Novel Image Capture and Presentation in Archaeology and Cultural Heritage

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Will present 4 digital data capture technologies we are increasingly employing in archaeology and heritage research.

Not necessarily new technologies but increasingly they are becoming more accessible due to advances in sensors, computer power and algorithms.

Will present examples from each technology, how they are being used at The University of Western Australia.

Will end with the challenges, delivery software is not keeping pace with capture technology.

- 360 degree panoramic video
- Gigapixel images
- High definition volumetric scanning
- 3D reconstruction from photographs
Motivation

• Capturing higher order assets in archaeology and heritage.

• Maximise the usefulness of the assets captured as a digital record, for research, in virtual environments and public education.

• Develop accessible as opposed to highly technical or specialist technologies.

• Drivers for archaeology
  - Site time is often limited.
  - Sites are often remote and time consuming/expensive to reach.
  - The environments can be challenging, for example marine archaeology.

• Drivers for cultural heritage
  - Cultural events happen “occasionally”, if choreographed then not true representations of the event.
  - Many cultural events are dying out and there is demand for rich recordings.
360 degree panoramic video

- Cultural events usually occur within the context of a place.
- Often involve a number of interacting participants.
- A single directed camera is a very limited representation of the event.
- Challenge is acquiring sufficient resolution and frame rate.
Example: Mah Meri

- Remote indigenous tribe in West Malaysia.
- Have a healing ceremony involving masks and dance ritual.
- Ceremony occurs around the patient, goal is to capture that perspective, the view from “being there”.

![Image of Mah Meri with a person in traditional attire dancing](image1)

![Image of a healing ceremony in progress](image2)
Spherical panorama

- Projection onto a sphere and the result unwrapped to form an flat image.
- Everything is captured from the camera position (except for a portion under the camera).
iDome

- One means of experiencing the 360 video from the perspective from which it is captured. Image no longer appears distorted.
- Gives the viewer a sense of presence, of “being there”. Whole visual field is filled.
- Observer can navigate within the video.

![iDome setup](image)
Example: Ngintaka

- Example of traditional story from Indigenous Australians.
- Performed in a remote cave, the belly of Ngintaka (lizard).
Gigapixel images

- While digital camera sensor resolution has increased over the years one cannot buy an arbitrarily high resolution camera.
- How does one to acquire images that capture both the detail and the context of a site.
- Solution is to capture a large number of overlapping photographs and stitch together.
- Resolution determined by the field of view of the lens.
- There are a number of automated ways of acquiring the photographs using robotic and motorised camera heads.
- Not a new or specialist exercise any more and improvements in the algorithms for finding feature points, planar transformations, and blending images are resulting in higher quality results.
- Two categories: first is where the camera is fixed, the second where it moves. The later normally known as image mosaicing.
Example: Wanmanna

- Rock art site in Western Australia.
- Dates back to 50,000 years of human habitation.
- Over 250 rock art drawings over two sides of the ravine.
- Desire to capture both the context and detail of the rock art.
Gigapixel capture over a regular grid

13 x 3 grid

60,000 x 15,000 pixels
Photography

- A number of robotic and motorised camera rigs exist to automatically capture the underlying images.

- Well established feature points detection is employed to match and align pairs of images.

- Results are blended into the final high resolution image.

- Technology is no longer specialised nor necessarily expensive.
Arm-chair archaeology
Gigapixel aerial image mosaicing

- Extend to aerial surveys of heritage sites using octocopter.
- Also referred to as mosaicing when the camera is shifted between shots.
Gigapixel underwater mosaics

50,000 x 20,000 pixels
Rock art

Movie
High definition volumetric scanning

- CT (X-ray computed tomography) and microCT scanners.
- Increasingly available outside medicine for other sciences and heritage objects.
- Yields a 3 dimensional density map.
- Volume visualisation techniques map density to colour and opacity.
- Present example of Pausiris mummy. Prepared for the Museum of New and Old Art (MONA).
CT Scan

- Traditional way to look at data is to simply view the slices.
- There is no colour, only density scale.
- Not an effective way of exploring or presenting the underlying object.
Pausiris

- Egypt, Ptolemaic to Roman Period, 100 BCE – CE 100.
- Human remains encased in stucco plaster with glass eyes, incised and painted decoration.
- Provenance and identity had been confirmed.
- Skeletal structure was intact, unopened.
Volume visualisation

- Very powerful exploratory techniques have been developed mainly in the science and engineering fields for visualising volumetric data.
- Arises both from scanned volumes but also from simulations.
- Can often be performed in realtime on today graphics cards.
- Increasingly these can be performed on standard desktop computers.
**Porosity**

- Volume rendering can also be applied to small samples for forensic or materials testing.
- Example: a $1\text{cm}^3$ sample.
3D reconstruction from photographs

- Magic: by taking multiple photographs of an object or place we can automatically create a 3D model.
- Entirely unintrusive, “just a camera”, can handle variable lighting conditions.
- Traditionally part of photogrammetry except that covers the derivation of any metric from photographs.
- Current algorithms arising largely from research in machine vision.
Motivation / Aims

• Creating richer more informed digital records of archaeologically significant sites.
• Not content with “point clouds” which is usually the end point for other 3D scanning processes.
• Wish to avoid in-scene markers, many sites or objects preclude this.
• Want a highly automated process, some survey sites have hundreds of objects to be recorded.
Dragon gardens - Hong Kong
Photographs

- While the algorithms can work with ad-hoc photographs, there is some advantages in quality and accuracy for a more rigorous photographic approach.
- The exact shooting style depends on the subject matter.
- Blue squares show the camera locations, example scanning linearly or radially.
2.5D

- Often only need a few photographs, typically under 20.
- Mesh quality depends largely on image resolution and lens focus quality.
- By contrast full 3D objects often require hundreds of photographs.
Repurposing for different applications

- Important to consider actual mesh resolution vs apparent mesh resolution.
- Texture resolution rather than geometric resolution.
- Requirements vary depending on the end application
  - Realtime environments require low geometric complexity and high texture detail
  - Analysis generally requires high geometric detail
  - Digital record seeks high geometric and texture detail

<table>
<thead>
<tr>
<th>Application</th>
<th>Geometric resolution</th>
<th>Texture resolution</th>
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<tbody>
<tr>
<td>Gaming</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Analysis</td>
<td>High</td>
<td>Don’t care</td>
</tr>
<tr>
<td>Education</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Archive/heritage</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Online</td>
<td>Low/Average</td>
<td>Low/average</td>
</tr>
</tbody>
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1,000,000 triangles

100,000 triangles
Indigenous Australian artefacts

- Which one is the photograph and which is a 3D model?
Ngintaka - Indigenous Headress
Reconstructing a detailed cave

- A very exciting emerging technology.
- The quality achievable today was not possible only 2 years ago.
Challenges

- Challenges are around the storage and presentation of these novel and demanding assets.

- Examples
  - Representing these higher order assets in conventional databases. They need to interacted with following a search.
  - Delivering gigapixel (or terapixel) images interactively. Standard image formats are not good enough.
  - Delivering volumetric data online and/or from the result of a database search. Almost no solutions.
  - Tagging/locating meta data spatially within gigapixel images and volumetric data.
  - Online viewers for textured 3D mesh data. Exist but lots of cross platform, browser and reliability issues. None do obvious things like automatic level of detail delivery.

- In summary: Software for meaningfully storing, searching and delivering these assets to researchers is not keeping pace with the capture.
Thank you