3D COLOUR IMAGING FOR CULTURAL HERITAGE ARTEFACTS

Research in colour object recording and documentation for heritage end users

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My research aims and objectives

• Can digital collections, with a combination of scientific imaging and 3D technologies, be used for a new scientific exploration of a virtual object in a museum context?

• Development of a fit for purpose platform for methodology decisions and research tool

• Technology transfer so that CH specialists have their voice in the decision making process of 3D recording
context: cultural heritage

- The Venice Charter – 1964 International Charter for the Conservation and Restoration of Monuments and Sites (ICOMOS), ICOM, ECCO
- cultural heritage professionals – strong interdisciplinarity
- conservators and curators: code of ethics
- museum: memory institutions, public accessibility, mission of stewardship and care for objects and collections
- common goal: to safeguard and preserve our heritage for future generations
cultural heritage recording

UCL Collections
Review ©UCL
Museums and
Collections
http://www.ucl.ac.uk/museums/review/

Mobile Mapping System
versus hand cartography of damages, city hall of Neuburg/Donau Germany, University of Bamberg, 2004

Object handling session,
E-Curator workshop, Feb 2008
Egyptian quartzite UC55606,
UCL Petrie Museum
cultural heritage recording

UC14306 – UCL Petrie Museum of Egyptian Archaeology – Online database

• combination of text, photography, drawings
• provenance and metadata
• plus scientific imaging results

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context: engineering metrology

• imaging and survey technology, non-contact non-destructive measurement techniques
• numeric evidence, quantitative recording, evaluation methods for results,
• deliver consistent high image quality in 2D and 3D
• But also: ground truth versus ‘in the field’ / ‘in the museum’ / ‘in the storage’
triangle of forces

museum object

environment/context

cultural heritage recording

conservator
curator

best practice

recording technology
stakeholders in cultural heritage recording

• biography of the object / conservation
• highly detailed documentation / conservation & metric survey
• accessibility for the researcher and the public / museum and curator
• evaluation of recording quality / recording technology & conservator
• decision tree / curators & conservators
Context: Heritage professionals and digital documentation

Elizabeth Pye, UCL Archaeology, Workshop Feb 08

Sepik Yam Mask- Papua New Guinea, Z.0114 UCL Ethnographic Collection
Analysis results from 3D objects
Context: Heritage professionals and digital documentation

- Architectural survey
- Museum object recording
- Photographic imaging
- Laser scan
- Optical microscopy

Scale:
- 100m
- 10m
- 1m
- 10 cm
- 1 cm
- 1 mm
- 100 µm
- 1 µm
- 1 nm

NB: not to scale!
The main conservation procedures are diagnostic examination and analysis, preventive conservation, remedial conservation, restoration and documentation. (UK Museums Association, 2007)

Documentation is essential in the practice of conservation (Pye 2001, p.103)
workflow in a museum – slide show

Object Acquisition

Conservation Check

Documentation before and after treatment

Condition Report

Accession

Documentation

Object entry

Object use or storage

Research/ Scientific Analysis

Storage

Exhibition

Events for the object

Reproduction

Digital Repatriation

Exhibition

Loans/ Despatch/ Deaccession

Regular Condition Check /Monitoring
E-Curator - 3D colour scans for object assessment

• The E-curator project aims to enhance existing conventional techniques through the use of a new software tool.

• 3D colour scanning: to develop a traceable methodology for recording surface detail and colour quality of a range of object types and materials.

• the deployment of e-Science for the sharing of the collected 3D data sets and related metadata between disparate locations and institutions.

• Participatory design approach: involve all stakeholders

A one-year research project at University College London Museums and Collections: September 07 to October 08

Ian Brown, Mona Hess, Sally MacDonald, Francesca Simon Millar, Yean-Hoon Ong, Stuart Robson, Graeme Were
3D imaging requirements for a museum end user

User designed interface: Formative workshops with curators and conservators. Catalogue entry and Condition report session and one-to-one interface testing.

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3D imaging requirements for a museum end user

Formative workshop with curators/conservators; object handling session

Requirement gathering process - Hierarchy of features from the brainstorming session BEFORE ‘encountering’ a 3D digital object

- tactile and multi-sensory feature
- visual requirements
- comparative and consultant feature
- machine sensing features
- condition and conservation

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User testing on E-Curator prototype and evaluation criteria

• The prototype was used to explore central data storage, and online viewing of the 3D models without the need for specialist software.

• User group of conservators and curators

• Higher specification and better rendition of colour, reflectivity and texture
research project 2007-2009: E-Curator - 3D colour scans for object assessment - FILM

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3D imaging requirements for a museum end user

• user testing on E-Curator prototype
  – User group: varied disciplines. 20 cultural heritage specialists, 13 of whom were either curators or conservators

• Result: 3D objects
  Higher specification in terms of higher resolution, better rendition of colour reflectivity and texture

![Diagram showing requirements: colour, texture, material, geometry, accuracy, authenticity, reliability, user-friendly, analysis options]
UC79377 cartonnage mask, currently undergoing conservation, UCL Petrie Museum

**Decision Tree**

**Object**
- Digital documentation
- Measurement
- (identify) quantify damage
- Monitoring/comparison
- Multimedia representation
- Replica

**Goal**
- Sensor portability
- Resolution
- Colour (fidelity)
- Metric accuracy
- Data output

**Criteria**

**Alternatives**

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Future work: decision tree development

- User survey: development of e-questionnaire and hardcopy questionnaire.
- Decision tree based on multi-criteria decision analysis
  - criteria preferences
  - eg analytic hierarchy process (AHP)
- Integrate: imaging recommendations
- Integrate: taxonomies with equivalent expressions for
  - conservation and heritage specialists
  - recording technology
- evaluation of results!
Future work: user survey to find out about 3D imaging requirements for a heritage end user

- Target audience: for cultural heritage professionals, dedicated, non mediated survey
  - Statistical data about the target audience
  - General information about technology/ documentation in the institution/company
  - Use of 3D digital documentation in the institution or company
  - Motivation/ curatorial or conservation questions for a 3D documentation
  - Persuasive characteristics, criteria and requirements of a 3D image and the ranking of criteria
  - Extent of exploitation for scientific analysis of the 3D images
  - Integration of 3D images in the daily workflow and how a workflow could be optimized

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Area of interest/ Imaging methods at UCL

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recording technology@UCL

Fig 18 Measurement using a time-of-flight or a phase-comparison measurement system.
close range photogrammetry - processing pipeline

setup

- object set-up
- camera exposure/ aperture/ lighting/ flash
- coded targets

image acquisition

- highly convergent images
- calibration object
- object

image calibration, orientation, processing

- camera calibration
- resection
- intersection
- bundle adjustment

matching & 3D point cloud generation

segmentation, structuring, surface generation & edition, texture mapping

final 3D model

- Interpolated mesh after automated stereo matching/
  Coded and contoured surface/
- Orthophotograph/
- Texture mapped photograph
Photogrammetry of cartonnage masks for the UCL Petrie Museum – repeatable/standardized procedure

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Current activities at the UCL Petrie

Photogrammetry of cartonnage

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recording technology@UCL
recording technology@UCL

OZ Optics Laser Source:
Wavelengths 473 532 635

Arius Foundation Model 150 scanner:
designed to deliver a 100μm laser spot over a width and depth of field of ~50mm

Highest resolution:
point spacing 100 x 100μm with geometric and colour information (XYZ RGB IJK)

Accuracy:
single point accuracy better than 25 μm

Speed/area of scanning:
25 mm /minute at 100 x 100 μm

CMM+ Arius scanner,
Chorley Institute, UCL
<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquire scan data from multiple view points</td>
<td>• Multiple clouds of 3D points, each point with its own sources of error</td>
</tr>
<tr>
<td></td>
<td>• Scanning method, scan spot size, object surface qualities, colour information</td>
</tr>
<tr>
<td>Register data together</td>
<td>• Known transformations</td>
</tr>
<tr>
<td></td>
<td>• Common points</td>
</tr>
<tr>
<td></td>
<td>• Mathematical fitting based on surface similarities</td>
</tr>
<tr>
<td></td>
<td>• A single point cloud with overlapping areas and data of varying degrees of quality</td>
</tr>
<tr>
<td>Post-process data (for optimal visual effect)</td>
<td>• Edit spatial (xyz), colour (rgb), and normal (ijk) data to improve the quality</td>
</tr>
<tr>
<td></td>
<td>• Filter data, enhance the colour, or segment the data into structures.</td>
</tr>
<tr>
<td>Convert data into a model suited to final purpose</td>
<td>• Triangles, mesh or NURBS model</td>
</tr>
<tr>
<td></td>
<td>• Reduce quantity of data for final purpose</td>
</tr>
<tr>
<td></td>
<td>• Web delivery, Education and Exhibition</td>
</tr>
<tr>
<td></td>
<td>• Archive</td>
</tr>
<tr>
<td></td>
<td>• Sharing information between institutions (E-Curator application)</td>
</tr>
<tr>
<td>Add Metadata</td>
<td>• Object metadata: SPECTRUM (1996)</td>
</tr>
<tr>
<td></td>
<td>• Scan metadata:</td>
</tr>
</tbody>
</table>
Now some case studies....

real or replica?

Photograph/Scan: Ivor Pridden - UCL Petrie Museum
3D print: DMC (Digital Manufacturing Centre) – UCL Bartlett
NIABARA – THE WAR CANOE
FROM VELLA LAVELLA,
SOLOMON ISLANDS

Niabara – partners - slideshow

- Project partners:

**UCL – E-Curator Project**: Graeme Were (UCL Anthropology), Mona Hess (UCL Museums and Collections), Prof Stuart Robson (UCL Civil, Environmental and Geomatic Engineering), Francesca Simon Millar (PhD candidate, UCL Anthropology)

**Bergen Pacific Studies Group**: Prof Edvard Hviding, Arne Cato Berg, Rolf Erik Scott (Department of Social Anthropology, University of Bergen, Norway [funding by the Research Council of Norway]);

**British Museum**: Lissant Bolton (Section Head Oceanic Collections), Ben Burt (Department of Africa, Oceania and the Americas)
Niabara – team
Canoes of the British Solomon Islands


War canoe, New Georgia, ca. 1900

Charles M. Woodford, JRAI 1909 – Canoes of the British Solomon Islands
Canoe parts – later digitally added to the canoe

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Composite high-resolution photographic documentation
Niabara – complete model 3D scan and reconstruction
**Niabara – publication**


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3D documentation of UCL Grant Museum of Zoology before its move to a new location

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Conclusion: How can we work towards a best practice for 3D colour imaging?

- recommendations for the object scale imaging
- towards an informed best practice with common semantics -> decision tree for CH specialists
- controlled measurement techniques for museum objects
- traceability and repeatability of recording processes
- best scientific and metric documentation results > fit for purpose imaging
- suitable infrastructure for communication and scientific research as heritage application
Conclusions: How can 3D colour imaging serve as analysis tool for heritage end users?

- The right communication and technology transfer between imaging technologist and CH professional
- Convincing and feasible best-practice recommendations to ensure high-quality models, optimal presentations and viewing conditions
- Clear criteria for a high-quality 3D object in a metric manner: accuracy in geometry and high-fidelity colour information.
- Create user-friendly environment with analysis tools, that would not surprisingly have great impact on the museum community.
Thank you for your attention!

Q&A

Acknowledgements

- My colleagues at UCL Museums & Collections: Sally MacDonald, Ivor Pridden, Margaret Serpico, Stephen Quirke, Susi Pancaldo, Chia-Han Chou, Mark Carnall, Andrea Fredericksen, ..... 
- Prof Stuart Robson, CEGE, UCL, Dietmar Backes 
- British Museum: Ben Burt, John Osborne 
- Pacific Studies Group, Uni Bergen/Norway: Prof Edvard Hviding, Cato Arne Berg