as the US National Gallery (Washington) and the Rijksmuseum (Amsterdam). Recently, six museums are giving common access to their collections via a Eurogallery,[10] namely, the National Gallery (London), the Louvre (Paris), Mauritshuis (The Hague), the Hermitage (St. Petersburg); Kunsthistorisches Museum (Vienna) and the Van Gogh Museum (Amsterdam). There are similar trends in the library world such as the Gateway to European National Libraries (GABRIEL) and The European Library (TEL).

In the early 1990s, there were no clear standards for scanning in images. By 1995 some clear trends emerged. In the United States, the National Gallery (Washington) took a pragmatic approach of scanning in its 105,000 works at 30 MB per painting/drawing. In France, the Louvre decided it was wiser to scan in at 100 MB per image in order that they could subsequently be used for research purposes only. In Italy, this conservation dimension is more important. Hence, the Uffizi scans at 1.4 gigabytes per square meter. By 1999, the Louvre was scanning famous works such as *Mona Lisa* in Japan at 300 MB. The Japanese themselves through projects such as the Kyoto Virtual Archives are scanning photos of temples in at 3 Gigabytes using a method called Vector Format for Zooming (VFZ or Vzoom).[11] This brings to the PC methods similar to the infinite resolution techniques developed by Infobyte for the high end Silicon Graphics machines.

While many online images remain poor quality, there are now isolated examples, which give a glimpse of possibilities. The Christus Rex site of the Catholic Church has a section on Renaissance paintings which shows Leonardo da Vinci's *Annunciation* (Uffizi, Florence) in standard resolution (176k, 1372x600), high resolution (244k, 1757x768) and very high resolution (484k, 2342x1024).[12] Elsewhere on this site, images of the Brancacci Chapel demonstrate how one can move from a wall surface to individual details using regular connections.[13]

According to those at the frontiers of technology we are still only at the beginning in terms of possibilities. John Feldcamp, CEO of Xlibris, claims that "we should have 1,200 DPI LCD screens by 2008, and 3,600 DPI screens "a couple of years later."[14] Meanwhile, in November 2000, IBM announced a new kind of screen which is 12 times sharper than regular screens and 4.5 times clearer than HDTV: "The unit is capable of displaying 200 pixels per inch and more than 9 million pixels on a 22-inch screen."[15]

Argentina	23	Honduras	8
Bolivia	12	Mexico	24
Brazil	51	Nicaragua	3
Chile	17	Panama	4
Columbia	37	Paraguay	4
Costa Rica	10	Peru	15
Cuba	33	Puerto Rico	7
Ecuador	36	Republica Dominicana	12
El Salvador	4	Uruguay	20
Guatemala	11	Venezuala	16

Figure 1. Latin American websites on the ICOM site in January 2001.

While there is much hype about e-content in the media, effectively no one has systematic access to the extraordinary resources, which have already been scanned in. A basic problem was been that the high-speed networks were developed as pipelines in the 1990s without co-ordination with or direct links to the institutes with actual content. This is changing. At the level of science (e.g. high energy physics), there is a new trend towards computational grids[16] whereby all the experts in a given field are connected on a global level. This grid includes virtual laboratories and collaboratories.

This idea is spreading to the arts and culture. At the INET Global Summit (Yokohama, August 2000), there were demonstrations linking Internet 2 in the US with other high speed networks such as the Trans European Networks (TEN) in a number of domains. In September 2000, the Canadian Advanced Network for Research in Industry and Education (CANARIE) appointed an officer for e-content. In Europe, Philippe Busquin has outlined a new vision of a European Research Area.[17] In this context, there is hope that researchers will have access to the new resources via high bandwidth connections and thus be able to begin studying at a practical level the implications of the new media developments.

3) International Developments beyond Euro-centrism

For a number of years Dr. Jonathan Bowen has made a list of museum websites. This has evolved into the W3C's Virtual Library museums pages under the auspices of the International Council of Museums (ICOM).[18] Striking is the enormous growth of this site especially in the last two years. Under Italy alone there are links to over 3000 museums. Germany, Austria and Switzerland have some 8,000 sites.

While the majority of online museums remain in Europe, the web presence beyond the narrow boundaries of Europe is striking. For instance, Dr. Bowen's ICOM site has well over 100 countries including Australia (22 sites), Egypt (61); Japan (56); Korea (39); Latin America (337 see figure 1); Russia (515 in English and 550 in Russian); United States (1034). Some of these sites contain only minimal descriptions. Others have rich and often unexpected content. Bulgaria, for instance, has information on 16 museum towns. While many sites are in English, German, Spanish, Russian, French, Japanese are well represented. According to the Global Internet Statistics (30

December 2000) the percentage of English sites world-wide has dropped to 47.6% and there over 70 languages are represented on the Internet.[19]

UNESCO is playing a significant role in this internationalization of web presence. On the Internet it is mainly visible through four projects:[20] Heritage Projects and Campaigns (CLT); World Heritage Centres (WHC); Memory of the World Programme (MOW)[21] and the Man and the Biosphere Programme (MAB).[22]

UNESCO has a number of important activities including a World Culture Report[23] and a World Commission on Culture and Development and Cultural Policies for Development.[24] It has sections on creativity, copyright, cultural industries, cultural heritage (including preserving and revitalizing non-material heritage and legal protection). It is also active in intercultural dialogue, cultural pluralism, as well as general and regional histories.[25] In October 1999, in conjunction with the World Bank and the government of Italy, UNESCO organized an important conference which brought together 40 ministers of culture and experts from all over the world to address problems of training and education at a global level.

In addition to these main sites UNESCO has regional locations such the Almaty office.[26] They in turn are linked with projects such as Persian manuscripts in Czechoslovakia.[27] These projects are very important in making us aware that the riches of cultural heritage are truly global and not limited to the well publicized European museums.

At the European level, the Council of Europe (Strasbourg) has created a European Heritage Net.[28] This site also offers a portal to other heritage sites.[1] This regional dimension also includes a new awareness of different languages. To the outside world France has always been a country where one speaks French. There are in fact 80 languages spoken in France.[29]

1	Stimulate persons to look more attentively at the originals in physical museums.
2	Include other sensorial effects such as sound, touch, or even smell which would usually be inappropriate in a public physical museum.[30]
3	Orientate visitors to find paintings more quickly.[31]
4	Raise awareness of other works in storage.[32]
5	Contextualize objects.
6	Visualize techniques used (perspective, *chiaroscuro*, *pentimenti*, etc.).
7	Provide virtual restorations and reconstructions of paintings and sites.[33]
8	Bring together objects in a fictive space, which cannot be brought together physically and see works when there when there is no museum. [34]
9	Provide a virtual history of exhibitions.[35]
10	Provide a history of the museum.[36]
11	Show collections in distant sites.[37]
12	Show sites not open to the public.[38]

Figure 2. Twelve Roles of Virtual Museums.

4**) Imaginary Museums and Virtual Exhibitions**

Initially many assumed that the Internet would serve primarily as a new way of drawing attention to physical museum collections and by extension it became a new marketing tool for museum shops. As noted above there are indeed thousands of museums listed on the ICOM site. Interestingly enough this is by no means the whole story. While virtual museums cannot replace the experience of the original objects, they serve at least twelve valuable purposes (figure 2):

There is an increasing interest in the realm of museum exhibitions. For instance, the Rijksmuseum already has a list of their 1250 past exhibitions online.[39] The Internet can also draw attention to upcoming exhibitions and can offer virtual online exhibitions, which would not be physically feasible. This is an area where CHIN, in collaboration with heritage and educational institutions, has been active: "Partner institutions provide the content on a given theme in addition to contributing their knowledge and expertise to the online project. *Virtual Exhibitions* bring fascinating subjects in the sciences and humanities to life by combining text, pictures, video & sounds. These exhibitions can be used as resources for a multitude of subjects, such as history (*Meiji: Tradition in Transition*), art (*Gestures and Words*) and environmental studies (*Endangered Species in Endangered Spaces*)."[40]

CHIN has produced a useful Virtual exhibition production guide.[41] There are now a number authoring tools, such as Toolbook, Macromedia Director, and SuperCard.[42] At a high level Infobyte's Virtual Exhibitor[43] allows one to simulate elaborate spatial settings. Infobyte, which was one of the pioneers in recreating the spaces of churches such as San Francesco (Assisi), St Peter's Basilica (Vatican) in virtual reality, has introduced a novel idea of using these spaces as a starting point for a new interactive game called the Holy Grail:

> The main idea is to connect already built virtual monumental and artistic environments (such as Giotto' frescoes, S.Peter Basilicas, the Nefertari Tomb, etc.), via appropriate passing environments modelled and implemented for this purpose, in order to form a virtual artistic universe made up of all these interconnecting worlds.
> There are two classical roles; the goody and baddy. The former, who holds the Grail, has to find the Temple whilst the latter has to oppose this search. In order to facilitate this search the environment is covered with clues which have to be found and interpreted so that they can lead to the final goal. This virtual environment was installed in the Guggenheim-Soho room for virtual reality. Each game involves the participation of two players and a crowd of spectators in front of them. The two players each wear a head mounted display and have the commands to move freely within the universe. Each player is only be able to see the portion of world in front of him and meets other only if they are both in the same environment at the same time. The spectators are however able to see the entire universe. Each session lasts about 15-20 minutes. Since the universe is open to many interconnectable worlds it gives the possibility, within the hardware limits, to add (or substitute) new worlds in time so that the universe can grow and evolve.44

In their reconstructions of San Francesco (Assisi) and Stanze (Vatican), Infobyte has recreated not only the space wherein the frescoes exist but also the space within the frescoes. This opens up new areas of study for art history. In the context of the game outlined above one can imagine future cultural studies which would include new combinations of a classic text such as Dante's *Commedia* and then walking through the described spaces using reconstructions of famous paintings. This would give the phrases: "Go to hell" and "go to paradise" an entirely new meaning. Similar journeys could be imagined using other classics such as Persian, *Shanahmah* or the Japanese, *Tale of Gengi*.

In the realm of culture the theme of personalization has taken interesting forms. There is a growing commitment to create personal virtual museums. For instance, Professor Isidro Moreno Sanchez (Madrid), notes that in the sixteenth and seventeenth centuries only princes were able to have their own collections in the form of private museums (called *Kunst-* and *Wunderkammer*). Today, this is potentially open to everyone in digital form. One of the most interesting examples of such a personal museum is Carol L. Gerten-Jackson's Fine Art (CGFA).[45] The Metropolitan Museum in New York has a feature, which allows one to create one's own Met Gallery.[46]

Professor Sanchez foresees the creation of virtual spaces in which individuals make their own collections of art. This would begin as extensions of the idea of bookmarks, whereby persons collect their favourite sites. As a next step, this would entail three-dimensional virtual spaces in which persons collected paintings and sculptures from all over the world. While basic versions of these images would be available free of charge, high-definition images could be bought in the manner that one now buys postcards. Such images could then be swapped among friends in the manner that children now trade their hockey cards etc.

This idea is gaining ground in the educational field. The Louvre (Paris) has a special section devoted to education, i.e., Louvre.edu. They have created software, which allows children to tour a virtual digital Louvre, make their own personal subset of this enormous collection and then create their own exhibitions. The Hermitage (St. Petersburg), which has 60 persons working full time in their multimedia education department, is developing various games which children can play using images from their collections. A Spanish project[47] uses paintings from museums for educational purposes. For instance, a still life with flowers becomes a starting point for botany lessons. Details from paintings are used to develop children's sense of what are real and false objects. The National Museum for Science (Madrid) has a CD ROM (*El Peque Museo*), which uses virtual spaces to introduce children to basic concepts of physics such as light and heat.

Such developments can be seen as reflections of a larger trend. When collections were private, paintings typically had no descriptions at all. It was assumed that one knew. Indeed, in the case of visitors, it was often an excellent way to test the knowledge of guests to see if they were really aware of different painters, their students and their schools. In the nineteenth century, with the rise of large public museums, which were primarily storehouses, individual items typically had only a minimal description, which reflected the authoritative statement of the curator. The twentieth century saw an increasing awareness that there were in fact numerous different audiences each requiring their own descriptions.

In the past decade, there were a number of European projects, which attempted to provide multiple descriptions for different audiences. One such project (CAMPIELLO) attempted to combine the formal knowledge of museum experts with the informal knowledge of local residents. In the United States, paintings became associated with the stories connected with them, their narratives, often very anecdotal in form. In some radical cases, such as the Art Gallery of Ontario, (Canada), a pioneering curator, Doug Worts, allowed visitors to provide their own commentaries on paintings. As a result a painting is no longer simply an object with a laconic name-tag: it has a number of descriptions and stories attached to it all of which can potentially be made accessible on demand.

Companies such as Sony foresee using devices such as their Navicam (figure 112b-c) to create personal viewing histories. Hence, I could record my own commentaries on each painting during a visit to a great museum such as the Louvre. On my next visit, the Navicam could remind me of what my thoughts were about the *Mona Lisa* last time and also remind me which other things I might want to see while there. Nokia speaks of personal information bubbles. Philips is concerned with collecting all one's personal experiences in a more systematic form such that the various photos from scrap albums, home movies, etc can all be stored digitally. This is effectively the traditional idea of memory theatres in virtual form, but such that they can be shared with other persons.

Just as not every home-movie is necessarily memorable, these personal memory collections will vary greatly in quality. What is important from our point of view is that they will introduce new kinds of personal documentation, which will be as important for future biographies as correspondence was in the past.

6) New Topics

In addition to bringing together pictures and artifacts not usually found in a single building, these imaginary museums are exploring new topics. The Museum of the Mind[48] is an example. Many of these topics involve objects, which could not be contained in a single building such as the Museum of Unnatural Mystery; the Newfoundland Salt Fisheries[49] or Volcano World,[50] which includes images of 95 current volcanoes which have been active since 1995.[51] Other examples of new topics include: 1) *el teatro Campesino,* a reconstruction of popular theatre in California;[52] 2) Future Lab (Linz);[53] 3) Net-Art Interactive Space for Art and Communication (Rome);[54] 4) Computer Games Museum;[55] 5) Viladonga, which combines the museum and the archaeological site on a single web location[56] and 6) the *Museo de la erotica* (Barcelona)[57] or the National Museum of Arts and Popular traditions which collects records of various processions during feats throughout Italy.[58]

The above list is by no means exhaustive but it points to an interesting insight. The new media are not only presenting our physical museums in new virtual ways. They are also greatly expanding the realm of what we can be and is considered as a museum.

7) Memory Institutions

Historically we have tended to put objects into museums and galleries and to collect the knowledge and information concerning those objects in libraries and archives. Accordingly the European Commission have, in the past five years, devoted increasing attention to the realm of memory institutions as an umbrella concept to link the materials in museums, libraries and archives. There is also a trend to see virtual reference rooms as a search engine relating to the collective memory of mankind.

In retrospect, since the Renaissance, we have used media to separate objects: books into libraries, paintings into art galleries, drawings into drawing collections (French: *cabinets de dessein*), engravings into engraving collections (German: *Kupferstichkabinett*), maps into map rooms etc. We need a re-organisation of knowledge whereby a theme such as the *Last Supper,* which entails most of these individual media will be hyperlinked to all these objects spread out through numerous institutions around the world.

As a result of this insight the whole domain of digital culture is shifting considerably. A decade ago it was assumed that all one needed to do was to scan in one's resources. In the past few years we have begun to realize that this is only the beginning. Marshall McLuhan pointed out that the introduction of print culture changed the way knowledge is organized: printed facts were static and in linear form. By contrast, the new media introduce the possibility of dynamic, augmented knowledge and culture. In this context virtual museums are emerging as one aspect of a complete reorganization of knowledge which will transform our education and almost every aspect of our lives.

8) Historical Contextualization

In the past, a museum was a static building which showed objects as we now know them. The new media introduce a new historical contextualization of knowledge. Here, one of the most striking examples, is the *Nuovo Museo Elettronico* (NUME) project at the University of Bologna (and CINECA).[59] This project studies the core of the city of Bologna in virtual reality over a millennium from the year 1000 to the present. It allows us to study what happens to a given building in the course of centuries or to trace how an altar, originally in a street, was subsequently dismantled and its various parts disbanded to the local cathedral (San Petronio) and a distant museum (i.e. Cleveland).

NUME potentially introduces a whole new way of looking at the built environment. Today I enter a church and see it in its present state. In the case of San Clemente, the church was once a Mithraic Temple, upon which was built then a Romanesque church, over which a Renaissance church was built. NUME points the way to intelligent buildings, which can offer us virtual reality reconstructions of how they looked in different phases of their existence. Infobytes treatment of two phases of Saint Peter's Basilica was an early attempt in this direction.

Projects analogous to NUME are underway with respect to Pompeii and the city of Rome (especially the Roman Forum). Unlike earlier reconstructions these are so elaborate that they are being used to simulate scenarios of everyday life, history and

economics. In the 19th century historians such as Ranke believed that they could reconstruct the past as it actually was (*wie es eigentlich gewesen*). The 20th century drew attention to the complexities entailed in being able to reconstruct objectively the past; emphasized the "re-" in reconstruct and urged that one avoid trying to imagine what might have been. Ironically as the new media provide us tools to reconstruct the past with ever greater realism, there is a new fascination with the potentials of simulation to "play through" a number of hypotheses.

A half century ago when the internet began there was great excitement about hypertextual links. This led to hypermedial links and is leading to concepts such as hypercontextualization. What may be emerging is a new world in which every object, every (primary) source (*Quelle* and *fontes* as 19th century scholars thought of them) will have linked with them not only their (secondary) literature, but also a collection of visual reconstructions, which show how different times and different cultures have interpreted and reconstructed very differently the same basic object.

9) **From Intelligent Objects to Self-Describing Landscapes**

In the realm of manufacturing and industry there has been an important new approach to objects. In architecture, for instance, there is a trend towards Industry Foundation Classes, whereby all the salient characteristics of individual elements such as doors or windows are recorded in international databases. One now speaks of intelligent doors which "know" what characteristics they would need if they were being used in a cottage or a skyscraper. Some are now working on self-maintaining objects, self-healing objects etc.

These trends in industry open many new horizons in the realm of museums, memory institutions and culture in general. At a most obvious level the concept of intelligent doors could be extended to include cultural and historical dimensions, such that we learn not only the universal characteristics of a safe door, but also the particular characteristics that make Florentine doors different from others, and Renaissance Florentine doors different again.

Other applications invite themselves. Memory institutions typically display three-dimensional objects such as vases and books. These are usually in display cases, often against a wall. In the case of a vase, this means one can usually see one side and not the other and certainly not the base. If this vase were photographed from all sides with a camera, a museum visitor could look at the original then put on glasses and see the rest of the object. Or one might carry a small portable screen for this purpose. The virtual object thus complements the physical object rather than competing with it.

This complementary function of the virtual can be extended. The glasses can show the original context of museum objects, which typically come from churches, palaces, monuments, archaeological sites etc. Standing in front of a museum display it is almost impossible to appreciate this original context. Virtual museums[60] can provide a history of where the object was situated: i.e. a three- dimensional versions of the Getty Provenance Index. As a result we can see where the painting hangs today along with all the places it hung previously in other galleries including where it was initially commissioned. We can also see a given painting in the context of others by that artist

and/or their contemporaries. As a result a given painting evokes a much richer set of connotations.

The glasses or portable screens can also provide a history of restorations. In the case of a painting, the same approach can allow viewers to look beneath the surface of the painting using infrared refrectography, x-rays and other methods. For conservators, the glasses can provide detailed views at a microscopic level. Electronic media thus allow viewers to see things invisible to the naked eye.[61]

In the case of rare books on display, the book is inevitably open on a given page. The book would soon be ruined if visitors continually flipped through the real pages. However, viewers can do this flipping of pages virtually on a nearby screen. The British Library has demonstrated this principle using Leonardo da Vinci's *Codex Arundel*. Alternatively, visitors could do this directly with the original using glasses. In so doing, visitors see more and the book does not suffer.

In present day museums, objects typically have a small explanatory caption. Sometimes there is no caption at all. Sometimes the caption is in a language we do not understand. Frequently the caption is too superficial or it goes into more detail than we need. In future, glasses can provide customized captions, simple for children, more advanced for adults, and much greater detail for experts. The same object remains visible, but the electronic tools surrounding it help reveal more about the object and its context. Projects such as HIPS and COMRIS point in this direction.[62] The intellectual consequences of new media are contextualization.

Intelligent museum objects can reveal aspects of themselves not readily visible from their position in a display. A scenario: A personal digital assistant (PDA) is linked through the Internet with a much larger array of materials in a virtual reference room. I am standing in front of a copy of Brueghel's *Winter Landscape* in the Bonnefanten Museum (Maastricht). My notepad computer is equipped with a camera, that recognizes the painting via pattern recognition, the title, or simply via the equivalent of a bar code. This information is taken up by a (low-level) agent, which notes that this is a copy of a more famous original now in the Kunsthistorisches Museum (Vienna). The software agent then offers me a possibility of seeing various other copies and versions of the same painting.

Implicit in this approach of intelligent museum objects is the notion that every cultural object or set of objects,[63] receives its unique identifier, which goes further than a traditional ISBN number in the book world, to identify a single object. This number with its links to descriptors can serve as the equivalent of a passport for cultural objects, which can be used in the case of stolen objects or illicit tracking in cultural policy.[64]

Through the notion of intelligent museum objects, one has much more than a new way of tracking the object itself. It offers a means of tracing its relatives (copies, versions, variants). It introduces a method for linking objects with the literature about them, with their analyses, descriptions and their stories. Botticelli's illustration of Dante's Inferno, thus becomes linked, augmented, with histories of hell and Hades. The statues in a Japanese temple become augmented with histories of Buddhist saints, Indian commentaries and potentially Vedic texts. Culture becomes augmented.

This idea of augmented culture becomes all the more essential when I look at works outside of my own heritage. In a global village we are all neighbours but we are also constantly ignorant of dimensions of our neighbours' many cultures. So the new technologies can help acquaint me with the many stories beyond those with which I grew up as a child.

Ultimately, augmented culture will go far beyond contextualizing intelligent objects through their various visible and invisible layers. Objects are in buildings, which are in towns, which in turn have their place in landscapes. In 1968, Charles and Ray Eames explored some potentials in a short film called *Powers of Ten*,[65] a theme which recurred recently in the IMAX film, *Cosmic Voyage* (1997). In 1994, the Berlin company, Art+Com demonstrated how one could zoom in from satellite photographs of Germany to the interiors of buildings in Berlin in a project called T-Vision.[66]

In the past two years the Complutensian University (Madrid) has made a reconstruct-tion in virtual reality of the whole of North eastern Spain based on satellite images. This geographical fly-through is connected with reconstructions of historical cities such as Santiago da Compostella such that one can go from an aerial view, zoom in, walk through the streets and then, enter individual churches and buildings. This project points the way to a new comprehensive treatment of landscapes, which is complementary to the important historical treatments in the NUME project. If these were combined in turn with the trend towards virtual museums and intelligent museum objects we would have a completely new ways of looking at both the past and the present.

Self -describing virtual landscapes would have information connected with each virtual object and potentially at a number of scales. At the level of aerial views the landscape would describe its geographical, physical and historical characteristics. At the scale of individual buildings in the landscape, each building have its own stories. One could connect this with avatars serving as virtual guides, such that one could have a tour of Florence from an English viewpoint (a la Room with a View mentality); a German viewpoint (a la Baedecker) or an Italian viewpoint (a la Touring Club Italiana).

One of the paradoxes of the Internet is that the creation of a digital version of the physical world is leading simultaneously to an interpenetration of virtual and real. Web cams make available records of the physical world in virtual space. Digital copies are increasingly available in physical space. It is quite thinkable, therefore, that the advent of self-describing digital landscapes will spread to the real landscape. In the world of manufacturing it is already the case that objects are become intelligent, self-maintaining, self-healing, self-repairing. In the past we had plaques whereby buildings "told us" about who lived there, who died there, what important things occurred there. If we have truly ubiquitous computing and every object has its inbuilt, embedded chips then every building, potentially every object in a landscape will one day be self-describing: i.e. will provide visitors with an online, wireless version of Baedecker and Michelin. Preparing these more comprehensive guides, making them available will become new industries.

10) **Conclusions**

While the earliest experiments with electronic media in the museum world go back nearly three decades, it is only in the last decade that computers linked via the Internet have become a serious topic. Initially, there was a general assumption that if one had the right scanner one's problems would soon be solved. The past decade has seen dramatic amounts of scanning such that a number of the greatest collections are now in digital form. To be sure this is still but a small fraction compared to the vastness of our historical collections. Nonetheless, e-cultural content is now becoming a reality. And after a decade of early experiments with techniques such as digital watermarks, there is a trend towards convergence in the treatment of intellectual property rights using a whole range of media.

In retrospect, most of this seems obvious. At the same time, as we have noted, there have been at least eight surprising and important developments:

1) A decade ago many assumed that the technological limits of image resolution and transmission rates were rapidly being reached. The past five years have proved that we were wrong. The bad news is that we may some day have to redo all our scanning. The good news is that we shall one day have a level of quality of images which most persons think impossible.

2) The realm of virtual museums and digital culture has expanded very dramatically beyond an initial English language experience, to a decidedly multilingual phenomenon, with an accompanying shift from a euro-centric approach to a truly international one.

3) An initial interest in virtual digital museums as electronic versions of existing physical spaces has expanded greatly to include virtual exhibitions and imaginary museums often entailing spaces, which could not exist physically or could not be integrated in a single physical location.

4) This expansion of virtual space beyond the narrow walls of physical museums has expanded the role of the virtual not only into archaeological spaces, but into a number of topics hitherto not within the bounds of museums.

5) The museum as a storehouse of memorable objects has become seen as part of a larger complex called memory institutions. Hereby, there is new hope of integrating the primary sources (objects in museums) with their secondary sources (literature about them in libraries and archives).

6) The new media are shifting our attention away from scanning static objects, to an interest in capturing, displaying and understanding dynamic knowledge about objects. In the process, multiple reconstructions, historical versions which show changes over time, which reveal differences due to cultural differences are becoming central to scholarly activity. A fashion for verbal de-constructionism of the last decades is shifting towards a more serious concern with visual re-constructionism.

7) A decade ago objects were passive entities waiting to be scanned. Now they are increasingly becoming active, "intelligent" objects, which are self-describing and potentially can tell their own stories from different viewpoints.

8) All this has transformed what we needs to be studied. A decade ago we thought the answer was simple. It was limited to those isolated objects, which we had neatly packaged into their display cases or hidden on shelves in the basement, the storage rooms and repositories. Now we realize that the problem is much bigger. The objects were and are parts of environments, which are constantly changing. The new media offer us new means of capturing the changing dimensions of knowledge. They open new ways of understanding the world in which we live and the worlds we have made therein. But in these very possibilities they open up many new challenges. For the world of virtual museums points to new ways for dealing with past, present and future worlds of knowledge.

Acknowledgements

Notes

[1] This essay surveys developments in the treatment of virtual museums over the past decade. These developments are partly a reflection of changes in the treatment of physical museums, a topic beyond the scope of this paper but of which we must remain mindful. Interested readers are referred to two recent conferences 1) at the *Louvre on L'avenir des musées* (March 2000) and 2) sponsored by ICOM (Germany, Austria, Switzerland), *Der Standort des Museums an der Schwelle zum 21. Jahrhundert*, (Lindau, May 2000). These conferences also contain two other surveys on recent Internet developments in museums by the present author. Cf. also Harold Kraemer, Hartmut John, *Zum Bedeutungswandel der Kunstmuseen*, Nürnberg: Verlag für moderne Kunst, 1998. For an early definition of virtual museum by Jamie McKenzie (1994) see: http://www.bham.wednet.edu/muse.htm. For a discussion of the changing role of docents in museums see: W. Boyd Rayward, Michael B. Twidale, "From Docent to Cyberdocent: Education and Guidance in the Virtual Museum," *Archives and Museum Informatics*, vol. 13, 1999, pp. 23-53.
    See: http://alexia.lis.uiuc.edu/~wrayward/CyberdocentPaper.htm.
[2] See: http://www.chin.gc.ca/
[3] See: http://www.fotomr.uni-marburg.de/
[4] See: http://www.culture.fr/documentation/lrmf/pres.htm
[5] See: http://158.169.50.95:10080/digicult/en/activity.html#project.
[6] See: http://www.exploit-lib.org/
[7] See: http://www.cultivate-int.org/
[8] The term memory institutions has become popular within the EU's 5th Framework programme.
    See: http://www.litc.sbu.ac.uk/candleathens/accessmemory.html
[9] Cited from the cover of the CD-ROM.

[10] See: www.eurogallery.org

[11] 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.

[12] See: http://www.christusrex.org/www2/art/leonardo.htm

[13] See: http://www.christusrex.org/www2/art/brancacci.htm#La%20guarigione%20dello%20zoppo

[14] Cited by Jeffrey Harrow in the RfoC.
See: http://www5.compaq.com/rcfoc/20001030.html.

[15] See: http://www.infoworld.com/articles/hn/xml/00/11/10/001110hndisplay.xml

[16] Ian Foster, Carl Kesselman, eds., *The Grid: Blueprint for a New Computing Infrastructure,* San Francisco: Morgan Kaufmann Publishers, 1999.

[17] See: http://europa.eu.int/comm/research/area.html

[18] See: http://www.icom.org/vlmp/

[19] See: http://www.glreach.com/globstats/index.php3

[20] See: http://www.unesco.org/whc/nwhc/pages/home/pages/homepage.htm

[21] See: http://thoth.bl.uk/ddc/index.html

[22] See: http://www.inpaku.unesco.org/

[23] See: http://193.242.192.2/culture/ww/html_eng/wcr.htm

[24] See: http://193.242.192.2/culture/development/wccd/html_eng/index_en.htm

[25] See: http://193.242.192.2/culture/publications/html_eng/history.htm

[26] See: http://www.unesco.iatp.kz.

[27] See: http://digit.nkp.cz/persica.html

[28] See: http://www.european-heritage.net/en/index.html.

[29] Philippe Guedi, Marc Bounjnah, "Régions: Les langues se delient," *France TGV*, Neuilly sur Seine, pp. 24-30.

[30] An interesting example is the *el teatro Campesino*.
See: http://www.elteatrocampesino.com/campesin/campesin.html
While traditional museums such as the Gemäldegalerie in Berlin frequently now sometimes have a digital gallery, there are numerous cases where the new virtual museums entail unexpected contents not associated with traditional museums. For instance, there is:
1) Future Lab (Linz)
See: http://kultur.aec.at/lab/.
2) Net-Art Interactive Space for Art and Communication (Rome)
See: www.netart.it
3) Computer Games Museum
See: http://www.computerspielemuseum.de/indexf.html
4).Viladonga, which combines the museum and the archaeological site on a single web location.
See: www.aaviladonga.es.
5) Museo de la erotica (Barcelona)
See: http://www.eroticamuseum.com

[31] Initial examples of this approach such as the Micro-Gallery in London focussed on orienting users qua the public rooms.

[32] Classing these by themes and showing how there are shifts in what is shown and stored provides new insights into the history of taste.

[33] One can, for instance, do retrospective virtual colour restoration. Cf. Toshiro Kamiuchi, Nagaharu Hamada, Nobuo Ikeshoji, "Digital Image System and its Applications," *Hitachi Review*, vol. 46, no.5., 1997, pp. 215-219.

[34] This is the French concept of an imaginary museum (*le musée imaginaire*).

See: http://www.culture.gouv.fr/culture/exp/exp.htm.
 An example would be a collection of all the paintings of Leonardo's *Last Supper* would, for example, never be allowed to go on a travelling exhibition. Nor is it likely that the Louvre would ever consider lending all its Leonardos at once. Or one could have an imaginary museum of impressionism, which shows all the famous extant examples ranging from the Jeu de Pommes in Paris, the Metropolitan in New York, the Barnes Collection in Philadelphia and the Pushkin Museum in Moscow. An excellent example is the Museo Virtual de Artes El Pais (MUVA).
    See: http://www3.diarioelpais.com/muva/.

[35] This can both help to recall historic, blockbuster exhibitions and to imagine others which we we missed. Many of us know the experience only too well. There is an exhibition by Rembrandt, Monet, Van Gogh or Picasso in a city such as Paris or Washington and we miss it because we just cannot get away during the few weeks that the exhibition is in town. Or even worse, we get there only to find that the exhibition is sold out for the few days that we are there. Sometimes we manage to get a ticket and find that we have fifteen minutes to see a set of paintings because visitors are being hoarded through as if they were cattle. Alternatively, we get in and find that the hoards are so great that we effectively cannot see the painting at all. This even occurs with paintings, which are on permanent display such as the *Mona Lisa*. This same principle can be extended forwards, such that we can also see where paintings will travel for special exhibitions in the near future, which is particularly relevant for tourism.

[36] As the capacities of high level virtual reality one could have a history of a museum such as the Louvre which shows a) how the complex of buildings grow in the course of the centuries, b) how the paintings of the collection were configured differently over the centuries; c) how these changes in a painting and in their frames reflect shifts in the history of taste and d) in certain cases even show reconstructions of how paintings have changed in colour over the ages. Very interesting attempts at such retrospective colour conversion have, for instance, been carried out by Hitachi with respect to the famous engravings of Hokusai, such that one can effectively see how the engraving fades with time.

[37] Even those of us who are very familiar with European museums often do not have occasion to see the great collections and monuments of Russia, India, China and Japan. In fact, almost no one is able to see all the great museums.

[38] In the case of endangered sites, such as the Caves of Lascaux or the Tomb of Nefertari, such virtual reality reconstructions are a substitute for viewing the original, in the interests of long term conservation.

[39] See: http://www.rijksmuseum.nl/asp/framuk.asp?name=collectie

[40] See: http://www.chin.gc.ca/About_Chin/e_faq.html#ve1

[41] See: http://www.chin.gc.ca/Exhibitions/Virtual_Guide/indexa.html

[42] See: http://vads.ahds.ac.uk/guides/creating_guide/sect85.html

[43] See: http://www.infobyte.it/catalogo/index.html

[44] See: http://www.infobyte.it/catalogo/indexuk.html

[45] See: http://www.hol.gr/cjackson/index.html

[46] See: http://www.metmuseum.org/home.asp. At present this personal gallery is potentially limited to 50 paintings and the choice is from among 3,500 online images from a collection of 2 million pieces.

[47] See: www.educared.net

[48] See: http://users.pandora.be/drhugo/

[49] See: http://collections.ic.gc.ca/fisheries/main.asp?frame=on
[50] See: http://volcano.und.nodak.edu/vw.html
[51] See: http://volcano.und.nodak.edu/vwdocs/current_volcs/current.html
[52] See: http://www.elteatrocampesino.com/campesin/campesin.html
[53] See: http://kultur.aec.at/lab/.
[54] See: www.netart.it
[55] See: http://www.computerspielemuseum.de/indexf.html
[56] See: www.aaviladonga.es.
[57] See: http://www.eroticamuseum.com
[58] See: http://www.popolari.arti.beniculturali.it/
[59] See: http://www.comune.bologna.it/bologna/nume/numeindex.htm
[60] The International Committee on Museums (ICOM) has a Virtual Library and
Museums Pages (VLMP). It also includes other indexes or portals. For instance, in
Italy it links with museumland.com, Museionline, and Yahoo! Italia.
    See: http://vlmp.museophile.com/.
One country not sufficently reflected in this list is France. For russia, the ICOM site
mentions 515 museums.
    See: http://www.icom.org/vlmp/russia.html.
This does not list two concurrent attempts at a national list:
Russian Culture Net
    See: www.russianculture.ru
Russian Cultural Heritage Network
    See: www.rchn.org.ru
Important individual museum include:
Moscow
   See: http://www.tretyakov.ru
Leningrad
   See: www.oblmuseums.spb.ru
        www.kunstkamera.ru
        http://www.tzar.ru state museum tzarskoje Selo
At the regional level, the museums in the Novgorod region have linked 1000 cities as
objects of tourism itineraries with an interactive tour which allows one to evaluate the
itinerary
 See: www.museum.nnov.ru/tourism.
For some examples of virtual museum sites, See:
www.fri-art.ch
www.kunsthausglarus.ch
www.migrosmuseum.ch
www.kunsthaus.ch
www.kah-bonn.de
http://cyberatlas.guggenheim.org
www.nationalgallery.org.uk
www.cnac-gp.fr (Centre Pompidou)
www.sgg.ch (centre pour l'image contemporaine)
www.getty.edu/museum/
www.hermitagemuseum.org
www.echonyc.com/~whitney/
www.boijmans.rotterdam.nl
www.louvre.fr

www.ntticc.or.jp (ICCTokio)
www.walkerart.org
www.diacenter.org
www.v2.nl
www.ljudmila.org/scca/parasite
Cf. Barbara Basting, "Von der Kunst zum Cybershopping," *Tages Anzeiger* , 30 Mai 2000, p. 65.

[61] For a further discussion of such possibilities see the author's "Frontiers in Electronic Media", *Interactions Journal of the ACM*, New York, July-August 1997, pp.32-64.

[62] Notepad computers and Personal Intelligent Assistants (PIAs) described earlier offer many new possibilities. Some of these are being explored in the context of the Intelligent Information Interfaces (I3, Icubed) programme of the EC.
    See: http://www.i3net.org/i3projects/
For instance, the Hyper Interaction within Physical Space (HIPS).
    See: http://zeus.gmd.de/projects/hips.htm
This is being tested in the Museo Civico of Siena, allows visitors to listen to information using earphones and make notes on a Personal Digital Assistant (PDA). In this case the information used is limited to that contained within the PDA.

[63] For instance, there is debate among conservators whether a cup and saucer should be catalogued as one object with two parts or rather as two separate objects. In the case of collections of shells or fossils this problem becomes more acute.

[64] See: http://culture.coe.fr/pat/eng/epat4a.html

[65] Charles and Ray Eames, *Powers of Ten*, Film, 1968. Cf. Philip Morrison, Phyllis Morrison, *Powers of Ten. About the Relative Size of Things in the Universe*, New York: Scientific American Library, 1982.

[66] Subsequently SRI (Menlo Park) created a variant project called Terravision in a military content.