Developing a Reflectance Transformation Imaging (RTI) System for Inscription Documentation in Museum Collections and the Field

Case studies on ancient Egyptian and Classical material

Kathryn E. Piquette and Charles Crowther, University of Oxford
Outline

- Methods and problems of artefact documentation/visualisation
- Background
  - Shadow stereo, RTI
- Reflectance transformation imaging
  - RTI (physical lighting dome)
  - Highlight-RTI (virtual lighting dome)
- Egyptian case studies
- Classical case studies
Methods and problems of artefact documentation & visualisation

- First-hand observation
- Analogue photography
- Squeeze making
- Tracings
- Casting
- Line drawings or diagrams (based on?)

- Digital photography
  - Visible light
  - Multispectral
- Video
- Laser scanning
- 3D printing
- B/W, colour
- Partial representation
Ivory fragment with incised imagery and perforations, Abydos, Egypt, c.2950 BCE, EA 35513 (© Trustees of the British Museum)
Shadow Stereo: Vindolanda stilus tablet 974
Shadow Stereo

1. pick an azimuthal light direction, then take images at different elevations
2. for each:
   1. remove wood grain
   2. find shadows adjacent to highlights
   3. use these to detect candidate strokes
3. detect those candidate strokes that move as they “should” do
4. *the hard bit is to make these steps precise!*
Shadow Stereo

The movement of shadows gives a compelling sense of depth, and facilitates the differentiation between incisions and surface markings.
Fragment of a stilus tablet. Note the strong highlight and cast shadows.

The strokes detected that conform to a model of shadow adjacent to highlight.

Idealised model of an incision.
Key:  
**yellow:** highlight  
**Blue:** transition from highlight to shadow  
**Green:** shadow
Shadow Stereo: Vindolanda stilus tablet 974
Shadow Stereo: Vindolanda stilus tablet 974
Previous RTI work

Antikythera Mechanism, RTI image with specular enhancement
(http://gatekeeper.research.compaq.com/pub/hpl/antikythera/ak30a.ptm)
Previous RTI work

Vindolanda stilus tablet photographed with Southampton rotating arm PTM capture system in July 2008
Reflectance Transformation Imaging (RTI) System for Ancient Documentary Artefacts

- 12-month project funded by the Arts and Humanities Enhancement for Impact (DEDEFI) scheme
  - http://www.southampton.ac.uk/archaeology/acrg/acrg_research_DEDEFI.html
- University of Southampton and University of Oxford
- Development of a more portable, low cost and quick capture system for surface data (textual and other archaeological)
- Commitment to opening digital access to cultural heritage: results made publicly available through development and use of open source software
Reflectance Transformation Imaging

- Uses conventional raking light photography
- Digital images taken of inscribed surface with a camera in a fixed position and illumination applied from different angles
- Multiple captures are combined in order to:
  - produce interactive, relit records of the surface for examination of artefacts
  - Improved visualisation
    - Legibility
    - Materiality
- First algorithm for photo amalgamation developed by Tom Malzbender of HP labs in 2001, referred to as Polynomial Texture Mapping (PTM)
PTM Example: Cuneiform tablet envelope
RTI setups

1. Lighting dome RTI
   - Fixed camera
   - Light array

2. Highlight-based RTI
   - Fixed camera
   - Handheld light source
   - Reflective sphere
Lighting dome RTI

- 4 quarters
- 76 LEDs
Dome RTI system specifications

- Plastic dome in four quarters
- 76 LEDs
- Nikon D3x camera with 105mm, 50mm and 35mm lens
- 24.5 megapixel resolution
- Dome capture and download: 3.5 minutes
- Fitting captures into PTM file: 1 minute
RTI for conservation

Dome setup in British Museum

Mummy portrait, El-Rubaiyat, Fayum, AN299549001 (© Trustees of the British Museum)
RTI in tandem with flatbed scanning

- Ideal for imaging in quantity
- Important where surface shape variable, e.g. cuneiform tablets, ostraca, impressed sealings

Setup in Ashmolean Museum
Highlight RTI (H-RTI) system specifications

- **Equipment requirements**
  - Camera
  - Tri-pod
  - Handheld light source
  - Reflective spheres
  - Piece of string

- **Virtual dome of light**
  - Average of 35-40 shots taken with this method

Cultural Heritage Imaging (CHI) workshop at Southampton
H-RTI in museum and field contexts

Japanese Colour Woodcut with Embossing, captured by Cultural Heritage Imaging (CHI), Fine Arts Museums of San Francisco

Highlight based RTI in Libyan desert
H-RTI versatility

- Paper squeeze
- Object and camera fixed
- Consistent distance from object
- Light source moved by small iteration for each exposure
- 35-45 exposures

- RTI essential for maximising squeeze features
- Replacement for static imaging?
- PTM example

Setup in Centre for the Study of Ancient Documents (CSAD), Oxford
H-RTI versatility

H-RTI setup in Ägyptisches Museum und Papyrussammlung stores, Staatliche Museen zu Berlin

H-RTI setup in the Ashmolean Museum, Oxford
H-RTI capture and processing
H-RTI capture and processing
Fitting H-RTI captures
RTIViewer

- Developed by Gianpaolo Palma at Pisa
- Viewing of PTMs
- Surface normal manipulation
- RTISAD augmentation
  - Annotation
  - Bookmark light positions
- jpeg output
- Open source/open access
  - See handout

Screenshot of RTIViewer showing default view of impressed mud sealing
Surface normal manipulation

- Default
- Diffuse Gain
- Specular Enhancement
- Unsharp Masking
  - Normal, Image, Luminance, Coefficient
- Static Multi Light
Impressed jar sealing, c.2850 BCE, Abydos, Egypt, EA 32670 (© Trustees of the British Museum)
Egyptian case studies

- Material process of script and image production
  - Materials (substrate, constrate)
  - Tools (surface preparation, writing)
  - Technique (additive, subtractive)
  - Embodied engagement with, and experience of, text

1. Relief-carved ‘proto-writing’/early art on ceremonial mudstone palette, c.3100 BCE
2. Incised early hieroglyphs on ivory funerary label, c.2850 BCE
3. Ink-inscribed Aramaic on leather, c.500 BCE
1. Relief-carved proto-writing/art on mudstone palette

- Dome RTI
- Altered ‘gaze’
- Tool and technique
- Process of surface transformation
- Mark making as dialogue
- Embodied practice

2. Incised early hieroglyphs on ivory label

- Dome RTI
- Surface preparation
- Ductus
- Past concepts of craft
- Textual ‘life histories’

Abydos, BM EA 32268, c.2850 BCE, Petrie 1900: pl. 17, 26.
Normal rendering settings can help distinguish intentional from unintentional surface marks: Diffuse Gain (left) and specular enhancement (right); EA 32268 (© Trustees of the British Museum)
3. Ink-inscribed Aramaic on leather

- H-RTI quality
  - 35-45 ideal, but 15 exposures can give useful results
- Contrast vs. substrate
- Visualising materiality
- Scribal practice

Visualisation of leather surface using specular enhancement (ink too low lying to cast shadow)

P. 13443, Elephantine, 500 BCE, Ägyptisches Museum und Papyrussammlung, Staatliche Museen zu Berlin
Classical case studies

- **Reading and decipherment**
  - Degraded surfaces
  - Surface patina and discoloration
  - Deliberate erasures

1. Curse Tablet WH77.1180 from Uley
2. Vindolanda Stilus Tablet 974
3. Honorific base from Chios with erasure and surface damage
1. Lead curse tablet from Uley

- Dome RTI
- Uneven surface
- Surface patina
- RTI brings out surface relief across the tablet
- Specular enhancement filter removes distracting surface colour variations
1. Lead curse tablet from Uley

- Dome RTI
- Uneven surface
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- RTI brings out surface relief across the tablet
- Specular enhancement filter removes distracting surface colour variations
2. Vindolanda stilus Tablet 974

- Dome RTI
- Partial palimpsest
- Surface discoloration
- RTI brings out surface relief
- Specular enhancement filter removes distracting surface colour variations
2. Vindolanda stilus Tablet

- Dome RTI
- Partial palimpsest
- Surface discoloration
- RTI brings out surface relief
- Specular enhancement filter removes distracting surface colour variations
3. Honorific base from Chios with erasure and surface damage

- Highlight RTI (black billiard ball with highlight in top right)
- Text irrecoverable in deep erasure at the beginning of lines 2-3
- Text partially visible and recoverable in surface damage on right edge
Summing up

- Methods and problems of artefact documentation/visualisation
- Background
- Reflectance transformation imaging (RTI and H-RTI)
- Egyptian and Classical case studies
- Future direction and collaborations
RTI-related links

- Project award announcement
  - http://www.soton.ac.uk/archaeology/acrg/acrg_research_DEDEFI.html
- Preprint on interim results
  - http://eprints.ecs.soton.ac.uk/22357/
- Technique description and PTM example
  - http://www.soton.ac.uk/archaeology/acrg/acrg_research_PTM.html
- PTM information from our project partners, Cultural Heritage Imaging
  - http://c-h-i.org/examples/ptm/ptm.html
- RTISAD project synopsis in CSAD Newsletter
- RTISAD project synopsis on Ashmolean website
  - http://www.ashmolean.org/departments/antiquities/research/research/rtisad
- Information on RTIViewer
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