Heritage Imaging at UCL

Alejandro Giacometti, Adam Gibson, Mona Hess, John Hindmarch, Lindsay MacDonald, Kazim Pal, Stuart Robson, Melissa Terras, Tim Weyrich

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Heritage Imaging at UCL

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— and many more…

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Digital acquisition is now prominent in CH applications
  • Monitoring / Documentation
  • Visualisation / Analysis
  • Digital Surrogate
  • Archival

We investigate principles and system designs with respect to
  • Quality, Usability, Scalability, Cost effectiveness, etc.
Stability Monitoring

- Ivory panel suspected of movement after transport
- 3D laser scanning revealed: 300–400 µm change induced by humidity variations

Hess, M., Korenberg, C., Robson, S., Entwistle, C., Ward, C., with British Museum
Non-Invasive Analysis

- Mould of unidentified bust at Science Museum
Non-Invasive Analysis

- Mould of unidentified bust at Science Museum
- Reconstruction and “inversion” from laser scans

Mona Hess, Ben Russel, Stuart Robson
Non-Invasive Analysis

- Mould of unidentified bust at Science Museum
- Reconstruction and “inversion” from laser scans

James Watt

Mona Hess, Ben Russel, Stuart Robson
Visualising Spaces
Visualising Spaces
Visualising Spaces

A Prugnon, J Hindmarch, Matthew Shaw, William Trossell, Anita Soni, Prof Stuart Robson

http://www.sciencemuseum.org.uk/about_us/history/shipping.aspx
To what extent may a 3D scan replace the original?
Digital Surrogate

- To what extent may a 3D scan replace the original?
- With Petrie Museum and Arius Technology Inc.:
  - Development of workflow
  - Development of presentation software
  - Evaluation of scanning technologies
  - Evaluation of audience engagement
- 130+ objects scanned, 70+ virtual surrogate 3D models
- Exhibitions and iOS apps

Tonya Nelson, Stuart Robson, Margaret Serpico, Mona Hess, Ivor Pridden, Giancarlo Amati and Arius Technology Inc.
Digital Surrogate

- processed 3D scan → post-processed
- reference photograph
## Digital Surrogate

<table>
<thead>
<tr>
<th>Method</th>
<th>Colour</th>
<th>Surface geometry recording, detail (mm)</th>
<th>Automation for processing?</th>
<th>Cost (GBP), Hardware + Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>3d colour laser scanning</td>
<td>YES</td>
<td>YES/ 0.1 mm (high resolution geometry)</td>
<td>NO</td>
<td>GBP 250,000 and up</td>
</tr>
<tr>
<td>Photogrammetry (professional software) (high resolution texture)</td>
<td>YES</td>
<td>YES/ 0.1 mm (high resolution geometry)</td>
<td>NO</td>
<td>GBP 2,000 + SLR camera</td>
</tr>
<tr>
<td>PTM/ RTI (2.5D)</td>
<td>YES/ 0.003 mm</td>
<td>NO</td>
<td>Some models</td>
<td>estimate GBP 3000</td>
</tr>
<tr>
<td>Handheld 3D laser scanning</td>
<td>NO</td>
<td>YES/ 0.25 mm</td>
<td>NO</td>
<td>GBP 10,000 and up</td>
</tr>
<tr>
<td>3D laser scanning (e.g. Nextengine)</td>
<td>YES</td>
<td>YES/ 0.4 mm</td>
<td>NO</td>
<td>GBP 5,000 and up</td>
</tr>
<tr>
<td>Photogrammetry / Structure from Motion (low resolution texture)</td>
<td>YES</td>
<td>YES / 1 mm</td>
<td>YES</td>
<td>SLR camera + freeware or GBP 100 and up</td>
</tr>
<tr>
<td>Low cost 3D scanning (based on IR game sensors e.g. Kinect)</td>
<td>NO/ YES (specific software only, but low resolution)</td>
<td>YES / 1-3 mm</td>
<td>NO</td>
<td>Sensor + software + Laptop: GBP 1000 and up</td>
</tr>
</tbody>
</table>

Mona Hess, Margaret Serpico
Training
An inlaid metal bag at the Courtauld Gallery: 14th century Islamic craftwork from Northern Iraq

UCL created a 3D model from laser scans and photogrammetric image reconstruction

Rich appearance of materials, however, only visible in lighting-dependent data

Hindmarch, J., MacDonald, L., Terras, M., Robson, S., & Gerstein, A. with the Courtauld Gallery
Light-Dependent Imaging

- Common imaging approach: PTM / RTI dome

Hindmarch, J., MacDonald, L., Terras, M., Robson, S., & Gerstein, A. with the Courtauld Gallery
Light-Dependent Imaging

- Common imaging approach: PTM / RTI dome
- Records images of varying incidence
Light-Dependent Imaging

- Common imaging approach: PTM / RTI dome
- Records images of varying incidence
- Standard RTI viewers skilfully superimpose images
- Improved reconstruction by “fitting” physical reflectance properties

Hindmarch, J., MacDonald, L., Terras, M., Robson, S., & Gerstein, A. with the Courtauld Gallery
RTI On One’s Desk

Miika Aittala, Tim Weyrich & Jaakko Lehtinen
SLR camera to record light

Monitor as a programmable area light source

Approximately flat material sample

Miika Aittala, Tim Weyrich & Jaakko Lehtinen
RTI On One’s Desk
RTI On One’s Desk
RTI On One’s Desk
RTI On One’s Desk

Diffuse Albedo

Surface Normals

Specular Albedo

Glossiness

Kurtosis
Free viewpoint and lighting
Digital surrogate can be an elusive goal
  - holistic acquisition is labour-intensive
  - quality requirements unclear
  - uncertainty about future use cases

Few projects design acquisition around (humanities) research questions and problems
Let CH questions guide system design and data analysis

- Implications on
  - what data to acquire
  - quality requirements
  - usability
  - scalability

- Informs system design and trade-offs
  - technology, workflow, processing, rendering, …

- Allows for targeted algorithms and computational analysis
Example: *Theran Wall Paintings of Akrotiri, Greece*

- Major archaeological excavation since 1967
  - Well-preserved by ash
  - Our focus: the wall paintings
  - Material excellently preserved
  - But shattered in pieces by earthquake
Data Requirements

- Relevant fragment characteristics translate to:
  - accurate overall shape (3D geometry, ± ⅛ mm)
  - high-quality colour reconstruction of front (albedo)
  - fine surface detail on flat surfaces (normals)
Acquisition & Processing

- Low-cost, bespoke acquisition rig
- Automated processing enabled by
  - highly specialised scanner setup
  - tightly controlled workflow
  - allowed for custom algorithm design
- Workflow developed with conservators
  → high usability
Digital Restoration

Example: *The Great Parchment Book*

- 1639 survey of estates of Irish county of Derry
- Important source on the Protestant colonisation
- Damaged by a fire in 1786
- Has been unavailable to researchers for 200 years

Nicola Avery, Alberto Campagnolo, Caroline De Stefani, Kazim Pal, Matthew Payne, Philippa Smith, Rachael Smither, Ann Marie Stewart, Emma Stewart, Patricia Stewart, Melissa Terras, Laurence Ward, Tim Weyrich, Elizabeth Yamada with London Metropolitan Archives
Requirement Analysis

Key Requirement

- Transcription of content

Lesser Requirement

- Nice flattened display version

NOT Required

- Recovery of realistic colour / surface reflectance / sheen
- Re-staging of reading experience (virtual reality)
- Spectral ink analysis
- ...
Digital Conservation

Example: *Multi-Spectral Imaging of Parchment Damage*

- Before/after studies for various modes of damage
  - fire damage
  - wine and blood stains
  - humidification
  - mechanical abuse
  - ...
- Ongoing analysis; ultimate goal: inversion of damage

Alejandro Giacometti, Alberto Campagnolo, Lindsay MacDonald, Simon Mahony, Melissa Terras, Stuart Robson, Tim Weyrich, Adam Gibson
Design space for digitisation efforts is complex

Best practice is highly object-dependent...

... but also subject to scholars’ research questions

Ongoing work toward general guidance and modular solutions

Open access of designs will be key
Contacts

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