ARIADNE *Web Magazine for Information Professionals*

E-Curator: A 3D Web-based Archive for Conservators and Curators

Mona Hess, Graeme Were, Ian Brown, Sally MacDonald, Stuart Robson and Francesca Simon Millar describe a project which combines 3D colour laser scanning and e-Science technologies for capturing and sharing very large 3D scans and datasets about museum artefacts in a secure computing environment.

Introduction: The Evolving Field of Artefact Documentation

Digital heritage technologies promise a greater understanding of cultural objects cared for by museums. Recent technological advances in digital photography and image processing not only offer a high level of documentation, they also provide powerful analytical tools for conservation monitoring of cultural objects.

Museums are increasingly turning to digital documentation and relational databases to administer their collections for a variety of tasks: detailed description, intervention planning, loan. Online collection databases support the remote browsing of collections [1].

Such imaging technologies open up radically new ways of knowing and engaging with collections, something which we are only really beginning to understand as of now. From remote accessing of objects to 3D displays and documentation, digital heritage technologies offer the potential to transform the very nature of the museum experience both from a professional viewpoint, and from the perspective of the visitor.

The *E-Curator* Project [2] was set up in 2007 precisely to explore some of these issues, using state-of-the-art imaging facilities at University College London (UCL). A collaborative project involving anthropologists, curators, and engineers, the principal aim of the project was to develop a new tool for museum and heritage conservation documentation. The use of an Arius3D laser scanner, housed in the UCL Geomatic Engineering Department, has enabled us to experiment with 3D documentation and the collaborative sharing of virtual 3D images of museum artefacts. We are evaluating 3D laser scanning for cultural heritage with methods from engineering metrology, bridging the gaps between conservation, curation and metric survey.

Our premise was that archives containing interactive three-dimensional artefacts should complement and support the existing databases and image archives of museum collections.

Aims of the E-Curator Project

The E-Curator Project '3D colour scans for remote object identification and assessment', based with UCL Museums and Collections [2], was an interdisciplinary collaboration drawing on UCL's expertise both in curatorship and in e-Science. The one-year project, which ended in October 2008, aimed to:

- develop a traceable methodology for recording the surface detail and colour quality of a range of object types and materials.
- explore the potential for producing validated datasets that would allow closer and more scientific examination of groups of objects, the processes involved in their manufacture, and issues of wear and deterioration.
- examine how the resulting datasets could be transmitted, shared and compared between disparate locations and institutions.
- begin to build expertise in the use and transmission of 3D scan data as a curatorial tool.

Figure 1: Visitors to the Petrie Museums of Egyptian Archaeology, UCL Museums and Collections. Photograph: Gary Black

The project is one of seven projects, all part of the e-science initiative of the Arts and Humanities e-Science Support Centre (AHeSSC) [3]. The project was jointly funded by the Arts and Humanities Research Council (AHRC), the Engineering and Physical Sciences Research Council (EPSRC) and the Joint Information Systems Committee (JISC).

Museum Practice Translated into a Virtual World

The E-Curator Project was an opportunity to exploit and test e-science technologies and to explore some of the opportunities they offer museum practice in a virtual world.

The research looked at the way curators and conservators examine and document objects for object identification, comparison and condition reporting. The project also focused on the extent to which 3D colour laser scans of artefacts might enhance our understanding of physical objects. We asked whether highly accurate 3D scans allowed us to extend beyond the limitations of the 2D photograph and catalogue entry or condition report.

We were interested to explore whether such deployment would enable curators and conservators to compare high resolution 3D colour records collected at different institutions stored remotely, or collected over a period of time under different conditions, in order to assess and monitor change. The project also provided an opportunity to test close-range scanning methods and critically assess their capability for heritage recording and documentation.

Our research also addressed the impact that digital heritage technologies have on the museum space as they attempt to recreate a digital facsimile of objects, museum spaces and displays in the digital realm. We aimed to understand the way different groups of stakeholders engage, form attachments and mediate material knowledge with the digital image [4].

Figure 2: E-Curator Workshop: object handling session discussing a painting by Walter Westley Russell "Beach Scene" from UCL Art Collection. Photograph: Ian Brown

Method and Technology Overview

UCL's varied collections [5] allowed us to select a range of diverse objects to form the basic study. Each object had curatorial or conservation-related questions embedded in its form; 3D colour digitisation combined with a digital curatorial process might seek to capture and present these to the museum user.

Each of these objects was scanned using a state of the art Arius 3D scanner, which is the highest resolution and most geometrically accurate 3D colour laser scanning system currently in the UK [6]. The 3D object scans and relevant catalogue information are stored on an e-Science

storage system, Storage Resource Broker (SRB) [7]. Curators and conservators can remotely access the 3D object scans and catalogue information via the E-Curator Web site [8].

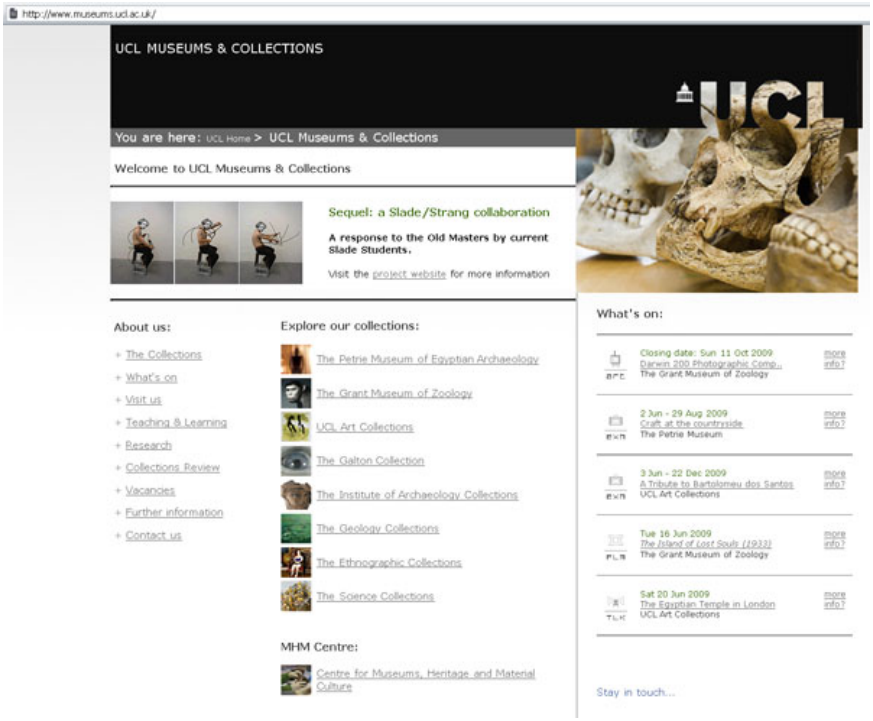


Figure 3: Entry page of Museums and Collections, showing the great variety of collections at University College London [5].

Digital Heritage Documentation

Museum specialists have traditionally used a combination of photography, text and drawings to document museum artefacts. These two-dimensional record formats suffer the limitations of being selective and insufficient to record nuanced information about the complete shape, colour and texture of an object.

Today some of the limitations of conventional documentation techniques can be addressed not only by using 3D colour scanning, which has the ability to record the whole object in the round, but also by disseminating the data with a shared Web-based database platform. These methods could in future become an accessible tool for heritage and museum specialists, laying a foundation for 'Virtual Heritage' [9].

The engineering sector has developed an understanding of these sensing technologies combined with precise measurement tools and guidelines to best practice, providing an established body of knowledge that can be directly exploited by the heritage sector to foster the rapid adoption of digital recording techniques [10][11].

3D Colour Laser Scanning

The 'Arius3D Foundation Model 150' scanner [6] offers a detailed non-contact and non-destructive documentation and examination method which makes it particularly suitable for conservation recording.

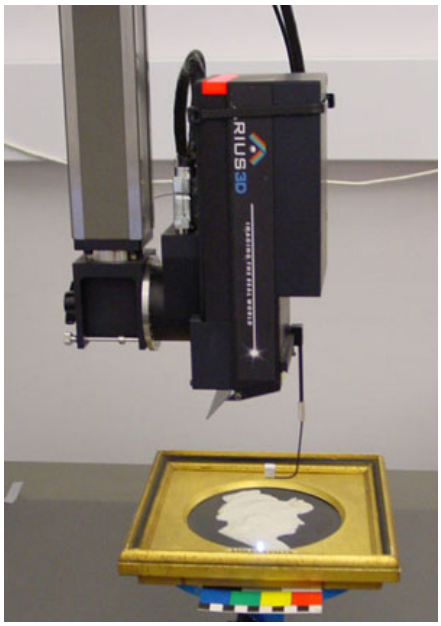


Figure 4: An object from UCL Art Collections (Portrait of Mrs Flaxman) under the Arius3D scanner. Photograph: Mona Hess

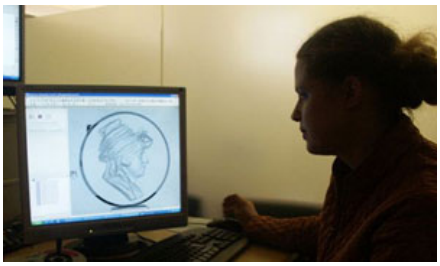


Figure 5: First results of 3D scan of Mrs Flaxman. Photograph: Wynn Abbott

Surface scanning is carried out by a scanner head which emits three laser beams of different wavelengths, red (R), green (G) and blue (B), in a focused white laser beam. The scan head simultaneously measures colour reflectance and geometry by triangulation between the laser and a camera, recording the laser reflection at each location illuminated by the lasers. Every point therefore has an XYZ coordinate location and an RGB colour value. A calibrated 'white cube' is used to supply data to enable any variations in background illumination and laser output power to be corrected on a scan line by scan line basis as part of an off-line colour calibration process. The Arius3D scanner head is mounted to a motion control system (Coordinate Measuring Machine), which moves it over the object. The single point accuracy of the scanning head in use at UCL is better than 25 microns in depth with the scan head and motion control system delivering a minimum spatial sampling interval of 100 microns. This sampling interval is commensurate with the laser spot diameter used to sample the surface within the field of view of the scanning head. To ensure consistent dimensional capability the unit is installed in an air-conditioned room that maintains temperature at 20 degrees and can control relative humidity to suit the objects being recorded. The scan product is a high-fidelity coloured three-dimensional point cloud with a point spacing of 100 μm (see Figure 10).

Our objective for the digital documentation of museum objects was to document the artefacts very precisely in geometry, scale and colour to produce a virtual three dimensional archival document that widens our knowledge of the object.

Impact of 3D Documentation on Conservation and Curatorship

The direct encounter with the material object will always have value for conservators and curators and includes an important learning process. Viewing and handling of the real object provides an essential comparison against which to assess the value of real time user interaction with the 3D digital colour model by museum specialists working within the *E-Curator* user interface. We are currently investigating how conservators can use the capabilities of the 3D documentation process to manage, understand and conserve the real object.

By these comparative means the digital image can be explored as a conservation analysis tool as it, for example, allows the eye to read the surface of an object, navigating inscriptions, paint strokes and the topology of the object by means of artificial raking light or the production of profiles. Further interpretations are made possible through the 3D record of an object: virtual reconstructions, animations and films for multimedia and education. Digital documentation can also draw on the dimensional and colour fidelity of a temporal succession of such digital records to allow reliable comparison and monitoring of the object over time.

Once scanning capture and data processing best practice are established, the method could provide an invaluable tool to test authenticity, to confirm authorship and to assess any change of damage or decay following a loan or exhibition by comparison of 3D data surface information.

E-Curator Prototype: A User Designed Interface

A particular strength of the *E-Curator* project lay in the participation of all stakeholders in all stages of the design and development process.

During the project, a number of internal and external formative workshops were held to offer curators, conservators and other museum specialists at UCL the opportunity to look in more detail at the proposed project and produce a more detailed specification and review criteria. The goal of the workshops was to find out what capabilities the users would like to have within the *E-Curator* application and to seek an optimal design for the Web-based interface by consulting and involving cultural heritage specialists. These workshops also allowed the team to refine the user interface of the E-Curator application, and to understand curatorial requirements for labelling and linking to

external data sources.

Figure 6: Building up a hierarchy of requirements after the E-Curator brainstorming session. Photograph: Mona Hess

A participatory approach to user-designed systems was used during the workshop. It began with a 'Condition Report and Catalogue Entry' session (see Figure 2), in which curators and conservators demonstrated the preparation of condition report and catalogue entry using objects from UCL Museums and Collections.

A brainstorming session was then carried out to tease out common requirements from the broad range of specialisms represented by those attending. Participants were requested to write a list of the features they would think as being most useful within the software. These features were then brought together and ranked. For example the brainstorming at the first workshop at UCL in March 2008 produced the following list of requirements: tactile and multi-sensory feature, visual requirements, comparative and consultant feature, machine sensing features, condition and conservation.

During the second half of the project single users were asked to browse their objects on a prototype of the *E-Curator* application and the direct one-to-one feedback further influence the software design. Evaluation sessions with curators and conservators and a summative workshop completed the software development phase.

Sharing 3D Colour Scans in a Secure Computing Environment

The use of digital technologies within the museum environment has led to the development of various software applications, which are used to manage the text and image records of museum artefacts. Most of the images administered by these museum applications are 2D images. In the *E-Curator* project, a Web application was developed to manage 3D images and relevant metadata [8].

For 3D colour scans to be of practical use, robust means of sharing and validating the data obtained need to be established. High resolution colour scans of one object can require hundreds of megabytes of storage space, and can only realistically be shared using the distributed file systems such as Storage Resource Broker (SRB) being widely deployed in the e-Science environment.

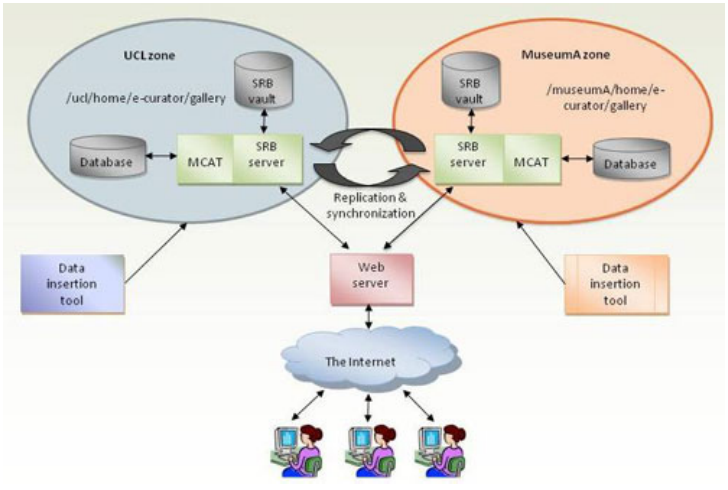
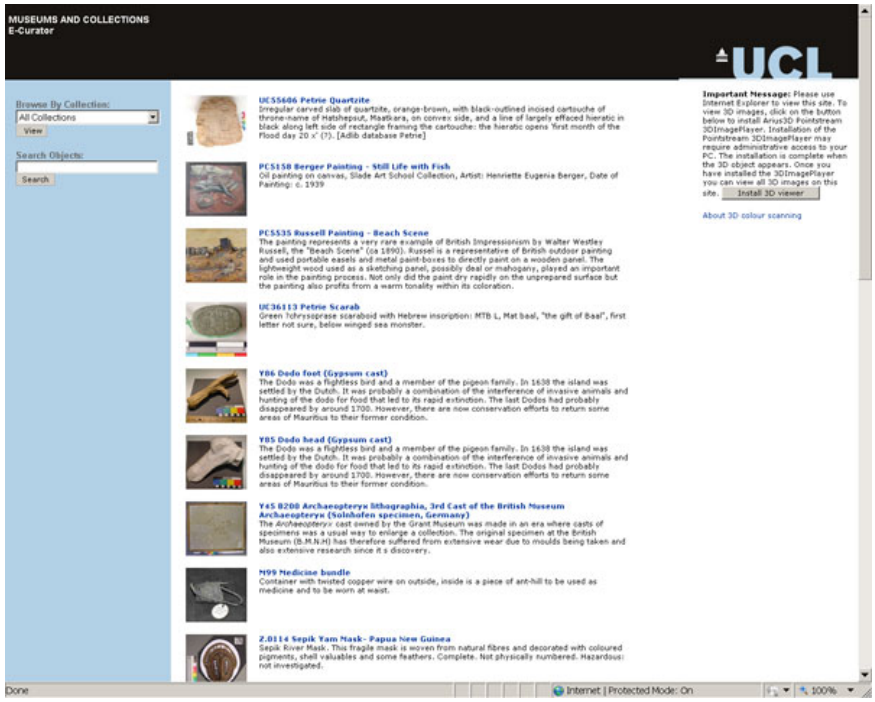


Figure 7: The E-Curator prototype architecture. Current implementation (top left) and future planned development (top right). Diagram:

SRB is a data grid middleware software system produced by the San Diego Supercomputer Centre (SDSC) [7]. The system implements logical namespaces (distinct from physical file names) and maintains metadata on data-objects (files), users, groups, resources, collections, and other items in an SRB Metadata Catalogue (MCAT) stored in a relational database management system. System and user-defined metadata can be queried to locate files based on attributes as well as name. The SRB system is middleware in the sense that it is built on top of other major software packages (various storage systems, real-time data sources, a relational database management system etc) and it has callable library functions that can be utilised by higher level software. However, it is more complete than many middleware software systems as it implements a comprehensive distributed data management environment, including various end-user client applications. It has features to support object management and collaborative (and controlled) sharing, publication, replication, transfer, and preservation of distributed data collections.

3D scans in Arius3D Pointstream format are loaded into SRB server using the SRB client software inQ [12]. These images are organised as a collection hierarchy. Images from different museums, for example, can be stored in separate sub-collections.



Figfure 8: Entry site of the E-Curator prototype with objects from UCL Museums and Collections [8].

We created a Web-based interface for users to access the 3D scan collection (see Figure 8). The interface provides both browsing support for examining the collection hierarchy, and analysis tools for manipulating both 2D and 3D coloured point clouds (see Figure 9). The Web interface also allows users to display multiple 3D images at the same time and thus facilitates the visual comparison of collections of museums artefacts. A hierarchy for these records has been established including the aligned 'registered' version of the point cloud without colour or point processing, a 'processed' version with cleaned colours and geometry, and a 'presentation' file with optimised colours and filled data voids. For the use of conservators and curators the second model will be the most relevant since it encompasses the complete object in one data set but has undergone the least data alteration and processing.

Thus the Web site and its SRB supporting system is designed to function as an essential interface for object identification and assessment. With an appropriate storage infrastructure, data sets may also be interrogated more widely by researchers around the world.

The utilisation of Grid technology through SRB and an allied Web based interface is expected to prove extremely useful in providing a scalable solution for the dissemination of information from the *E-Curator* project to a multitude of users (figure 8). Currently the user group is limited to a museums and collections community who are involved with project assessment and the development of further E-Curator capabilities, but the system will be made available to external users on both real and virtual visits to UCL Museums and Collections sites in the near future.

Object Metadata

3D representations of heritage objects and museum artefacts need to contain a clear 'provenance' of object history and ownership, but also a set of data describing the genesis of the 3D files. User access to metadata within the *E-Curator* application allows further study of the history, exhibition and conservation information of each of the objects (see Figure 9).

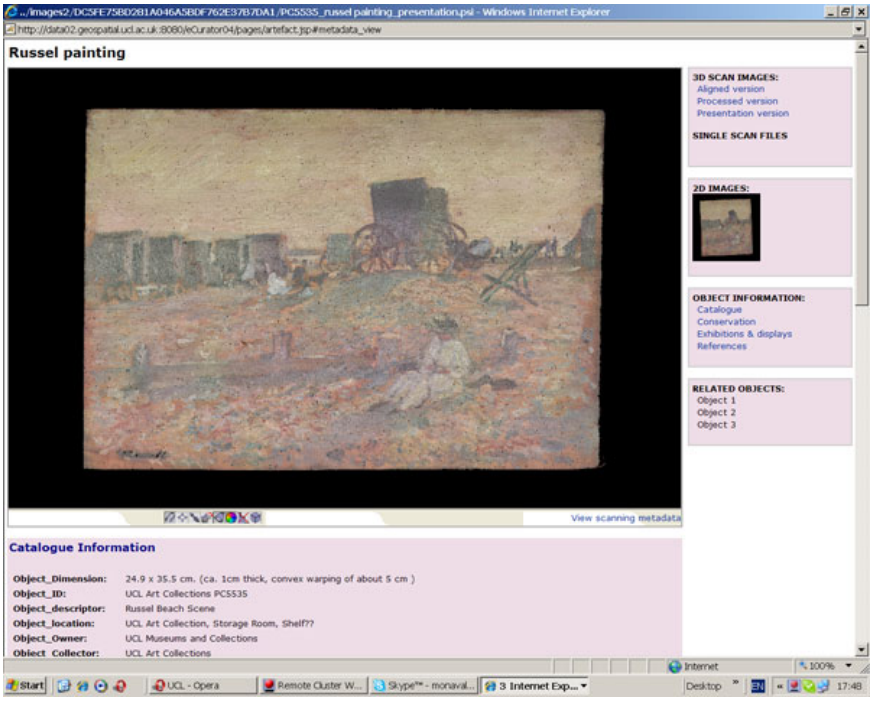


Figure 9: Russell painting from UCL Art Collections ready to browse in the E-Curator prototype, object metadata underneath the 3D object

The metadata used to describe the 3D images generated within *E-Curator* is based on SPECTRUM, the UK Museum Documentation Standard, for catalogue entries [13]. These metadata provide information about the object ID, physical description, location, historical facts, condition, exhibition and conservation

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We developed a specific metadata set for the *E-Curator* application that includes UCL Museums and Collections catalogue entries, images and photographs, even microscopic images. Every three-dimensional record is also annotated with metadata concerning capture, import and colour calibration filters, and any particular scan process and post processing information. This dataset provides the user with clear information about the production and the authorship of the 3D image. The development of the scan metadata set has largely followed the recommendations of English Heritage for Scandata [14] and the 'Big Data' project' for Arts and Humanities data [15].

The current version of the London Charter [11] is directed towards some of the problems and possibilities that arise from 3D colour scanning as a documentation tool in heritage documentation and thus to the E-Curator research project, but it does not yet embrace established engineering metrology approaches which could provide a common basis for 3D data comparison. A common file format for archiving 3D scans in the museum sector is yet to be agreed on, let alone formalised [16].

Users' Impressions

A key feature of the E-Curator Project was the participation of potential application users in the design and development process. The Web site functions as an essential interface for object assessment which in the future can be built upon to include a wider selection of objects and a richer tool repertoire.

Users' overall impression of the interface, expressed in surveys and interviews, can be summarised as 'user-friendly and intuitive'. Users felt that 3D colour scans provided significant new information, but they raised questions about the authenticity of images. They felt that clear protocols were needed for processing data and the final results must integrate fully with existing museum digital collections records. Users opted for higher resolution images (only 'light' reduced resolution versions of 3D images had been uploaded on the prototype) together with a better representation of colour and texture in the model.

The E-Curator application source code has been made freely available under an open source GPL licence in Sourceforge [17]. It is thus open to further community development so long as new modifications are made freely available under the same GPL licence.

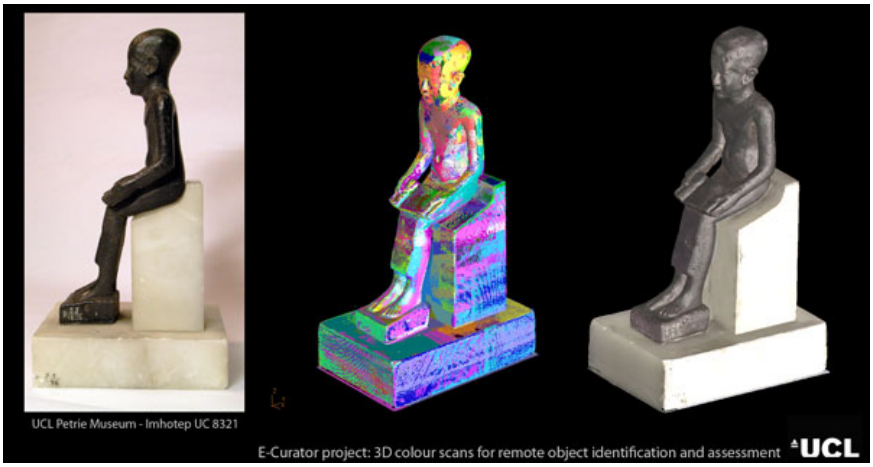

Figure 10: From physical to virtual object: Imhotep bronze statuette (UC8321) of the UCL Petrie Museum of Egyptian Archaeology. Left: Photograph of the object, middle: single scans aligned in false colour mode, right: aligned 3D colour scan.

Conclusion

E-Curator brought e-science and 3D colour recording technologies together to develop a Web-based system for 3D colour digital records of museum and cultural objects. The processes and procedures adopted follow and further develop best practice in disciplines ranging from museum curatorship, engineering metrology, computer science and cultural object handling to deliver a state of the art e-science application which is being tested by experts in all three fields.

Digital heritage technologies are radically changing the way we engage with material culture and are negotiating new ways of knowing and understanding the object. The digital objects and tools offer a reconfiguration of practice and suggest different means of virtual engagement with objects. In this realm of Virtual Heritage, examination of the surface materiality and object topology is possible through detailed 3D documentation. E-Curator could be further developed to incorporate haptic technology and microscopic images into the 3D structure.

The developed system, a novel cultural heritage application, accessed through its supporting Web site, has the capability to provide an interface and storage infrastructure capable of supporting the dissemination of both existing museum records and a hierarchy of 3D colour models to a global audience.

Acknowledgements

We would like to thank the AHeSSC for its support, and all the participants of our workshops from UCL, MAA Cambridge and English Heritage York. Many thanks to Manjula Patel and Richard Waller of UKOLN who invited Mona to beautiful Bath in March 2009 to give a talk at UKOLN, which triggered the writing of this article.

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Author Details

Mona Hess
UCL Museums and Collections (now UCL Civil, Environmental and Geomatic Engineering)
University College London
Gower Street
London WC1E 6BT
United Kingdom

Email: m.hess@ucl.ac.uk

Web site: http://iris.ucl.ac.uk/iris/browse/profile?upi=MHESS91
E-Curator project website: http://www.ucl.ac.uk/museums/petrie/research/research-projects/3dpetrie/3d_projects/3d-projects-past/e-curator

Graeme Were
University of Queensland, Australia

Email: g.were@uq.edu.au
Web site: http://researchers.uq.edu.au/researcher/2505

Ian Brown
Oxford Internet Institute, United Kingdom

Web site: http://www.oii.ox.ac.uk/people/brown/

Sally MacDonald
(now Museum of Science and Industry, Manchester)
UCL Museums and Collections
University College London
Gower Street
London WC1E 6BT
United Kingdom

Stuart Robson
UCL Civil, Environmental and Geomatic Engineering
University College London
Gower Street
London WC1E 6BT
United Kingdom

Email: s.robson@ucl.ac.uk

Francesca Simon Millar
UCL Museums and Collections
University College London
Gower Street
London WC1E 6BT
United Kingdom

Article Title: "E-Curator: A 3D Web-based Archive for Conservators and Curators"
Author: Mona Hess, Graeme Were, Ian Brown, Sally MacDonald, Stuart Robson and Francesca Simon Millar
Publication Date: 30-July-2009 Publication: Ariadne Issue 60

Date published: *Thursday, 30 July 2009*