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A Grid for Culture

Introduction

A series of technological developments are transforming new media and the Internet. Telecommunications, Broadcast and Internet, are predicted to converge into a single network within the next decade.[1] Developments in miniaturization in the direction of nanotechnology mean that electronic devices, which once consumed much space will "disappear" from sight and become part of ambient intelligence.[2] As a result walls, windows and other surfaces can function as computer screens and interaction devices. A report from the BBC News (12 January 2000) indicated that: "1 gramme of dried DNA can hold as much information as 1 trillion CDs." Once this becomes a reality then we can almost literally have the whole world in our hands as far as replicas of culture go. Even if this long-term future vision holds a promise that we can carry all the knowledge we need with us, the need to share via networks and to update that knowledge and information is destined to become of central importance in the next decades.

We are told that the Internet is growing at a rate of 7 million pages per day, that the surface web is 2.1 billion pages[3] and that the deep web, including pages generated on demand, "on the fly," amounts to 550 billion pages.[4] The number of users has risen from 5 million in 1995, to 200 million in 2000, 650 million in April 2003 and is predicted to reach 940 million in 2004.[5] The press may continue to speak of a dot.bust since 2000. The reality is that the first four years of the millennium are bringing seven times as many users as the first hundred years of the telephone.

Parallel with this there has been a dramatic increase in collaborative technologies. For instance, the Search for Extraterrestrial Intelligence (SETI) project makes use of volunteers' computers while their screen savers are on: i.e. using their idle capacity. From 30 July 2000 to 30 April 2003 volunteers increased from 2,192,077 to 4,454, 985. Their combined capacity grew from 11.17 to 32.60 trillion instructions (or teraflops) per second.[6] In layman's terms, SETI's volunteers now have 50% of the combined computational power of all the 500 top computers in the world in 2000.[7]

In 1995, the Internet was 98% English. In the past year, English has fallen from 40 to 35.2%. Chinese, Japanese, Korean and Russian now account for 29.1% and it is predicted that by 2007 Chinese will be the number one language of the Internet. The major European languages (Spanish, German, French, Italian, Portuguese and Dutch) now account for 26.6 % of an Internet where over 70 of the world's 6,500 languages are represented.

Changing Needs

Parallel with these developments has been an explosion in means to capture images of the world around us. These range from UMTS and I-Mode phones and web cams to digital cameras. At the high end, there have been a number of new scanners. IBM produced the

Brandywine scanner used for Andrew Wyath, the Archivio de los Indos, the Vatican Library, the Hermitage, Edo Museum and others. The National Research Council of Canada produced a laser scanner now licensed by Arius 3-D. The Thomson flat scanner, developed in 1990, led to 140,000 images being digitized at the Centre de Recherche et Restauration des Musées de France at 6,000 dots x 8,000 lines. High-level three-dimensional objects now have 24 images per rotation. These new scanners and cameras also allow us to see hitherto invisible scripts and other features through x-rays, ultraviolet,[8] multi-spectral[9] and infrared reflectography.[10]

Partly as a result of this new equipment, the past fifteen years have seen a transformation in the perceived needs of users. In 1990, individual pages of books or images of paintings were typically scanned in 1 to 10 MB. By 1995, high-level users were scanning individual pages and images at 100MB. The latest scan of the Gutenberg Bible by the Library of Congress entails 767 MB per page,[11] which leads to half a terabyte for a single book. In the CRISATEL Project, paintings are being scanned at 30 gigabytes per image.[12] Reconstructions of monuments, churches and buildings, which were 5-20 MB in 1990 are now in the 20-1000 MB range and there are thousands of them. Reconstructions of sites and cities, which were in the 10-50 MB range in 1990, are now in the 2-6 terabyte range.

The potential uses of these images, which now amount to petabytes of information are enormous and include restoration, reconstruction, contextualization of themes, contextualization of space and time, alternative interpretations and world-views as well as creativity. It is suggested that these developments introduce the need for a cultural grid, which has major implications for e-learning, tourism and new forms of e-work and e-creativity.

Conservation and Restoration

In 1987,[13] the Getty Trust created a Conservation Information Network working with the Canadian Conservation Institute (CCI), the Canadian Heritage Information Network (CHIN), the Conservation Analytical Laboratory of the Smithsonian Institution (CAL), the International Centre for the Study of the Preservation and the Restoration of Cultural Property (ICCROM), the International Council of Museums (ICOM), the International Council on Monuments and Sites (ICOMOS), and The Getty Conservation Institute. This led to Bibliography of the Conservation Information Network (BCIN), which is now hosted by CHIN.[14]

In Europe, Japan, and elsewhere there is increasing interest in networked conservation and restoration centres, whereby museums and research institutes can share their experiences online. For instance, in the Netherlands, the MOLART project has brought together frontiers of science and art:

> The object of MOLART is to contribute to the development of a scientific framework for the conservation of painted art on the molecular level. The focus of MOLART is the determination of the present chemical and physical condition of works of art produced in the period from the 15th to the 20th century. Studies of

> historical paint manufacturing and workshop practice must give insight into the nature of the painter's media and the painting technique used originally. Fundamental studies are undertaken to understand the molecular aspects of ageing….Quantification of the changes in chemical structure across the varnish, paint layers, grounds and support is therefore an important objective within MOLART…. Studies of primary and secondary archival sources on restoration technique and museum archives are guiding the investigations of the long-term effects of certain restoration methods on the present condition of paintings.[15]

Related to this has been the development of a Virtual Laboratory,[16] which can be used in a grid context. A next logical step would be direct connections between such scientific laboratories, museums, conservation networks and research institutes in universities. Among the recent Expressions of Interest was the development of a specialized International Network of Curators of Contemporary Art (INCCA) with respect to preservation of contemporary art.[17]

Related also to these trends towards networked conservation and restoration are plans for a Digital Centre for Memory of Culture (DCMC), which would effectively take the notion of backups to the level of national collections. In some circles this is seen as complementary to an update of the traditional (analog) notion of legal (copyright) depots through national digital depositories. Also related are discussions of a distributed European Digital Documentation Centre (EDDC). In short, the worlds of conservation, preservation, access and e-learning are increasingly becoming intertwined.

Museumland.com has over 10,000 museum sites[18]. The official International Council of Museums (ICOM) virtual library museums page has many thousands more.[19] The number of online libraries is much greater. Libweb alone lists 6,600 pages from libraries in 115 countries.[20] The Ohio Computer Library Centre (OCLC) links 43,559 libraries in 86 countries and territories and has over 49 million cataloging records.[21] The Research Library Group (RLG) has access to well over 100 million records.[22] If such institutions were to begin scanning systematically their collections at the level of 747 MB per page the resulting size of digital depositories would be astronomical.

Reconstruction

In many cases the monuments and objects which we would like to conserve are literally ruins and we need to reconstruct them in order to understand their original appearance and how they might have functioned. To share such reconstructions is another enormous incentive for networks with a grid architecture. There are literally thousands of reconstructions of monuments, churches and even ordinary buildings. Sometimes, as in the case of a sixteenth century farm house near Saint Sebastian (Igartubeiti Ezkio-Itsaso),[23] a modern reconstruction in virtual reality is used to explain details to prepare visitors for a site which maintains its original atmosphere completely intact without electricity or modern signs. Sometimes a reconstruction can include theories about different phases in the construction of a building complex such as the Abbey at Cluny.[24] An excellent book by Maurizio Forte provides an early survey of this field.[25] His recent

work on a reconstruction of Giotto's Cappella degli Scrovegni in Padua offers insights into evolving possibilities with interactive sites.[26]

Projects such as the Nuovo MUseo Elettronico (NUME, Francesca Bocchi),[27] which reconstruct the city core of Bologna from the year 1000 to the present, offer a glimpse of future possibilities, whereby one follows the reconstruction over time and can effectively follow changes in a given building over the decades and centuries, how, for instance, a Romanesque church acquires Gothic, then Renaissance and Baroque features.

Sometimes the reconstruction may represent a space with no equivalent in the physical world. For instance, the Museo Virtual de Artes El Pais (MUVA)[28] shows a wonderful series of rooms with the art of painters whose works are not politically acceptable in their country. In such a case, a virtual museum in the sense of an imaginary museum –in keeping with the vision of André Malraux-- serves to unite images of objects, which are dispersed in the physical world. MUVA is already available online using the regular Internet. With a cultural grid one could show these objects in a high-resolution format.

Contextualisation of Themes

The incentives for sharing digital information from museums, libraries and archives are many. In the nineteenth and twentieth centuries paintings were often broken up into pieces. One part of an altar would remain in one museum while other parts ended up in other museums, not infrequently on a different continent. For instance, Carpaccio's *Two Venetian Ladies* (Museo Correr, Venice) and *Hunting on the Lagoon* (Getty Museum, Los Angeles) were once a single painting.
In the past painters often created multiple versions of a subject. For instance, Paulo Uccello created three versions of *The Battle of San Romano* now in the Uffizi, Louvre and National Gallery (London) respectively. In exceptional cases, such as Brueghel there were as many as 128 versions of a single painting. If these images were all online then a visitor in a museum could readily consult parts, copies, versions, which have been dispersed elsewhere.

The Hyper Interaction within Physical Space (HIPS)[29] project explored the potentials of hand held PDAs for acquiring such information, starting form the assumption that the portable device would have its own memory or be linked to a local hard-drive. In our vision such PDAs would be linked to the equivalent of virtual reference rooms that would provide a far more detailed knowledge. Other visions would link such devices with Virtual Heritage Centres (VHCs, Maurizio Forte) and Cybernariums (Rolf Kruse).[30]

Systematic access to the images of artists would allow one to trace the development of an artist. In the case of Claude Monet, for example, one could follow how after he moved to Giverny, the garden surrounding his home became the chief theme of his paintings and how, after 1901, when he built a Japanese bridge in his garden, this became a leitmotif for his oeuvre of the next decades. Such comparisons would reveal much more than a tendency towards repetition of a theme. They would allow us to trace how an artist who began as a serious student of naturalism moved gradually towards a near abstract version

of impressionism. In other words, the roots of the modern lie in an evolution from, rather than a rejection of, the natural. Such a comparative study would also reveal a complex interplay between Japanese and Western art, which is also reflected by the reappearance of Hokusai's *The Great Wave* on the title page of Debussy's *La Mer*.

Such contextualisation allows not just access to images of paintings but also, potentially to their depicted spaces. For instance, in the case of Infobyte's reconstruction of the *Incendio nel Borgo,* one can walk through the spaces of the suburb of the Vatican depicting an event of the year 847.[31]

Such contextualization also entails new links between visual expressions and their literary sources, such as the *Bible*, the *Tale of Gengi* or other classics. As will be discussed further below, the written beliefs, myths, epics and literature are one of the main sources of cultural expressions and creativity in the form of paintings, frescoes, sculptures and other media.

Contextualisation of Space and Time

Traditionally treatments of objects, buildings, sites, cities, landscapes and geographical areas all had their own software and interoperability was impossible. Already in 1994 Art+Com's TerraVision (T-Vision) project[32] demonstrated a vision whereby one could move from a satellite image of the earth, zoom down to a city, enter into a reconstruction of a physical building and then focus on an object in that building. This idea was subsequently taken up under the same name by SRI international with major funding from the military resulting in the Digital Earth project.[33]

The past decade has seen enormous strides with respect to systems such as MapQuest, which link maps around the world, to navigation systems for automobiles and yet a systematic integration of geo-spatial information, whereby we can move seamlessly from satellite images to real images on the street is still the subject of spy and thriller films rather than everyday reality.

With respect to the historical centre of Bologna, the NUME[34] project, mentioned above, has demonstrated how one can link a given object with a monument or building, trace its context in the city and link this with historical maps and photographs: how objects which were once a part of an monument in the middle of a street may now have moved to a nearby church or a museum in the United States. If applied systematically such an approach would open enormous possibilities with respect to our abilities to access information.

When computers were first used in the cultural field they were typically applied to a single painting, a piece of sculpture or a page from a manuscript. A next step was to recreate both real and virtual museums to house such objects. Inherent in projects such as NUME is a trend to transform the notion of a museum from a physical building to include much larger areas. In Bulgaria, for instance, there is a concept of museum towns, where the whole town is treated as a museum.[35]

The SANTI (Sistema Avanzado de Navegación sobre Terrenos Interactivo)[36] project takes this concept further to link reconstructions of monuments and buildings in a town with satellite images of a whole territory, in this case Northern Spain, such that one can potentially trace the pilgrimage routes leading to Saint James of Compostella. Elsewhere there is increasing concern with reconstructing cultural sites, cultural landscapes, including aboriginal landscapes with no visible signs of human intervention. These range from an Aboriginal Cultural Landscape in Darwin Sound, Canada, to the Yellow Mountains White Cloud Stream Scenic Area in China. Narrow definitions of culture as physical objects have expanded via notions of intangible culture to include the whole spectrum of human expressions.

In the 1990s, UNESCO spent a decade studying the phenomenon of the Silk Routes[37] and the Spice Routes, which have provided bridges between East and West for over two millennia. In the past two years UNESCO working with the National Institute of Informatics (NII) in Tokyo has launched an important initiative to create a digital silk roads project.[38] The UNESCO initiative includes partners in China, Afghanistan, Kazakstan, Iran, Iraq, indeed all the countries which were traditionally part of the silk and spice routes. In the United States, under the auspices of the National Science Foundation (NSF), the University of Michigan Dearborn, Wayne State University have established a Digital Silk Roads Cultural Grid Project which will work with NII's Asian Network of Excellence on Digital Silk Roads and with E-Culture Net in Europe.[39]

The Silk Roads project also has links with the International Institute for the Study of Nomadic Civilizations (IISNC)[40] in Mongolia, which reminds us that the 27 nomadic societies still extant today have very different values and definitions of culture than those associated with the memory institutions of sedentary societies with their traditions of hoarding objects.

Such projects confirm that a grid for culture faces many challenges that go far beyond sending images of pretty pictures and attractive sculptures. How can we communicate the complex traditions of language, dance, music, customs, food, ornament, decorative arts as well as the more traditional dimensions of built environment?

National, Regional and Local

Scholars such as Innis,[41] McLuhan[42] and Matellart[43] have drawn attention to important links between the global spread of communications media (e.g. the telegraph, telephone, television and more recently the Internet) and the rise of global claims for knowledge.

When this global vision emerged in the second half of the nineteenth century, it seemed at first as if the challenge was merely one of collecting everything into centralized institutions. This was the assumption behind Sir Anthony Panizzi's vision of the British Museum,[44] that inspired a series of national libraries and collections in Europe and elsewhere. A generation later, visionaries such as Otlet and LaFontaine developed the idea of an *Encyclopaedia Universalis Mundaneum*,[45] the notion that one could collect

things from the whole world in a single place. These visions built on earlier attempts such as the *Encyclopédie* of Diderot and D'Alembert and the ancient goal of the Library of Alexandria.

The twentieth century saw a rebuilding of the British Library and the Bibliothèque de la France, and many attempts at centralized systems both politically (e.g. fascism, communism), and physically, which had their parallels in the many attempts to create supercomputers, a single enormous machine that was supposed to solve everything. In retrospect, the great discovery of the twentieth century was that such centralised approaches do not work in politics, cultural collections or in (super-) computing.

In computing, we have recognized that no single machine, which we are able to build today can even approach the computing challenges that are already at hand. The Large Hadron Collider (LHC) project at CERN has become emblematic of a trend that is equally evident in radio astronomy, satellite imagery, seismic information[46] and, as this paper shows, culture. Distributed Systems and grids are not fashionable alternatives. They are vital necessities if we are to keep up with the expansion of knowledge. Hence, there is every reason why many aspects of an e-science grid can be used to build an e-culture grid. There are many fruitful links between science and culture, which are expressed both as scientific cultures and cultural sciences.

At the same time, it is essential to recognize that there are important ways in which the goals and needs of science and culture are different. Science is concerned with universal laws. An experiment to prove the existence of an atomic particle needs to have the same results in Beijing as in New York. If there are scientific laws, they have to be universal and apply everywhere in the same way.

Culture is also concerned with universal themes such as love (e.g. *Apollo and Daphne*), beauty (e.g. *Birth of Venus*), sacrifice (*The Crucifixion*), and hope (*The Annunciation*). But whereas science aims at finding single, universally applicable laws and formulae, culture is concerned with creating as many possible different expressions of a given universal theme. There is no single formula for the *Annunciation.* Indeed, the *Anuunciation* is one of the richest examples of painting in Western culture precisely because there are many thousands of different expressions of the same subject.[47] Some depict the event as happening inside a church, some in a room, others in a courtyard and others still in a garden. As a result we can speak of classes of *Annunciations,* we can identify characteristics and qualities, which make some examples into first-rate masterpieces and others into second- and third-rate derivative copies, and versions, but we cannot pretend that there exists a single law for *Annunciations* as in science.

There was a time when it was fashionable to assume that these first-rate examples were created only in great cultural centres. This led to a histories of art and culture which focused on a handful of such centres. In the case of Italy, it often seemed as if culture were limited to Florence, Rome and Venice, with some activities in Bologna, Milan and Naples. The research of André Chastel,[48] exploded this view by drawing attention to the role of smaller centres such as Castiglione d'Olona, Mantua, Ferrara, Cremona, Pavia,

Pisa, Siena, Volterra, Arezzo, Perugia, and Assisi. The importance of courts came into focus whereby the role of country homes also came into view (e.g. Villa d'Este, the Medici villas, Caprarola)

All this is leading slowly to a reassessment of the entire cultural landscape. Nineteenth century notions of capitals (which still remain in the idea of European capitals of culture)[49] and provinces, which gave way to notions of centres and peripheries are leading to views which include national (capitals), regional and local levels. In the case of Italy, this means that in addition to the eternal Rome, Florence and Venice, provinces such as Umbria, the Abruzzo and Reggio Calabria are recognized as significant, as are cities and towns such as Altamura, Atri, Gerace, Matera, Montefalco and Spoleto, which were often absent from earlier cultural maps.

Methodologically, this implies that culture is confronted with at least three parallel versions of history: an official version at the national level, a regional version and a local version. And while some cultures with a melting-pot mentality may be tempted to extend the capital-centred views of the past, the only hope for true cultural diversity is to develop methods, which keep alive and help us to compare these alternative views.[50] Technologically, this implies that we need access to vastly more knowledge and information than the earlier universalists of the eighteenth and nineteenth centuries ever dreamt. Here the approach of Professor Manfred Thaller with respect to Digital Autonomous Cultural Objects (DACOs) is important.[51]

Similarly, in terms of our views of past, present and future, there is a growing awareness that there are at least three fundamental approaches. There are the standard histories that trace the mainstream and predict how it will evolve. Second, there are over-imaginative visions of yesterday's tomorrows, which in retrospect are dead-ends and sometimes amusing non-starters. Third, there are aspects of earlier visions which the mainstream obscures and which then become the starting points of major developments at a later date, just as in scholarship it is often said that the near hidden footnotes of a great scholar in one generation become the themes of future works. Needed are new ways whereby our access to knowledge throws light on all three of these trends and not just on the mainstream, which is the fashion of the day.[52]

Alternative Interpretations and World Views

In science, the idea of using visualization to test scientific hypotheses is leading to a new field of scientific visualization.[53] This also has its parallels with respect to historical and cultural studies. For instance, scholars at Warwick have recently reconstructed the Odeon of Pericles to claim that 40 % of the spectators could not see the stage properly.[54] Virtual reality reconstructions of Pompeii are being used to test theories about economic and social life in the ancient Roman city.

A decade ago reconstructions were often uncritically treated as authoritative versions of how things actually were. Even today technologists are still struggling with a number of formidable challenges in mastering shifts between different technological settings. For

instance, CINECA working with RAI is working on the frontiers of translating a virtual reality reconstruction of Pompeii into a virtual set for television programmes.[55] A next step will be to adapt such reconstructions for use in virtual classrooms. Instead of reading about Pompeii a student of the future will potentially be able to walk around in a virtual archaeological site.

Projects such as Archeoguide provide us a glimpse of how one might combine a virtual reconstruction with a physical site to create an enhanced reality view of the Temple of Hera at Olympia.[56] The MUVII[57] (Multi User Virtual Interactive Interface) project explores how haptic modalities might be added to this experience.

Historians since the time of Ranke know, of course, that this quest for how it actually was (*wie es eigentlich gewesen*) is much more elusive than it would at first seem. Once we have mastered the initial technological hurdles of reconstructing visual surrogates of objects, monuments, sites and landscapes, we could use technology to provide access to alternative interpretations of the same object or site. In any case one of the major incentives of a cultural grid is to share methods and develop critical thought together.

In future, the methods being used to view augmented reality versions of the *Temple of Hera* in the Archeoguide project could be extended such that a visitor is able to see the differences among interpretations of Greek, French, German and British archaeologists. As such reconstructions offer a tool to visualize differences between national traditions, schools of thought and even some particularly articulate individuals: e.g. Heinrich Schliemann (Troy) or Sir Arthur Evans (Knossos).

J.C. Spohrer[58] building on the ideas of Steve Feiner, has shown how, using a small screen interposed in front of one's eye one can use augmented reality to impose upon the night sky the Greek constellation. In future, an extension of the same principle could enable viewers to see the constellations of the Arabic, Indian, Chinese, Mayan or even the Chaldaean astronomers. An extension of the same principle would help us to see the same statue from a Greek or a Roman viewpoint, from a Hinayana or a Mahayana Buddhist viewpoint. As such augmented reality can become a tool for entering into different world-views.

So-called world-views are more complex than we often imagine. In the West, our cultural expressions are linked with a concept of aesthetic distance, which led to the subject-object distinction. We use cultural expressions to separate ourselves from the depicted or represented reality. In the Orthodox West (Byzantium and Russia), cultural expressions function almost as visualizations of the Greek middle verb. They both link and separate us simultaneously.

By contrast, in the Far East, the purpose of cultural expressions is often to remove subject-object distinctions and to join us with the object in question. For instance, a Japanese Zen Garden is not something we are intended to look out at: we meditate in order that the distinction between the garden's out and our in is transformed into one experience.

One of the great challenges for the future of e-learning and creativity is for our cultural expressions to make us more aware of such differences and to help us in moving between these different worlds of perception and experience. Theoretically it should be possible to build into our systems these perceptual differences between world views such that we could don an augmented reality "hat" which would help us to see through the eyes of an Indian, an Inuit, etc. If so the new media, which are too often used to impose the single viewpoint of a dominant group, could become instruments for helping us to see, experience and to understand the world views and world-senses of others.

Creativity

The incentives for sharing culture via cultural grids go far beyond a general desire to have access to the whole range of cultural materials and include the quest for new creativity. The Romantic period gave rise to notions of the artist as a lonely and heroic individual, isolated from everyday life, who left behind past and present, and in the cauldron of originality created entirely new things. In the past century we have come to recognize that the quest for the new is a much more subtle process. There are jokes about a land of unlimited impossibilities where nothing is so old as the new.

We might begin with an example from architecture. There was a mediaeval tradition of combining a wooden structure filled in with stucco, known as *Fachwerk* in German and remembered as Elizabethan architecture in English. This well-known principle was used throughout most of Europe. What is remarkable, however, is how each town and city: e.g. Bamberg, Braunschweig, Hildesheim, Hornburg, Marburg, Quedlinburg and Wolfenbüttel develop their own inimitable version of the same technique such that an expert need only to look at the pattern to recognize the town involved.

Almost all of the greatest works of the Renaissance are about well-known topics. Some derive from age-old topoi such as the four seasons, or the twelve months. Most of the best-known Renaissance paintings are derived from a handful of literary sources including the Greco-Roman classics such as Ovid with themes such as the *Three Graces*, the *Birth of Venus* and the *Bible*. Indeed, two of the most famous paintings of all time, the *Last Supper* of Leonardo and the *Mystic Lamb* of Van Eyck are both based on the *Bible*. From the stories of these shared written experiences come many of the creative high points of cultures.

Scholars such as Hanfmann and Gombrich[59] have noted that already in antiquity there were complex interplays between the rise of verbal storytelling and the rise of visual narrative. Accordingly a key to creativity lies paradoxically not in the newness of a story, but rather in how universally well-known is a story. A new story imposes many constraints on an artist or creator in order to make the unknown topic comprehensible to viewers. A universally known story such as the *Birth of the Virgin* or *Birth of Christ* allowed Renaissance painters to take for granted the basics and to concentrate on versions that reflected regional traditions or local schools.

The rise of new visual creativity thus went hand in hand with well-known verbal texts. If we examine the great fresco cycles[60] from the Romanesque versions in the Reichenau, through the examples of Giotto at Assisi and all through the Renaissance, it is striking how these great visual expressions all have verbal texts as captions. Visual quoting was much more than borrowing images: it was a visualization of verbalizations, which brought a creative rearrangement of known elements.

One of the reasons why these local and regional variants are so rich and so centrally connected with the "essence" of culture is that they transform the universally known stories, themes and topics into expressions that reflect the local realities and ultimately the unique, individual characteristics of a given painter, sculptor or other creative spirit.

More recent examples such as Marilyn Monroe may bear little resemblance to the Virgin on a moral plane and yet offer interesting parallels on a visual plane. It is precisely because this portrait has become well known to the point of effectively being a modern day topos through the variants of pop artists such as Andy Warhol, that Marilyn is inspiring an enormous amount of copies, variants, and creative versions, not just as paintings but also as computer animations and potentially even as film.

Part of the secret to this creativity is a free access to sources and our ability freely to share these sources. Would there ever have been a Renaissance if the theme of the *Birth of Christ* or all the possible images of the *Bible* had been copyrighted? Would we have such interesting images of Marilyn Monroe if companies such as RetroFilm.com literally owned the rights of all possible movements of virtual thespians such as Marliyn Monroe? In both cases the answer is almost certainly not.

In retrospect, the genius of the Renaissance was to establish close links between enduring knowledge (of memory institutions at the time looked after by both the Church and increasingly by Dukes, Princes, Kings and their feminine, often superior, counterparts), collaborative knowledge (at the time in the form of bottegas, workshops and ateliers) and personal knowledge (in the form of individual artists and creators).

Instead of pretending that the originals were owned exclusively by certain individuals there was a conviction that by sharing this common heritage (or patrimony) the original would lead to copies and via shared and personal versions to new creativity. The past was a cumulative collection to inspire an ever-evolving future.

If we look around today we have lots of tools for verbal quoting in the form of footnotes and references, but really very little in the form of serious quoting from the visual realm. Admittedly Adobe makes some quoting and editing possible. Techniques such as Scaleable Vector Graphics (SVG) and Web 3-D address some problems in this field. There are some tools for editing film. There are tools by Avid, Philips, Sony, but we have effectively no tools for systematic cross-media visual and verbal quotation.[61]

Individuals and Particulars

The quest for originality and creativity takes us back to an age-old debate in philosophy that has been around at least since the time of Plato and Aristotle. There were universal categories and then there were individual or particular examples. If one could understand the universal category, then the "minor" variations within that category were no longer very important. Or so it seemed at the time. One understood the big picture and was therefore spared the embarrassing trouble of the details. This led to a triumph of deductive over inductive science.

It took western philosophy more than a millennium before Mediaeval philosophy brought universals and particulars back to the forefront of discussion and concluded that the particulars were every bit as important as the universals and might indeed be more important. This led to an increasing commitment to inductive science and ultimately to fruitful combinations of inductive and deductive approaches, using the details of the inductive as touchstones and tests for the deductive. These combinations led to the breakthroughs of Kepler, Galileo and later Lavoisier and much of modern science.

As with all fundamental problems they never go away: they only take on new forms. In the world of computer programming there is an extreme group usually associated with artificial intelligence who have taken up the side of the universals: who believe that *if* only one could find the absolute categories *then* one could solve all the problems without needing to pay attention to the details.

This school has had an enormous impact on the world of industry. It has led to the creation of Industry Foundation Classes (IFC), the belief that if one defines all the characteristics of a door for different kinds of buildings one will arrive at intelligent doors such that one is spared the trouble of ever drawing all the local complexities of doors. This quest is linked with larger visions for a Standard for Exchange of Product Information (STEP) and of Intelligent Manufacturing Systems (IMS). It is leading to specific programmes such as the Building Objects Warehouse (BOW) and Advanced Reusable Reliable Objects Warehouses (ARROWs), which serve as distributed object libraries (databases) created, populated, and maintained by information providers.

It is important to recognize that this quest for "intelligent" doors, windows and other building elements, represents the quest for the universal in a new guise. Applied naively it will lead to precisely that McDonaldization against which the anti-globalists warn. Universal programmes produce universal doors and windows but give us no clues about the uniqueness of the doors of Saint Zeno in Verona, Ghiberti's doors for the Baptistry in Florence or any of the other myriad entrances of the Renaissance.

History reminds us that the solution is both/and rather than either/or. The power of the universals is the power of the generic based on universals that is the basis of science, technology, manufacture and industry. The richness of the particulars is the abundance of the original, and the unique that we associate with the arts and culture.

Needed somehow is a combination of these approaches: technology, which provides us a) with the universal structures and b) gives us access to databases with all the variations such that we can build into the standardized safe structures the unique characteristics which will express the inimitable regional and local dimensions.

These databases need to be linked with new editing tools whereby both verbal and visual quoting are an integral part of the software, where access to enduring knowledge is combined with spaces for collaborative and personal creation and co-creation.
The challenge is to find new ways of visual and verbal quotation, of reference, of building on the richness of the past to arrive at a more creative future. Combining the universal approaches of science and the particular approaches of art from the past and the present is a key to future creativity. Networks such as E-culture net,[62] with links to artnouveau[63] and Netzspannung[64] are needed. Linking the partners in these networks with high-speed networks is essential. Needed and essential also is a grid for culture whereby the richness and cultural diversity of the past inspires new insight and creativity in the present and the future.

Conclusions

The first large-scale computer, the ENIAC (electronic numerical integrator and computer)[65], was developed to deal with ballistic trajectories of large guns. The Internet began in a military context with close links to high-energy physics. Ever since there has been an assumption that computers are mainly for science and technology because these are the only fields with large-scale challenges for High Performance Computing (HPC). As long as supercomputers came with a price tag from one to over one hundred million dollars only the military and big science could hope to buy such machines and so a small elite perpetuated that perception. For years the military literally seemed to provide the only killer applications.

This paper has drawn attention to the fact that culture potentially offers even greater challenges than science for the future of High Performance Computing. The large data sets in high-energy physics (CERN), radio astronomy, satellite imagery, geo-sciences, seismology and meteorology are well known. They are also relatively straightforward. In theory, if the instruments are working, each event or experiment produces one set of measurements, which then need to be analysed.

In culture, the process of scanning paintings, pages of books, manuscripts and images of objects already produces petabytes of information when viewed from a global scale but this is merely the surface. In the case of priceless objects, which are often very fragile, there are further petabytes of information concerning their conservation and restoration. In the case of objects, which have been damaged, are in ruins or in some cases are no longer extant, there are reconstructions, which account for further petabytes of information. This is especially so because there are inevitably different interpretations as to how these ruined or lost monuments and artefacts might have appeared and functioned.

In science, access to the raw data is a primary challenge although increasingly there is a need for complex ways of visualising results through scientific visualisation. In culture, access to images of cultural objects is only the tip of the iceberg. To understand an image of a painting requires comparing related works by the painter and their contemporaries, antecedents, copies, versions, literary and other sources, a contextualisation of subjects and themes, of space and time and potentially much more if one seeks to understand philosophical, social and other contexts.

In science the focus is on one set of data, which are universally valid. Once one has done an experiment in Paris one may do it again in San Francisco just to check that the experiment is repeatable but once this is established then there is no need to continue collecting other examples. By contrast, in culture, knowing about an *Annunciation* in the Louvre and the Uffizi does not mean one can become complacent. In culture, to study the *Annunciation* thoroughly means that one needs to study national, regional and local examples with their different expressions and interpretations. Each subject and theme does not culminate in a handy formula: it results in ever increasing and ever more diverse sets of examples. In this cumulative diversity lies the true richness of culture. And as we have shown, paradoxically, it is precisely the well-known examples from that cumulative diversity, which are often the sources for new creativity.

If a single large-scale experiment such as the LHC overburdens the largest computers of the world, it is clearly futile to imagine that a single computer could cope with the challenges of culture, which entail simultaneously realities at local, regional and national levels internationally. Only a distributed approach using grids can hope to approach these challenges and that is why a grid for culture is not just a fancy idea: it is a necessity.

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Notes

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[2] See: http://www.ercim.org/publication/Ercim_News/enw47/intro.html

[3] Cyveillance report, 10 July 2000.
See: http://www.cyveillance.com/us/newsroom/pressr/000710.asp

[4] "Web Is Bigger Than We Thought, *San Jose Mercury News*, 28 July, 2000,
See: http://www.nua.ie/surveys/?f=VS&art_id=905355941&rel=true
Mark Frauenfelder, "Deep-Net Fishing," *The Industry Standard Magazine*, June 18, 2001. See: http://www.techinformer.com/go.cgi?id=490878.
Mike Nelson (IBM) at the INET 2001 Global Summit claimed that in the next 9 years there will be a 1 million fold increase in information. This amounts to the equivalent of 550,000,000,000,000,000 pages.

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

[6] See: http://setiathome.ssl.berkeley.edu/

[7] See: www.top500.org

[8] See: http://www.csdl.tamu.edu/~arpita/Digital%20Atheneum%20Project.ppt

[9] See: http://www.byu.edu/news/releases/archive01/Apr/scrolls.htm

[10] See: http://www.ino.it/~luca/rifle/rifleesempio_en.html

[11] See:
http://www.npr.org/programs/atc/features/2002/feb/gutenberg/020219.gutenberg.html

[12] See: http://inf2.pira.co.uk/factsheets/inform/digicult/crisatel.html

[13] See: http://palimpsest.stanford.edu/waac/wn/wn09/wn09-3/wn09-304.html

[14] http://www.bcin.ca/English/home_english.html

[15] See:
http://www.amolf.nl/research/biomacromolecular_mass_spectrometry/molart/Introduction.html#objectives

[16] H. Afsarmanesh, R.G. Belleman, A.S.Z. Belloum, A. Benabdelkader, J.F.J. van den Brand, G.B. Eijkel, A. Frenkel, C. Garita, D.L. Groep, R.M.A. Heeren, Z.W. Hendrikse, L.O. Hertzberger, J.A. Kaandorp, E.C. Kaletas, V. Korkhov, C.T.A.M. de Laat, P.M.A. Sloot, D. Vasunin, A. Visser and H.H. Yakali, "VLAM-G: a grid-based virtual laboratory," *Scientific Programming* 10 (2002) 173-181

[17] See: http://eoi.cordis.lu/dsp_details.cfm?ID=33118

[18] See: http://www.museumland.com/index.html

[19] See: http://icom.museum/vlmp/

[20] See: http://sunsite.berkeley.edu/Libweb/.
Cf. http://www.ifla.org/

[21] See: http://www.oclc.org/navigation/libraryusers/.

[22] Cf.: http://www.rlg.org/toc.html

[23] Cf. http://www.gipuzkoakultura.net/museos/igartu/index.htm

[24] See: http://www.uni-muenster.de/Fruehmittelalter/Projekte/Cluny/links_cluny.htm

under les Images.
[25] Maurizio Forte, *Archeologia, percorsi virtuali nelle civilta scomparse*, Milan: Mondadori, 1996.
[26] See: http://www.itd.ge.cnr.it/ted03/scrovegni_descrizione.htm
[27] See: http://www.storiaeinformatica.it/nume/italiano/ntitolo.html
[28] See: http://www.elpais.com.uy/muva/
[29] See: http://www.cs.ucd.ie/prism/HIPS/Default.htm
[30] See: http://www.cybernarium.de/
[31] See: http://www.kfki.hu/~arthp/html/r/raphael/4stanze/3borgo/
See: http://www.stud.uni-karlsruhe.de/~um9t/sa/ART311_4_6.html
[32] See: http://www.iamas.ac.jp/interaction/i97/artist_artcom.html
[33] See: http://www.ai.sri.com/TerraVision/
[34] See: http://www.storiaeinformatica.it/nume/italiano/ntitolo.html
[35] See: http://www.travel-bulgaria.com/content/museum_towns.shtml
[36] See: http://videalab.udc.es/trabajos/trab_santi.htm
[37] See: http://www.unesco.org/culture/silkroads/
[38] See: http://infolac.ucol.mx/observatorio/cooperation.html. Cf. "European Networks of Excellence and Japanese/UNESCO Silk Roads," *Tokyo Symposium for Digital Silk Roads, UNESCO, National Institute of Informatics, National Center of Sciences, Tokyo, 11-13 December, 2001*, Tokyo: National Institute for Informatics, 2002. pp. 135-145.
[39] See: http://www.mmi.unimaas.nl/eculturenet/index.htm
[40] See: http://www.nomadic.mn/meetings.html
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[42] See: http://mcluhan.utoronto.ca/marshal.htm;
Cf. http://spot.colorado.edu/~calabres/mcluha~1.htm
[43] Armand Matellart, *Mapping World Communication*, Minneapolis: University of Minnesota Press, 1994.
[44] See: http://www.thebritishmuseum.ac.uk/visit/datelist.html
[45] See: http://www.mundaneum.be/
[46] See: http://www.serenate.org/
[47] A quick search on google Images on 10 May 2003 revealed 5,800 images of the Annunciation.
See: http://images.google.com/images?hl=en&lr=&ie=UTF-8&oe=UTF-8&q=Annunciation
[48] Cf. André Chastel, L*e Grand Atelier d'Italie*: *1460-1500*, Paris, 1965.
[49] See: http://europa.eu.int/comm/culture/eac/capeurcult_en.html
[50] Cf. Giorgio Ruffolo, *The Unity of Diversities. Cultural Co-operation in the European Union*, Florence: Aneglo Pontecorboli Editore, 2001.
[51] See: http://www.mmi.unimaas.nl/eculturenet/publicPDF/periodicreport1.pdf pp.6 ff.
[52] These challenges are being explored by my student Nik Baerten in his doctoral thesis (Maastricht) with specific reference to the rise of organic metaphors in science, architecture and software design.
[53] See: http://www.nas.nasa.gov/Groups/VisTech/visWeblets.html
[54] See: http://news.bbc.co.uk/2/hi/technology/2950661.stm

[55] See: http://www.cineca.it/HPSystems/Vis.I.T/Researches/rvm4vset.html
[56] See: http://archeoguide.intranet.gr/
[57] See: http://www.hpclab.ceid.upatras.gr/muvii/project.html
[58] See: http://www.research.ibm.com/journal/sj/384/spohrer.pdf.
Cf. http://www1.cs.columbia.edu/graphics/courses/mobwear/reading.html
[59] E.H. Gombrich, *Art and Illusion,* Princeton University Press, 1960.
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[61] For a review of this domain
See: http://viswiz.gmd.de/DVP/Public/deliv/deliv.221/Act221del.htm
[62] See: http://www.mmi.unimaas.nl/eculturenet/index.htm.
[63] See: http://www.inigraphics.net/publications/topics/2002/issue4/4_02a08.pdf;
Cf. http://www.artnouveau-net.org/firstworkshop/scientific.html
[64] See: http://netzspannung.org/start/flash/
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