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Mona Hess, Francesca Simon Millar, Yean-Hoon Ong,
Sally MacDonald, Stuart Robson, Ian Brown, Graeme Were

E-CURATOR: 3D COLOUR SCANS FOR OBJECT ASSESSMENT

E-curator project team: Mona Hess, Francesca Simon Millar, Yean-Hoon Ong,
Sally MacDonald, Stuart Robson, Ian Brown, Graeme Were
UCL Museums and Collections
University College London
Gower Street
London, WC1E 6BT
United Kingdom
E-Mail: e-curator@ucl.ac.uk, m.hess@ucl.ac.uk, f.millar@ucl.ac.uk, yean-hoon.ong@ucl.ac.uk, s.macdonald@ucl.ac.uk, srobson@cege.ucl.ac.uk, ian.brown@oii.ox.ac.uk
URL: http://www.museums.ucl.ac.uk/research/ecurator/

Abstract

Realising the importance of digital technologies and new interdisciplinary possibilities, the E-curator project has been undertaken by UCL Museums and Collections with the goal of applying two state of the art digital technologies: 3D colour laser scanning and e-Science technologies. This project captures and shares very large three-dimensional scans and detailed datasets about museum artefacts in a secure computing environment. This paper presents an overview about the E-curator project focussing specifically on the integration of user needs through the participatory user interface design process.

INTRODUCTION

The E-curator project in progress since October 2007 at University College London (UCL), Department of Museums and Collections, is an interdisciplinary project which draws on UCL's expertise both in curatorship and in e-Science.

The multi-disciplinary project group draws specialists from the departments of anthropology, computer science, geomatic engineering and remote sensing and college collections of UCL and University of Oxford. The E-curator project is an opportunity to exploit and analyze e-Science technologies and explore some of the opportunities they offer museum practice in a virtual world. Such deployment will enable curators and conservators to compare records collected at different institutions,

stored remotely, or collected over a period of time under different conditions, in order to assess and monitor change.

It is a one-year project which aims to: (a) develop a traceable methodology for recording the surface detail and colour quality of a range of object types and materials; (b) 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; (c) examine how the resulting datasets could be transmitted, shared and compared between disparate locations and institutions, for effectiveness in conservation reports and data transmissibility vis-à-vis conservation and object loans and (d) to begin to build expertise in the use and transmission of 3D scan data as a curatorial tool and to test close-range scanning methods and critically assess their capability for heritage recording and documentation.

Our complementary research with state of the art e-Science methods, using Storage Resource Broker (SRB) and investigation in the latest 3D colour laser scanner technology (Arius 3D) for museum objects should provide a useful user-friendly shared web-based shared platform for curators, conservators, heritage and museum specialists.

MOTIVATION

Museums have a responsibility for the stewardship and care of the objects and collections they contain. Codes of Ethics for museum staff and conservators protect objects or monuments from irresponsible damage and to ensure their preservation for future generations (AIC 1996). Curators and conservators have an obligation to the careful and thorough production of documentation and recording of an object as part of a collection, before and after a preservation or conservation treatment (ICOM 1996, Article 20). The Codes of Ethics call for '*written and pictorial records'* (ECCO 2006) and for the application *'highest possible standards'* (ICOM 1996) of as part of the

diagnostic examination and recording of a museum object. The E-curator project aims to enhance existing conventional techniques through the use of a new software tool.

Whilst the direct encounter with the material object will always have value for conservators and curators and includes an important learning process, museum specialists have traditionally used a combination of photography and text to prepare illustrated catalogues and reports for the purposes of object identification, object-tracking, object comparison and condition checking. Such examinations are typically made within an institution and when objects travel in touring exhibitions. Conventional imaging and documentation techniques have always been strictly two-dimensional. These standard record formats have the limitation of being very selective and insufficient to record nuanced information about the complete shape, colour and texture of an object.

State of the art digital technologies as e-Science and 3D colour laser scanning complement conventional documentation and examination techniques for cultural heritage and for the Arts and Humanities more generally. This digital data and virtual heritage (VH) is relatively new to the cultural heritage field and good practices and guidelines must be applied to ensure its effective use.

An important issue in the production of this new type of data is its longevity and accessibility. Museum staff have a responsibility to ensure availability of the data for their successors in cultural heritage preservation. Re-assessment of traditional recording and monitoring standards is necessary in order to begin building expertise in the use and transmission of 3D scan data as a curatorial tool. The E-curator project is addressing some these issues and working towards creating reliable and sustainable data.

The ‘highest standards’ of documentation for cultural heritage will change with new technologies. Some current limitations can be addressed through the use of 3D colour laser scanning, which has the ability to record the whole object in the round and in great detail, through dissemination of data via a shared web-based database platform,

and using e-Science expertise. These technologies must be both affordable by and accessible to heritage specialists if they are to be widely adopted.

METHODS AND APPROACH

A core group of six objects was selected from UCL Museums and Collections to form the basic study of the E-curator project. The objects span a range of disciplines; archaeology, anthropology and art. Each of these objects is scanned using a state of the art Arius3D Foundation Model 150 colour scanner.

Each of these objects presents curatorial or conservation questions embedded in its form that 3D colour digitisation combined with a digital curatorial process seeks to capture and present to the museum user.

Technical equipment for 3D colour laser scanning

The 'Arius3D Foundation Model 150' scanner[1] offers a detailed non-contact and non-destructive documentation and examination method which predetermines its use for conservation recording.

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 has therefore a XYZ coordinate location and an RGB colour value. A calibrated 'white cube' is used to provide a reference surface 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

[1] Arius 3D Inc., Ontario, Canada, www.arius3d.com accessed 28 May 2008.

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.

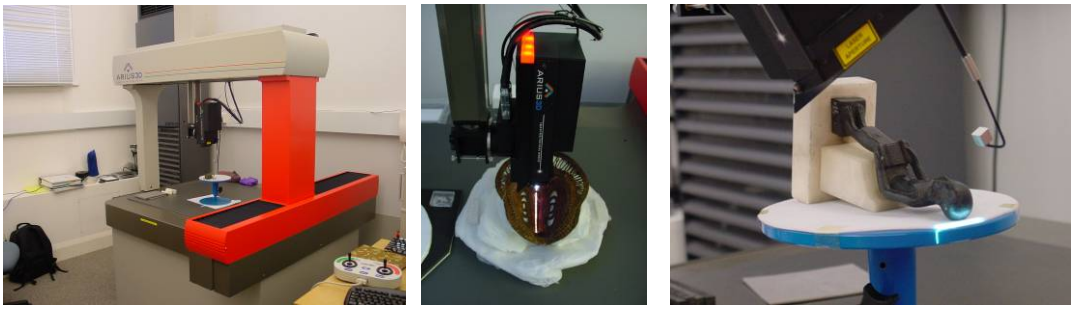

Figure 1 Arius 3D Colour Laser Scan of E-Curator core objects at UCL.

The post-processing work on the recorded data consists of several consecutive steps. First the raw scan data is imported into the proprietary Arius3D, Pointstream 3D Image Suite software[2], which is specifically designed software to process and visualize the densely sampled 'point cloud' data. The next step controls the optimum alignment of the different component scan records in order to register them together using a point cloud to point cloud iterative closest point procedure. The point cloud data are then cleaned to remove overlapping geometry using both manual editing and automatic filtering of multiple points based on combinations of geometry and colour content. After editing the geometry and colour information the component records are merged into a single scan image.

A systematic approach and methodology for organic and inorganic materials has been developed within the project to ensure repeatability of the scan process. The resulting coloured point cloud data available within the E-curator application provide a highly accurate surface analysis tool.

[2] Pointstream 3D Image Suite Software (Version 2.9.0.0.) by Pointstream Inc., Canada, www.pointstream.net accessed 28 May 2008

The Arius3D Scanner offers unique new possibilities to fulfil the claim of the Codes of Ethics of heritage professionals to use such tools for best documentation especially where traditional techniques cannot record all features. However traceable procedures and standards for good practice in close range 3D laser documentation must be further investigated and a common file format for archiving 3D scans in the museum sector is yet to be agreed.

E-science system Storage Resource Broker (SRB)

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)[3] being widely deployed in the e-Science environment.

SRB is a data grid middleware software system produced by the San Diego Supercomputer Centre (SDSC). 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), which is stored in a relational database management system. The SRB has features to support the management and collaborative (and controlled) sharing, publication, replication, transfer, and preservation of distributed data collections.

3D scans in Arius3D Pointstream format are stored on the SRB server as a collection hierarchy. A web-based interface is developed to allow users to access the 3D images.

Participatory Approach of User Interface Design

The novel approach and a particular strength of the E-curator project is in the expressed participation of all stakeholders into the design and development process at

[3] Storage Resource Broker (SRB), http://www.sdsc.edu/srb/index.php/Main_Page, accessed on 18 May 2008.

all stages. These range from the initial condition report through the scanning, data processing and visualisation of the selected objects to the final use of the application.

The workshops allow curators and conservators to articulate what they want from an application interface.

RESULTS

E-curator workshops: a requirement gathering process

An initial workshop was held in February 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. This workshop 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.

The goal of the workshop was to find out what capabilities the users would like have within the E-curator application and to seek an optimal outcome for designing the interface for the web-based software tool.

The user-designed interface takes into account the everyday practices of conservators and curators in an encounter with the real. A participatory approach to user-designed systems was used during the workshop. It began with a 'Condition Report and Catalogue Entry' session, in which curators and conservators demonstrated the preparation of condition report and catalogue entry using objects from UCL Museums and Collections. They were observed by the E-curator team, and asked to “talk through” each task so that a detailed understanding could be gained of how they undertake these processes.

The session was carried out in order 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, with each idea written on an individual Post-It note.

Figure 2 Impressions from the first E-Curator workshop at UCL, February 2008.

These Post-It notes were then clustered by similarity. The workshop participants organised the clusters into a rank-order list according to their priorities. The clusters were described as follows:

The *tactile and multi-sensory features* include analysis tools such as looking closely at paint strokes or inscription to examine depth and shape. The object was then scrutinized for its textures, colours, tool marks, motifs and inscriptions and for signs of wear and tear. Other desired features included multi-sensual information about the feel and the weight of the object, the roughness of the surface, its smell and its sound. These requirements are related to a corporal relationship to the object and how a tactile relationship is configured through an interanimated relationship with the real. These qualities were the ones thought most at jeopardy in an encounter with the 3D digital image.

The *visual requirements* related to the visual encounter with an object and the steps taken by the conservator to inspect the object from all sides and views. This initial visual encounter in conservational practice was supplemented by deeper analysis of the surface through the viewing of cross sections (that can easily be re-created from the three-dimensional point cloud) and “virtual blinking”.

In the *comparative and consultant feature* list a very important issue was raised by the conservators and curators who wanted to share their impressions and results with external specialists of other fields. The suggestion was that they should be invited to the E-Curator application website to leave comments about the objects. This would enable the platform to really function as a shared knowledge base for an object or a group of similar object with comments and interaction by specialists of different disciplines.

The *machine sensing features* suggest including images of analyses previously made on the artefact using other sensing tools such as X-radiographs, ultraviolet (UV) and infrared (IR) photography. Other interactive analysis tools, such as viewing under raking light and the change of surface specularity, are required to look at certain aspects of the object more closely.

Many *condition and conservation* questions arose about the objects' fragility and flexibility, surface conditions and overall condition and structure. Virtual reconstruction would in some cases be very helpful to assess the current condition of an artefact and provide a suspended animation of the form that could be used to document the object with future scan results.

The *interpretative* section raised questions about information beyond the object, for example about the object's background, its use and its connection to a greater group of object types, classification and morphology.

A general question was raised about the trustworthiness of the digital image and the extent to which the digital image could be relied upon for conservation practice.

The E-curator application prototype

Some of the user requirements have been implemented in a Web-based prototype and are now available to users. Users can access the 3D images via an Internet Explorer-

based interface. For each object, an Arius ActiveX browser plug-in allows users to tumble, pan, zoom and rotate the available 3D scans. Other analysis tools are to alter lighting conditions, colour display and check key dimensions of the objects. Scan data and object metadata is stored in an SRB database. Java middleware running on a Tomcat[4] server generates a browser-based user interface to provide user access to this data, making use of the JARGON[5] Java API to connect to SRB.

Links to different sets of raw and processed data are provided if the user is interested in examining the 3D images generated at different scanning and data processing stages. 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.

These features supplemented by relevant metadata could be used by curators and conservators in multiple ways. They offer the opportunity for remote identification, for example to compare similar artefacts or to document environmental damage over time.

[4] See http://java.sun.com/products/jsp/tomcat/ , accessed 18 May 2008.
[5] See http://www.sdsc.edu/srb/index.php/Jargon, accessed 18 May 2008.

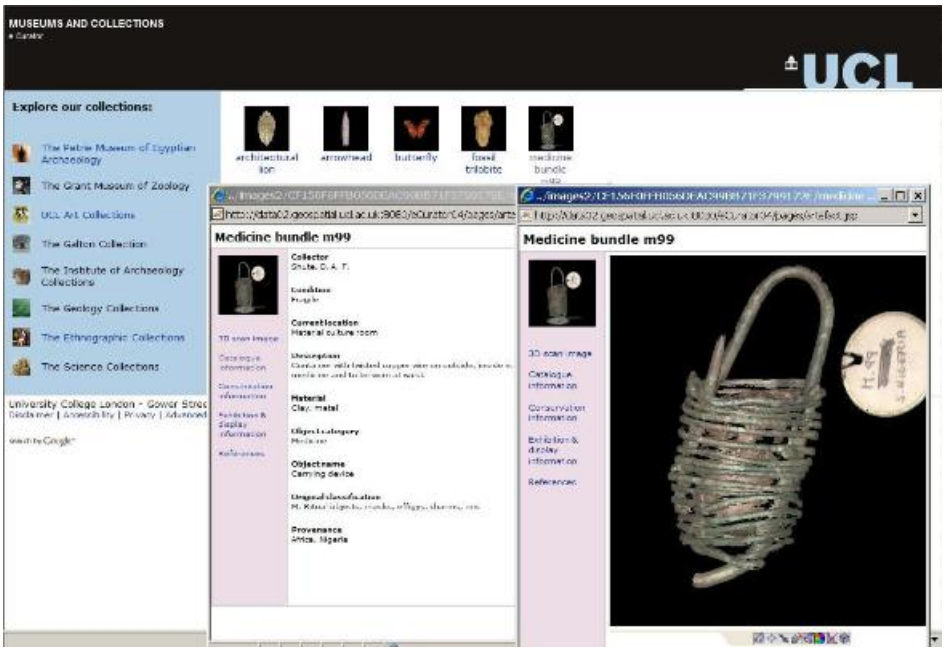

Figure 3 Prototype of the E-Curator application.
View of browsing one of the 3D core objects, a medicine Bundle from West Africa.

Metadata requirements for the E-curator prototype

3D representations of heritage objects and museum artefacts need to have a clear 'provenance'. This includes both a description of history and ownership of the object and a clear set of data that describes the production of the digital 3D scans of the object.

The E-curator team has developed a specific metadata set for the E-curator application that includes UCL Museums and Collections catalogue entries. The metadata used to describe the 3D images is based on SPECTRUM (1996), the UK Museum Documentation Standard for catalogue entries. These metadata include information about the object ID, physical description, location, historical facts, condition, exhibition and conservation information. The metadata provides a relevant framing for artefacts such as historical and archaeological facts, conservation information, exhibition and display information. The data is collected from local databases and paper documentation currently kept at UCL museums.

Every three-dimensional record is also annotated with metadata concerning its capture, the import and colour calibration filters used, 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.[6]

The London Charter is influencing the development of these processes as it is aiming directly at the problems and possibilities that arise from 3D colour scan as a documentation tool in heritage documentation.[7]

CONCLUSION AND FUTURE OUTLOOK

Our present research has revealed a series of results and several areas raise questions that need to be answered in different contexts. A follow-up project would greatly facilitate further developments both in the E-curator project and in the Virtual Heritage field.

Further requirement gathering processes for the E-Curator application

At this stage more workshops are planned, hence more clearly articulated and generalized requirements are expected. They will follow the format of the workshop described above. During the coming months single users will be asked to browse their objects on a prototype of the E-curator application and the direct one-to-one feedback will influence the user interface design. Evaluation sessions with curators and conservators and a summative workshop contribute will round up the software development phase.

The E-curator application prototype development

[6] The development of the metadata set has largely followed the recommendations of English Heritage for Scandata (2006) and 'Big Data' project for Arts and Humanities data (2007).
[7] The current version of the London Charter"*For the use of 3-dimensional visualisation in the research and communication of cultural heritage"* requires the careful creation of a metadata-set which should facilitate the 'Transparency Requirements' (Principle 4) of the process. The Charter also calls for a 'documentation of the interpretative decisions made in the course of a 3d visualisation' (Section 4.5). The E-Curator project aims to fulfill both these requirements.

Existing application features will be extended by inserting more information about the objects in the form of links to publications and references, conservation reports, photographs, microscopic imaging. A user interface will be designed to enable selected and trained people to upload files and information to the database.

A ranked list of objects, which are to be scanned for scientific and conservation reasons, will be set up. This list can encompass different collections and institutions across the country and possibly even abroad.

Unfortunately not all of the features requested by curators and conservators can currently be realized. Some of the envisioned computer features, such as smell and feel and 'virtual blinking', are futuristic, but necessary for an interanimated tactile relationship with the virtual. However the 3D digital images created in the E-curator project offer a reconfiguration of current practice and suggest a step forwards at a virtual engagement with digital objects

Virtual Heritage and the E-Curator project

In this realm of Virtual Heritage, examination of the surface materiality and object topology is possible through detailed 3D documentation. It is useful to further note the possibilities that can be built on the E-curator project incorporating haptic technology and microscopic images into the 3D structure.

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