Digital Tools for Museums and Cultural Heritage

A Methods Network Working Paper

The designation of this document as a 'working paper' is an acknowledgement that its content is not meant to be regarded as finalised or fixed. As part of the Methods Network remit to encourage discussion about the advanced use of ICT tools and methods for arts and humanities research, comments, annotations, corrections and recommendations relating to this paper are sought from anyone with an interest in the Museums and Cultural Heritage (MCH) sector. An online forum is being developed to accommodate this kind of feedback, please see the following web page for details:
http://www.methodsnetwork.ac.uk/community/participate.html

In the meantime, please feel free to send comments to:
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The prodigious number of tools that are potentially relevant to researchers working in the field of MCH inevitably means that the items mentioned in this relatively brief paper will only represent a partial and subjective selection. The references draw heavily on accounts of activities and research broadly related to the groups and individuals that have participated in Methods Network funded activities or who have otherwise come to our attention through our links to organisations such as the the AHDS[1] (Arts and Humanities Data Service), AHeSSC[2] (the Arts and Humanities e-Science Support Centre), 3D Viznet[3] and a number of other organisations who have interests in this area.[4]

Inevitably, this paper will duplicate some of the content featured in other working papers in this series. There is a particularly significant overlap between the MCH sector and activities relating to archaeology, history and art history, all three of which have been the subject of recent papers.[5] Certain tools and techniques that might broadly be defined as relating to the field of information management (i.e. ontologies, thesauri etc.) but which have specific relevance to the MCH sector, are also referred to in the working paper entitled 'Digital Tools for Library and Information Studies'.[6] This makes reference to the influential and very important ontology model, CIDOC-CRM[7] (see below) and also makes reference to a number of data standards.

EPOCH Tools

EPOCH[8] (The European Research Network of Excellence in Open Cultural Heritage) is an important starting point for investigating the use of ICT tools in the cultural sector. The members of this network include academic and commercial organizations from all over Europe and computing science and engineering departments feature alongside heritage pressure groups. Of particular interest in the present context is a long list of tools that EPOCH has gathered together, the stated aim of which is to provide 'one-stop access to all the software available for ICT applications to tangible Cultural Heritage.'[9] (see fig. 1)

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[1] Arts and Humanities Data Service, http://ahds.ac.uk/, (accessed 13 June 2007)
[2] Arts and Humanities e-Science Support Centre, http://www.ahessc.ac.uk/, (accessed 13 June 2007)
[3] Viznet, https://wiki.viznet.ac.uk/bin/view, (accessed 13 June 2007)
[4] See the 'References' section for a list of organisations related to the Museums and Cultural Heritage Sector
[5] Methods Network Working Papers, http://www.methodsnetwork.ac.uk/resources/workingpapers.html, (accessed 13 June 2007)
[6] Methods Network Working Paper, URL forthcoming …,
[7] The International Committee for Documentation of the International Council of Museums (ICOM-CIDOC), Conceptual Reference Model (CRM), http://cidoc.ics.forth.gr/, (accessed 14 May 2007)
[8] EPOCH, http://www.epoch-net.org/, (accessed 13 June 2007)
[9] EPOCH, http://www.epoch-net.org/index.php?option=com_content&task=view&id=46&Itemid=88, (accessed 13 June 2007)

	1. Multilingual and semantic data processing	2. Databases and knowledge management	3. Mobile wearable ambient system	4. Recording and data represent.	5. Visualisation and rendering	6. Multimodal interfaces	7. Virtual humans and other avatars
A. Project, Design, Background Research	1A multi-modal retrieval	2A multi-modal retrieval	3A	4A	5A	6A	7A
B. Data acquisition	1B knowledge extraction	2B (distributed) databases	3B portable logging tools AR overlays	4B geophysical methods 3D acquisition	5B	6B	7B
C. Interpretat. and analysis	1C grammar & spell checking	2C data mining	3C	4C shape analysis	5C data visualisation procedural methods	6C	7C
D. Scholarly publication and archiving	1D free machine translation	2D multi-modal retrieval	3D smart tags	4D	5D	6D	7D
E: Public Presentation	1E translation speech recognition	2E	3E VR/AR museum guides positioning technology	4E 3D acquisition space visualisation user profiling	5E virtual models VR/AR	6E storytelling AR presentation	7E virtual narrators & presenters populated sites

Fig. 1 EPOCH Tools table[10]

The matrix that provides an index to the tools list also usefully maps out the various activities that demand engagement with ICT tools. The X axis refers to methodologies and the Y axis to processes that take place in the course of undertaking MCH related work. The squares of the grid hyperlink to individual items on the list which range from fairly straightforward mono-functional tools such as *Sayz Me*[11] (a free text-to-speech reader that will help users with accessibility issues) to very high end suites of tools such as *MultiGen-Paradigm*, a collection of applications enabling very large scale virtual environments to be created which is also interoperable with other applications such as the widely used *ArcView*[12] GIS package.

[10] EPOCH, Tools, http://www.epoch-net.org/index.php?option=com_content&task=view&id=46&Itemid=88, (accessed 13 June 2007)
[11] Data Furnace, http://www.datafurnace.net.au/sayzme/, (accessed 13 June 2007)
[12] ESRI, ArcView, http://www.esri.com/software/arcgis/arcview/index.html, (accessed 15 June 2007)

Webs 1.0 2.0 & 3.0

The delivery of the results of MCH research via innumerable websites is, in common with every other discipline, a quotidian phenomenon and of negligible significance in itself. What this obscures however, is the complexity of certain systems[13] that present themselves simply to the user but are reliant on complex procedures and tools (e.g. server farm configurations, sophisticated data mining techniques, automated record linkage processes, probabilistic matching routines, etc.) at the back end to deliver content. The resources available to organisations in the MCH sector means that in comparison to corporate search engine technology configurations, system architectures will remain diminutive, but it should be acknowledged that some UK MCH datasets are in fact now very sizeable, largely due to the tools and techniques associated with standardising and aggregating data (e.g. OAI-PMH[14] and various forms of XML compliant data frameworks).

The Archaeology Data Service (ADS a.k.a. AHDS Archaeology) has cross-searchable records for over one million items;[15] *Canmore*, the online database of the Royal Commission on the Ancient and Historical Monuments of Scotland has details of around 250,000 sites and structures, totalling 800,000 catalogue entries;[16] and the Heritage Gateway has 1.2 million records online (with a further 1 million waiting to be added). Databases of this sort and the interfaces used to search them are powerful research tools and are, in some cases, augmented with point and click map interfaces allowing the retrieval of data using location criteria, functionality that is supported using GIS (geographical information systems) data.

The group of technologies and tools that are linked to Web 2.0 approaches are currently being investigated and evaluated by the MCH community. *Steve, the Art Museum Social Tagging Project*,[17] is an initiative to build up user-generated descriptions of works of art to improve access to museum collections and to encourage user engagement with the items in those collections. The tagger can be accessed without even registering and terms can be applied and submitted instantly for random images that are provided from the collections of the U.S. based project partners. Other examples where user-generated tagging has been used to provide alternative routes into the collection are the Powerhouse Museum[18] in Sydney, and the Metropolitan Museum of Art which tested the process in 2005.[19] More comprehensive user generated information is being solicited by the Coine Project.[20]

Whilst there is much debate about the ultimate value of this form of tagging, it is clear that this method and others that are associated with Web 2.0 approaches, such as tagclouds and syndication (using podcasts and RSS feeds), as well as approaches that take advantage of AJAX[21] (asynchronous javascript and XML) functionality to increase the interactivity of web pages, enhance the user experience of the web environment and will continue to be the subject of both technical and social research. Collaborative forms of publication such as blogs, wikis, fora and taxonomies are included as features, modules or plug-ins in the majority of modern content management systems and open source examples of these include *Joomla*,[22] *Drupal*,[23] and *Typo3*.[24]

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[13] An example of an MCH resource that defaults to a google-like single search box is: English Heritage, Heritage Gateway, http://www.heritagegateway.org.uk/gateway, (accessed 13 June 2007)
[14] Open Archives Initiative Protocol for Metadata Harvesting, http://www.openarchives.org/OAI/openarchivesprotocol.html, (accessed 22 June 2007)
[15] Archaeology Data Service, ArchSearch, http://ads.ahds.ac.uk/catalogue/, (accessed 13 June 2007)
[16] RCAHMS, Canmore,
[17] Steve, http://www.steve.museum/, (accessed 14 June 2007)
[18] Powerhouse Museum, http://www.powerhousemuseum.com/home.php, (accessed 14 June 2007)
[19] Jennifer Trant and Bruce Wyman, Archimuse, Investigating social tagging and folksonomy in art museums with Steve.Museum, http://www.archimuse.com/research/www2006-tagging-steve.pdf, (accessed 14 June 2007)
[20] Coine Project, http://www.ariadne.ac.uk/issue51/brophy-et-al/, (accessed 22 June 2007)
[21] Jesse James Garret, Adaptive Path, A New Approach to Web Applications, http://www.adaptivepath.com/publications/essays/archives/000385.php, (accessed 14 June 2007)
[22] Joomla, http://www.joomla.org/, (accessed 14 June 2007)

The development of what has been referred to as Web 3.0, but is more often called the Semantic Web, is the subject of ongoing debate across many subject areas. The principle concept that underpins aspirations for a more richly described Web is to remove the need for humans to mediate and make manual connections between items of content that have been unintelligently provided by current search and retrieval mechanisms. By the application of ontologies and descriptive frameworks that relate entities and concepts more explicitly to their knowledge domains, a great deal more precision and interoperability can be brought to the process of retrieving and analyzing data. As Jennifer Trant has stated:

> What we want them [Museums and their end-users] to buy into is the vision of interconnected, interoperable, easily integral resources that exist in multiple places and are used by multiple people to support different functions. You want them to buy into a vision of a shared, useful, integrated information environment in which museums play a robust part.[25]

The most prominent tools that have been designed to enable this framework are based on *XML* applications and principally involve elaborations on the use of the *Resource Description Framework* (RDF) model, a W3C recommended specification which has been extended to encompass:

- RDFa (for adding semantic attribute information to XHTML)
- RDF Schema (to provide basic elements for the description of ontologies)
- OWL (for defining web ontology information)
    - OWL Lite
    - OWL DL
    - OWL Full[26]

Obviously it makes no sense to build new ontology schemas in domains where people have already carried out effective work and the use of standardised methods such as *OWL* facilitate the appropriation of schemas wherever possible. *SchemaWeb*[27] and the *DAML Ontology Library*[28] provide searchable lists of existing specific ontologies whilst *SUMO*[29] (Suggested Upper Merged Ontology) provides a number of mid-level ontologies, e.g. transportation, engineering components, finance etc., but also links these to a very high-level conceptual framework consisting of broad themes and ideas. Recent work in the field of developing ontologies for historical information, including references specifically to the MCH sector, were showcased at an e-Science Institute event at which Mark Greengrass (Humanities Research Institute and the ARMADILLO project[30]) and Oskar Corcho (University of Manchester) introduced a variety of concepts relating to ontologies and their relationship with the semantic web, data mining, and knowledge engineering concepts.[31]

The most high-profile formal and extensible ontology used by the cultural heritage sector is the *CIDOC-CRM*, a system which has been designed to provide the 'semantic glue' to enable data to be shared between libraries, museums and archives.[32] Based on object-oriented modelling methodologies and displaying compatible properties with *RDFSchema* techniques in its use of triple entities (subject, predicate,

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[23] Drupal, http://drupal.org/, (accessed 14 June 2007)
[24] Typo3, http://typo3.com/, (accessed 14 June 2007)
[25] Jennifer Trant, UK Museums and the Semantic Web, Illustrating the Semantic Web, http://culturalsemanticweb.wordpress.com/workshop-reports/workshop-1/introduction/, (accessed 14 June 2007)
[26] W3C, OWL (Web Ontology Language), http://www.w3.org/2004/OWL/, (accessed 14 June 2007)
[27] SchemaWeb, http://www.schemaweb.info/, (accessed 14 June 2007)
[28] DAML Ontology Library, http://www.daml.org/ontologies/, (accessed 14 June 2007)
[29] SUMO, http://www.ontologyportal.org/, (accessed 14 June 2007)
[30] Historical Research Institute, ARMADILLO, http://www.hrionline.ac.uk/armadillo/, (accessed 19 June 2007)
[31] E-Science Institute, http://www.nesc.ac.uk/esi/events/773/, (accessed 19 June 2007)
[32] A list of projects that have used the CIDOC-CRM model is available at: CIDOC-CRM, http://cidoc.ics.forth.gr/uses_applications.html, (accessed 14 June 2007)

object)[33] to describe relationships, the CRM establishes context-independent descriptions of how one element of data is related to another and provides a richly granular method of integrating legacy or incompatible datasets into formalised searchable systems.

Documentation Standards

Definable as model, tool or standard,[34] consideration of the *CRM* usefully provides a conceptual and practical link with the broad and important field of standards development. The MCH sector has invested enormous amounts of time and energy into defining and refining cataloguing and classification standards over the years and has either taken the lead or contributed to the development of a number of systems that have gained broad acceptance by the community. The *Dublin Core Metadata Element Set*[35] (DC) is an obvious example of a very widely used model and represents a useful contrast to the *CRM* in that the prescriptive elements (the 15 terms that are designed to contain all the data that might be associated with digital objects) are purposefully 'underspecified' to allow a variety of information types to be accommodated. In his very useful description of the test mapping of the *Dublin Core Metadata Set* to the *CRM*, Martin Doerr expands on this idea:

> In other words, whereas the DC acquires its genericity by using "underspecified" notions, the CRM acquires genericity through constraint extensibility. Furthermore, whereas the DC makes proactive recommendations for developing finding aids, the CRM tries to interpret formats in a reactive manner.[36]

Other *CRM* mappings to standards that have significance to the MCH sector include *MIDAS*[37] (the Monument Inventory Data Standard) and the *Encoded Archival Description Element Set* (EAD – an XML document type definition (DTD) for encoding archival finding aids).

Another important system that is widely used is *SPECTRUM*[38] (Standard ProcEdures for CollecTions Recording Used in Museums) which is both a guide to good practice for museum documentation and a framework for identifying and describing the information which needs to be recorded to support those practices. An XML DTD has been developed to provide a system neutral document interchange format for museum collections systems which are based on or can map to the *SPECTRUM* standard. References to a number of other important initiatives, such as the *VRA Core Metadata Schema* and *CDWA* (Categories for the Descriptions of Works of Art) can be found in the reference section at the end of this paper along with links to sites that give summaries of current and retrospective standards.

Preservation

Preservation issues are quite obviously very central to the concerns of those working in the MCH sector. As is often the case when considering the application of digital tools to an area of activity, preservation can be examined in two different ways:

- Digital tools that assist with the preservation of the material object (e.g. digital multi-spectral imaging, virtual reconstructions of fragile objects, etc.)

[33] For a discussion of ontologies see: AHESSC, Ontologies Briefing Paper, http://www.ahessc.ac.uk/ontologies-briefing-paper, (accessed 21 June 2007)
[34] CRM was designated ISO standard 21127 in 2006
[35] Dublin Core Metadata Initiative, http://dublincore.org/, (accessed 14 June 2007)
[36] Martin Doerr, Mapping of the Dublin Core Metadata Element Set to the CIDOC CRM, http://cidoc.ics.forth.gr/docs/dc_to_crm_mapping.pdf, (accessed 14 June 2007)
[37] English Heritage, MIDAS Heritage, http://www.english-heritage.org.uk/upload/pdf/MIDAS3rdReprint.pdf, (accessed 14 June 2007)
[38] MDA (formerly stood for the Museum Documentation Association), http://www.mda.org.uk/spectrum.htm, (accessed 15 June 2007)

- Digital tools that help to preserve the digital information associated with material objects (e.g. system emulation programmes, file format migration techniques, data backup procedures, etc.)

The second of these two areas is the subject of an enormous amount of ongoing research by computing and information science-related disciplines and although these techniques are of critical importance to the MCH sector, they are also of importance to every other discipline and the literature on the subject is extensive. A long list of digital curation tools is available from the Digital Curation Centre (DCC), based at the University of Edinburgh, which also features short descriptions of each item and indicates the level of proficiency required to use it.[39] As funders of the DCC, JISC (the Joint Information Systems Committee) run a broad programme of activities relating to information management and digital preservation issues and have a number of briefing papers, reports and other resources on their website that refer to tools and techniques related to this area.[40]

Reverting to digital tools for the preservation of material objects, one of the principal ways that technology can help is with imaging processes and by representing very precise properties of objects. The use of multi-spectral imaging techniques is briefly discussed in another working paper in this series[41] and refers to the use of infra-red, ultra-violet, X-ray and other lighting and scanning techniques to discover non-visible parts of physical objects. It also refers to the *Video Spectral Comparator*[42] system that uses the same techniques to enable users to analyze inks, visualize hidden features and reveal alterations on documents that have been damaged or obscured either deliberately or due to the passage of time. Another widely used tool in this context is *VIPS*, a free image processing system that allows users to efficiently mosaic images together.[43] This is principally used in relation to infra-red images and can be used to create very large (life-size) representations of the under-drawing that can be found beneath the painted layers of works of art on canvas.

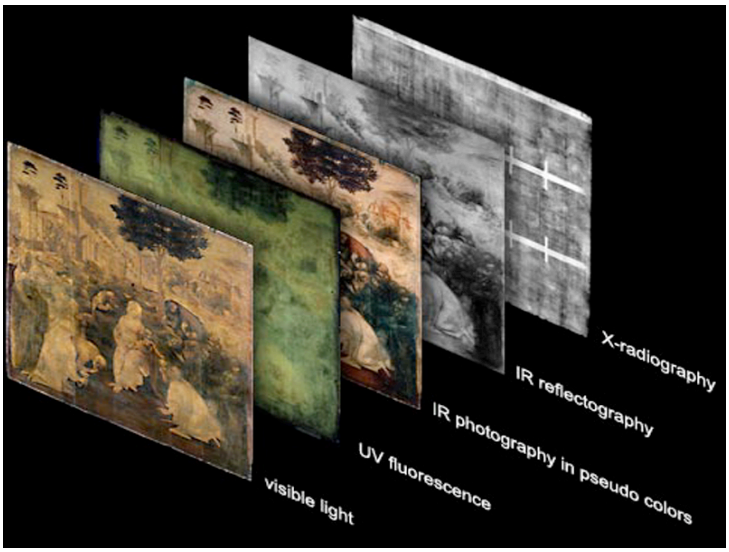

Fig. 2 Multi-spectral view of a Painting (Carl Smith)

[39] Digital Curation Centre, http://www.dcc.ac.uk/tools/digital-curation-tools/, (accessed 15 June 2007)
[40] JISC, Digital Preservation and Records Management Programme, http://www.jisc.ac.uk/whatwedo/programmes/programme_preservation.aspx, (accessed 15 June 2007)
[41] Methods Network Working Paper, What's in the Art Historian's Toolkit? http://www.methodsnetwork.ac.uk/redist/pdf/wkp1.pdf, (accessed 15 June 2007)
[42] Federal Bureau of Investigation, Advances in Document Examination: The Video Spectral Comparator 2000, http://www.fbi.gov/hq/lab/fsc/backissu/oct1999/mokrzyck.htm, (accessed 15 June 2007)
[43] University of Southampton, VIPS, http://www.vips.ecs.soton.ac.uk/index.php?title=VIPS, (accessed 15 June 2007)

Representation and Visualization

Summarising digital tools for the representation and visualization of cultural heritage is difficult, but perhaps not as difficult as defining what range of objects those representations might need to describe. The list of entities that could potentially be relevant include: historic environments, architecture, acoustic spaces, maritime and underwater landscapes, everyday objects, tools, building materials, toys, books, comics, artworks, sculpture, etc. It is of course possible to create period-specific representations of a huge variety of artefacts and locations in existing virtual environments, the most prominent of which is currently *Second Life*,[44] and references to the existence of a Victorian village[45] within that virtual world indicate that such attempts are already being made. Ultimately how plausible and useful these environments will prove to be in terms of advancing research across the MCH sector may depend on a number of factors, principally perhaps the levels of participation and the amount of genuinely interesting material that is created within these virtual worlds, two issues that are clearly mutually-dependent.

The King's Visualization Lab (KVL) and partners are beginning work on a collaborative project called SLEUTH[46] (Second Life Educational Undertakings in Theatre History) to import existing 3D models of historical theatres into Second Life. The models were created as part of the EU funded THEATRON project[47] in 2002 and bring an enormous amount of added value to the project in terms of the scholarly value originally invested in their creation. It is anticipated that these visually complex and high quality models will form the basis of a learning environment that can be used by a range of disciplines including history, performing arts, the study of dramatic literature and architectural and urban design.

Well established tools such as *3D Studio Max,*[48] *Maya,*[49] *AutoCAD,*[50] *SolidWorks,*[51] and the free open source system *Blender*[52] are all highly sophisticated programmes capable of constructing and rendering three-dimensional spaces, some of which are referred to in slightly more detail in the working paper on 'Archaeology'. (Alternative packages including additional open source options are featured on the EPOCH tools list,[53] grid ref. 5E – Virtual Models VR/AR). The sort of results that can be achieved by expert use of these systems are extremely impressive and can deliver images that facilitate innovative research.

At a recent Methods Network seminar entitled 'Theoretical Approaches to Virtual Representations of Past Environments',[54] several of the participants demonstrated work representing a range of pictorial approaches which was followed by discussions about ways of documenting and explaining the underlying data that such representations were based on. This is an issue which is very much at the centre of an ongoing initiative called the 'London Charter'[55] which is a collaborative attempt to formalise and ratify principles for 3D visualization methods which will enhance research outcomes and assist in their dissemination to wider communities.

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[44] Second Life, http://secondlife.com/, (accessed 15 June 2007)
[45] Blog: My Second Life: http://mysecondlife.sotario.com/2006_11_01_archive.html, (accessed 21 June 2007)
[46] Higher Education Academy, English Subject Centre, SLEUTH, http://www.english.heacademy.ac.uk/explore/resources/technology/sims/index.php, (accessed 21 June 2007)
[47] King's Visualization Lab, THEATRON, http://www.kvl.cch.kcl.ac.uk/theatron.html, (accessed 21 June 2007)
[48] Autodesk, 3D Studio Max, http://usa.autodesk.com/adsk/servlet/index?id=5659302&siteID=123112, (active 13 March 2007)
[49] Autodesk, Maya, http://usa.autodesk.com/adsk/servlet/index?siteID=123112&id=7635018, ((15 June 2007)
[50] Autodesk, http://www.autodesk.com/autocad, (active 13 March 2007)
[51] SolidWorks, http://www.solidworks.com/, (active 13 March 2007)
[52] Blender, http://www.blender.org/, (accessed 20 June2007)
[53] EPOCH, Tools list, http://www.epoch-net.org/index.php?option=com_content&task=view&id=46&Itemid=88#,
[54] Methods Network Seminar, Theoretical Approaches to Virtual Representations of Past Environments, 7 March 2007, http://www.methodsnetwork.ac.uk/activities/act15.html, (accessed 15 June 2007)
[55] London Charter, http://www.londoncharter.org/index.html, (accessed 15 June 2007)

Other approaches to visualization demonstrated at this same event included a wire frame model showing the architectural structure of Rievaulx Abbey (see fig. 3), and the 'Materialising Sheffield: Re-Presenting the

Fig. 3 Cistercians Reconstructed – Rievaulx Abbey (Carl Smith/Sheffield HRI)[56]

Past' project,[57] which shows how Benjamin Huntsman's Attercliffe Works would have appeared during the period 1771-1781. Original ground plans and elevations were scanned into *AutoCad*[58] and then overdrawn to produce 2D drawings. 3D models were produced by extruding these elements and using repeating sections where appropriate to build up volumes for the buildings and to be economical in terms of the size of the eventual 3D image files. Raster images of textured surfaces such as brick walls were applied to the 3D vector model and other images of trees and foliage were acquired to also add verisimilitude to the virtual environment. In order to add a sense of human presence to the scene, actors were filmed carrying out activities against a blue-screen backdrop and these were then placed into the virtual environment. The use of a volumetric particle system to represent smoke coming out of the chimneys of the melting house contributes to the dynamism and realism of the scene and all the elements are tied together using software lighting systems that reproduce the light coming out of the fire pits, through the open windows and ambiently in the external scenes. A number of illustrations and animations are available, copyright of the Humanities Research Institute and their technical media partner, Red Star Studios.[59]

The open source system *Radiance*[60] is an example of ray tracing system which allows developers of 3D models to introduce plausible lighting schemes across environments or onto objects. Comprising of a suite of over 50 tools, it was designed to work with a command-line interface on Unix and Unix-type systems and demands quite high levels of user knowledge. Very sophisticated results can be achieved however that can

[56] Humanities Research Institute, The Cistercians in Yorkshire, http://cistercians.shef.ac.uk/rievaulx/, (accessed 20 June 2007)
[57] Humanities Research Institute, Materialising Sheffield: re-presenting the past, http://www.hrionline.ac.uk/huntsman/index.html, (accessed 19 June 2007)
[58] Autodesk, http://www.autodesk.com/autocad, (active 13 March 2007)
[59] Humanities Research Institute, Materialising Sheffield: re-presenting the past, http://www.hrionline.ac.uk/huntsman/model.html, (accessed 20 June 2007)
[60] Radiance,

be used for examining the impact of different lighting conditions within a historic environment or a heritage related space.[61]

Fig. 4. Example of complex interior lighting scheme using Radiance

Useful representations of heritage-related environments can be further extended to include the audio properties of such spaces and this was also demonstrated at the recent Goldsmith's seminar. [62] Damian Murphy (University of York) presented the acoustic modelling work that he and others had carried out in a number of different environments and usefully illustrated the complementary ways in which aural and spatial research can be combined to add additional value to 3D digital models. His presentation referred to work carried out in the Hamilton Mausoleum,[63] (built 1848 -1857) a space that sustains sounds as echoes for fifteen seconds or more, and also Maes Howe in Orkney, a chambered cairn dating from 2450 B.C. that was studied for evidence of its resonance properties in order to determine whether this could shed light on the likely uses that the space was dedicated to. Acoustic measurement tools determined that strong standing wave effects that are well within the lower male vocal range were present within the interior, suggesting possible use as an effective location for ritual practices involving the use of the human voice.

Fig. 5 Acoustic research at the Hamilton Mausoleum (Damian Murphy – University of York)

[61] See reference to Methods Network Working paper: Archaeology: URL forthcoming ...
[62] Methods Network Seminar, Theoretical Approaches to Virtual Representations of Past Environments, 7 March 2007, http://www.methodsnetwork.ac.uk/activities/act15.html, (accessed 15 June 2007)
[63] Resonant Spaces, Hamilton Mausoleum, http://www.arika.org.uk/resonant-spaces/hamilton-mausoleum/, (accessed 21 June 2007)

Also resulting from research based at the University of York, *Roomweaver* is a Digital Waveguide Mesh (DWM) based tool that has been designed to ease the development and application of DWM models for virtual acoustic spaces.[64] The tool has the capability of generating Room Impulse Responses (RIR) and 3D models of the spaces under consideration and features a mixture of GUI and command line interfaces for the user to interact with the programme.

User Environments

The provision of digital information into the spaces set aside for museum, gallery and other cultural spaces encompasses some of the methods already described above (e.g. presentation/visualization) but also relates to the effective transmission of that data via a number of tools and techniques. A major report produced as part of the DigiCult[65] series, Thematic Issue 7 – The Future Digital Heritage Space[66] (2004), referred to a vision of 'ambient intelligence' and the ways that such a concept might have relevance to the heritage sector and its use of ICT methods. It quoted the Information, Society and Technologies Advisory Group[67] (IST) definition of the term to introduce the concept.

> The future generation of technologies in which computers and networks will be integrated into the everyday environment, rendering accessible a multitude of services and applications through easy-to-use human interfaces.[68]

The whole report is intended to provide a speculative roadmap of how and when this vision is likely to be implemented across the heritage sector and enumerates a number of different areas where ongoing research and technological development is required, all of which might usefully frame a discussion of the tools that are either being used or are in development.

- Intelligent and context-aware services incorporating technological and semantic interoperability to provide 'anytime, anywhere' information
- Personalised and multi-modal interaction with resources and environments
- An increased number of digital objects and environments to interact with including 3D, virtual and augmented reality examples
- New generations of large-scale, distributed libraries and archives of heterogeneous, complex and dynamic objects and resources
- Novel ways of sustaining resources and environments and providing persistent access

The DigiCult report references a number developments that the authors anticipated could make an impact on the MCH sector, an example of which is a technology in development that is being referred to as an 'intelligent carpet'.[69] These floor coverings are embedded with sensors and can also be combined with light emitting diodes, enabling software to determine the progress of visitors in a museum or gallery space and provide pro-active indications to guide them to specific exhibits or to steer them away from congested areas. Studies have also been carried out to determine what sort of visitor information can be harvested from data associated with how the visitor comes into contact with the floor surface and some studies suggest that combining information about weight, patterns of pressure, gait and frequency can give

[64] Digital Audio Effects Conference, 2004, Roomweaver: A Digital Waveguide Mesh Based Room Acoustics Research Tool, http://dafx04.na.infn.it/WebProc/Proc/P_268.pdf, (accessed 21 June 2007)
[65] DigiCult, http://www.digicult.info/pages/index.php, (accessed 21 June 2007)
[66] DigiCult, The Future Digital Heritage Space, http://www.digicult.info/pages/pubpop.php?file=http://www.digicult.info/downloads/dc_thematic_issue7.pdf, (accessed 21 June 2007)
[67] IST was an EU funded research and development framework programme (FP6: 2002 – 2006 and FP7 and beyond)
[68] DigiCult, The Future Digital Heritage Space, http://www.digicult.info/pages/pubpop.php?file=http://www.digicult.info/downloads/dc_thematic_issue7.pdf, p.10 (accessed 21 June 2007)
[69] Vorwerk Teppich, http://www.vorwerk-teppich.de/sc/vorwerk/thcarper_orgatech_en.html, (accessed 22 June 2007)

indications about the gender of a person (75% accuracy) and can make surprisingly good assumptions about their age.[70]

Another technological innovation the report cites as part of the vision of 'ambient intelligence' is the Smart-Its Project, a collaborative initiative of a consortium of organisations including Lancaster University.[71] The aim is to investigate the use of cheap, small and generic electronic devices that are embedded or attached to mundane objects. Through sensory functionality these devices are made aware of the environmental context in which they are placed and are also able to communicate with other devices in the vicinity and are customisable in what they perceive and how they transmit and receive data. This research and development group have designed and built a number of microcontrollers that communicate using *Bluetooth* and *Radio Frequency* and have investigated using context proximity as a paradigm for connecting artefacts, a field that clearly has implications for exhibition and event organisers seeking ways of intelligently providing information to visitors about adjacent or nearby objects.

Underpinning the intelligent and 'invisible' provision of data in an ambient information environment are wireless communication systems. Though not specific to the MCH sector, aspects of the way they function are interesting in the context of managing the visitor experience and have provoked research and user trials to assess their usefulness. Location Based Service (LBS) software can be used in conjunction with wireless network access points to plot where exactly a visitor is in relation to the exhibition space. The visitor is issued with a WiFi enabled device that picks up signals emanating from three or more wireless access points and this connection strength information is then analyzed by the LBS which uses triangulation methods to determine the whereabouts of the device and its relative location on a virtual exhibition map. LBS software takes up to 60 readings a second and averages out fluctuations in the readings. It also discards results that appear to be way outside of the average range of readings which helps with minimizing the effect of a number of issues that will alter the accuracy of these systems. Fluctuations in the radio signal strength; the number of simultaneous users on the system; atmospheric conditions such as humidity; and the number of bodies in the space, may all introduce errors to the system - although in general, systems are fairly accurate.

In addition to determining where visitors are in relation to objects and environments, a further step is to deliver relevant information that will enhance their experience of the exhibition or event. Obviously the easiest way of provisioning this data is to allow the user to manually navigate through menus on a hand-held device, but to take full advantage of location and/or context aware functionality, data could be streamed onto that device from a central server following appropriate proximity triggers. Alternatives to the use of LBS software include Bluetooth and infra-red tags or triggers, RFID tags (radio frequency identification), and GPS (global positioning systems) assisted devices where the environment is outdoors.

The choice of method will need to correspond to the type of data being delivered and the limitations of certain types of communication protocols have to be borne in mind. For instance, whilst WiFi is capable of connecting a potentially unlimited number of users (depending on the configuration of the TCP-IP network supporting it), and has a fairly effective theoretical data transfer rate (up to 54 Mbps for WiFi standard 802.11g) but it demands a significant power supply and therefore requires any object that takes advantage of this communications method to be relatively substantial. Bluetooth meanwhile was developed as a low power, low bandwidth, short range application for connecting a variety of devices together, but is unable to deliver large amounts of information efficiently and is thus not suited to disseminate rich multi-media content at the kind of transfer rates that would be acceptable to the average gallery-goer.

[70] Engadget, Intelligent Carpet Can Autodiscriminate, http://www.engadget.com/2006/07/26/intelligent-carpet-can-autodiscriminate/, (accessed 22 June 2007)
[71] The Smart-Its project, http://www.smart-its.org/, (accessed 22 June 2007)

An ICHIM 2005 paper by Nancy Proctor [72] refers to many of the above issues and also includes references to systems that take the idea of using networked communication between exhibitor and visitor one step further. Visitors are encouraged to bookmark items that catch their interest during the phase when they are actively engaging with the exhibits and are then able to review these items on a dedicated kiosk when they come out of the exhibtion area (e.g. Tate Modern Multimedia Tour Pilots and the *Visit+* system, in use at the La Cite des Sciences et de L'industrie in Paris). Such systems are designed to encourage the continuation of the cultural experience outside of the exhibition space and the use of printouts, emails or personal web pages to transfer and store information dynamically and intelligently gathered during visits is clearly an area where those responsible for the provision of cultural information should be looking to exploit.

Conclusion

Even this partial and skewed look at some of the tools and techniques that researchers in the field of Museums and Cultural Heritage might wish to engage with indicates what potential there is for a broad uptake of ICT methods in the sector. The widespread use of asset management systems such as TMS[73] (The Museum System) and MODES[74] is assumed throughout the community as is an understanding of digital imaging issues and at least some level of knowledge of cataloguing and classification methods. It is perhaps worth acknowledging however that there are yawning inequalities between the resources available to large national museums (to instigate and pursue technological solutions) and to those available to smaller regional and local organisations. As such, it may be worth underlining the value of collaboration between all levels of cultural organisations and researchers in a wide variety of academic departments, all of whom are looking to solve interesting challenges and would welcome the chance of doing so using rich and stimulating content matter as a starting point.

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Version control – 03 July 2007

[72] See: Nancy Proctor, Antenna Audio – Off base or on target? Pros and Cons of Wireless and Location-Aware Applications in the Museum, www.archimuse.com/publishing/ichim05/Proctor.pdf, (accessed 22 June 2007)
[73] The Museum System, http://www.gallerysystems.com/products/tms.html, (accessed 22 June 2007)
[74] MODES, http://www.modes.org.uk/, (accessed 22 June 2007)

References

The following are a sample selection of links that indicate the range of material that relates to the Digital Museum and Cultural Heritage sector. Some of these duplicate footnote references and others were consulted in the course of researching this paper. They are in no particular order within content headings

Contents

Blogs

UK Museums and the Semantic Web
http://culturalsemanticweb.wordpress.com/
AHRC funded thinktank for web 2.0/web 3.0 and museums discussion

MuseumBlogs.Org
http://www.museumblogs.org/
Directory of Museum and Museum related blogs and re-postings

Musematic
http://musematic.net/
Museum Computer Network and American Association of Museums discuss museum informatics and technology

Digital Heritage 2007
http://digitalheritage.wordpress.com/
Centre for Museology, University of Manchester

Open Objects
http://openobjects.blogspot.com/
Mia Ridge's blog

Conferences

International Cultural Heritage Informatics Meeting (ICHIM)
http://www.archimuse.com/ichim07/index.html
Organized by Canadian-based Archimuse but held in Europe and N. America

Museums and the Web

http://www.archimuse.com/conferences/mw.html
Also organized by Archimuse

Electronic Imaging Science and Technology
http://electronicimaging.org/call/08/
Not heritage related but very relevant for imaging related activities

InfoVis 2006
http://conferences.computer.org/infovis/infovis2006/
Information visualization conference that veers more towards art and design issues

VAST conference
http://conferences.computer.org/vast/vast2006/
IEEE Symposium on Visual Analytics Science and Technology

CHArt
http://www.chart.ac.uk/index.html
Computers and the History of Art

Guides and Good Practice

Good practices in Digitization
http://www.minervaeurope.org/bestpractices/listgoodpract.htm#digi
List from the MINERVA project of high quality centres of excellence for digitization

Digital Audio Working Group
http://www.cdpheritage.org/digital/audio/documents/CDPDABP_1-2.pdf
Very good overview of audio digitization issues

NINCH guide to good practice
http://www.nyu.edu/its/humanities/ninchguide/IV/
2002 guide to issues relating to Digital Representation and Management of Cultural heritage Materials

Organizations & Projects

Arts and Humanities Data Service
http://ahds.ac.uk/
UK based arts and humanities service offering storage, preservation and good practice services and advice

Arts and Humanities e-Science Support Centre
http://www.ahessc.ac.uk/
JISC funded project to promote e-Science methods

Viznet
https://wiki.viznet.ac.uk/bin/view
3D visualization Network

Society for Imaging Science and Technology
http://www.imaging.org/
non-profit organisation for imaging

DigiCult
http://www.digicult.info/pages/index.php

Technology Challenges for Digital Culture

RCAHMW
http://www.rcahmw.org.uk/nmrw.shtml
Royal Commision on the Ancient and Historical Monuments of Wales

Northern Ireland
http://www.magni.org.uk/future_developments/digital_museum/
The Digital Museum

Kinetica
http://www.kinetica-museum.org/new_site/index.php?ptitle=home%20page&mfile=home.php
New museum of kinetic electronic and experimental art – opened October 2006

British Museum Compass Project
http://www.thebritishmuseum.ac.uk/compass
UK contribution to good practice as quoted on MINERVA site

British Museum
http://www.thebritishmuseum.ac.uk/research/research_projects.aspx
List of Research Projects and activities at the BM

Research at the National Archives
http://www.nationalarchives.gov.uk/preservation/research/default.htm
open office and domesday discs research

Archimuse paper about Epoch's contribution
http://archimuse.com/publishing/ichim05/Niccolucci.pdf
technologies for the public's understanding of the past: Epoch's contribution

GUIDE project
http://www.guide.lancs.ac.uk/CrystalBall.pdf
GPS system for Lancaster tours

MDA
http://www.mda.org.uk/index.htm
formerly the Museum Documentation Association

Preservation & Repositories

Digital Curation Centre
http://www.dcc.ac.uk/
National centre for curation issues

Preservation Guide Wiki from BBC
http://wiki.prestospace.org/pmwiki.php?n=Main.Future
Refers to problems of audiovisual material

High Performance Storage System
http://www.hpss-collaboration.org/hpss/index.jsp
HPSS site indicates organisations that store petabytes of data

D-Lib on Format Migration

http://www.dlib.org/dlib/january05/rosenthal/01rosenthal.html
Transparent Format Migration of Preserved Web Content – emulation and migration

My Morph - data migration tool
http://www.imaging.org/store/epub.cfm?abstrid=30297
Web-based paradigm for file migration paradigm

DAITSS overview
http://www.fcla.edu/digitalArchive/pdfs/DAITSS.pdf
Digital preservation repository application

Global Digital Format Registry
http://hul.harvard.edu/gdfr/

National Library of Netherlands
http://www.kb.nl/dnp/e-depot/e-depot-en.html
e-preservation strategy for journal info

Digital Asset Management Strategic Plan – the Next Three years
http://www.cudenver.edu/SiteCollectionDocuments/Architecture%20and%20Planning/PDFs/StrategicPlanDigitalAssetManagementBackupWEBversion.pdf
plan for a slide library digitization process

JISC, Digital Preservation and Records Management Programme,
http://www.jisc.ac.uk/whatwedo/programmes/programme_preservation.aspx
UK funding body for various ICT related programmes

Resources

24 Hour Museum
http://www.24hourmuseum.org.uk/
Representing all UK museums and galleries

Public Catalogue foundation
http://www.thepcf.org.uk/index.php?id=43
Catalogue of publicly owned paintings in the UK

Heritage Gateway
http://www.heritagegateway.org.uk/gateway
Search and retrieval of records from English Heritage databases

ArchSearch
http://ads.ahds.ac.uk/catalogue/
Archaeology Data Service,

Software & Technology

Epoch – Tools
http://www.epoch-net.org/index.php?option=com_content&task=view&id=46&Itemid=88#
European Research Network of Excellence in Open Cultural Heritage

List of project management packages
http://www.infogoal.com/pmc/pmcswr.htm

commercial and free software

Choosing an XML editor
http://ahds.ac.uk/creating/information-papers/xml-editors/index.htm
AHDS report on a number of XML editors for different purposes

Wireless
http://archimuse.com/publishing/ichim05/Proctor.pdf
IR radio, wifi, bluetooth in museums

UWE page on the Video Spectral Comparator
http://science.uwe.ac.uk/ForensicScience/videospectralcomparator.htm
Developed for use in forensic science but with applications for cultural heritage

Damian Murphy acoustic modelling system
http://dafx04.na.infn.it/WebProc/Proc/P_268.pdf
Digital Audio Effects conference

AJAX methods
http://www.adaptivepath.com/publications/essays/archives/000385.php
Jesse James Garret, Adaptive Path, A New Approach to Web Applications,

The Smart-Its Project
http://www.smart-its.org
Context aware micro devices

Semantic Web

SIMILE
http://simile.mit.edu/
MIT based project to do various things with the semantic web

UK Museums and the Semantic Web
http://culturalsemanticweb.wordpress.com/
Blog run by Mike Lowndes and supporting discussion on web 2.0 and web 3.0

OWL
http://www.w3.org/2004/OWL
Web Ontology Language

SchemaWeb
http://www.schemaweb.info/
List of existing ontologies

DAML Ontology Library
http://www.daml.org/ontologies/
Further ontologies

SUMO
http://www.ontologyportal.org/
Suggested Upper Merged Ontology

Standards & Metadata

Persistent Identifiers
http://www.persistent-identifier.de/?link=204&lang=en
German website referring to DOI's (Digital Object Identifiers)

MIDAS XML case study
http://www.jiscmail.ac.uk/cgi-bin/filearea.cgi?LMGT1=FISH&a=get&f=/MIDASXMLCaseStudy_LBS.htm
English Heritage listed buildings

Critical Assessment of records management ...
http://northumbria.ac.uk/static/5007/tlkitrep.pdf
Toolkits for records management survey

Archimuse paper about open standards
http://archimuse.com/publishing/ichim05/Kelly.pdf
Dunning et al on open standards and the problems

CHIN on metadata standards
http://www.chin.gc.ca/English/Standards/metadata_documentation.html
Useful roundup of standards for museums

Getty research tools
http://www.getty.edu/research/conducting_research/
ULAN TGN and AAT

CIDOC
http://cidoc.ics.forth.gr/,
The International Committee for Documentation of the International Council of Museums

Open Archives Initiative Protocol for Metadata Harvesting
http://www.openarchives.org/OAI/openarchivesprotocol.html
Method for extracting metadata from archived information

Dublin Core Metadata Initiative
http://dublincore.org/
Widely influential metadata element set

The London Charter
http://www.londoncharter.org/index.html
Initiative to define standard approaches to visualization methods and documentation

Visualization & Imaging

King's Visualization Lab
http://www.kvl.cch.kcl.ac.uk/index.html
UK based visualization group

Cyark
http://archive.cyark.org/
3D and 2D models of world heritage sites

COOL
http://palimpsest.stanford.edu/bytopic/imaging/

Digital Imaging Links – Imaging and Imagebases

UCLA Cultural VR Lab
http://www.cvrlab.org/
Visualization lab

Cultural Heritage Imaging
http://www.c-h-i.org/technology/ptm/ptm.html

Second Life
http://secondlife.com/
Virtual World

ARCO
http://www.arco-web.org/index.html
Virtual object modelling EU project consortium

ARToolkit
http://www.hitl.washington.edu/artoolkit/
Software library for building AR applications

Web 2.0

COINE Project
http://www.ariadne.ac.uk/issue51/brophy-et-al/
Supporting Creativity in Networked Environments

STEVE
http://www.steve.museum/
Social Tagging for Museums Project

Powerhouse Museum
http://www.powerhousemuseum.com/home.php
Australian Museum initiative in social tagging

Social tagging and folksonomy
http://www.archimuse.com/research/www2006-tagging-steve.pdf
Jennifer Trant and Bruce Wyman, Archimuse, investigating tagging in art museums