Novel Image Capture and Presentation in Archaeology and Cultural Heritage

Assoc Prof Paul Bourke

Director, iVEC@UWA
Head of iVEC Visualisation Team
Visualisation Researcher

The University of Western Australia
Perth, Australia

iVEC @UWA

Contents

- 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.

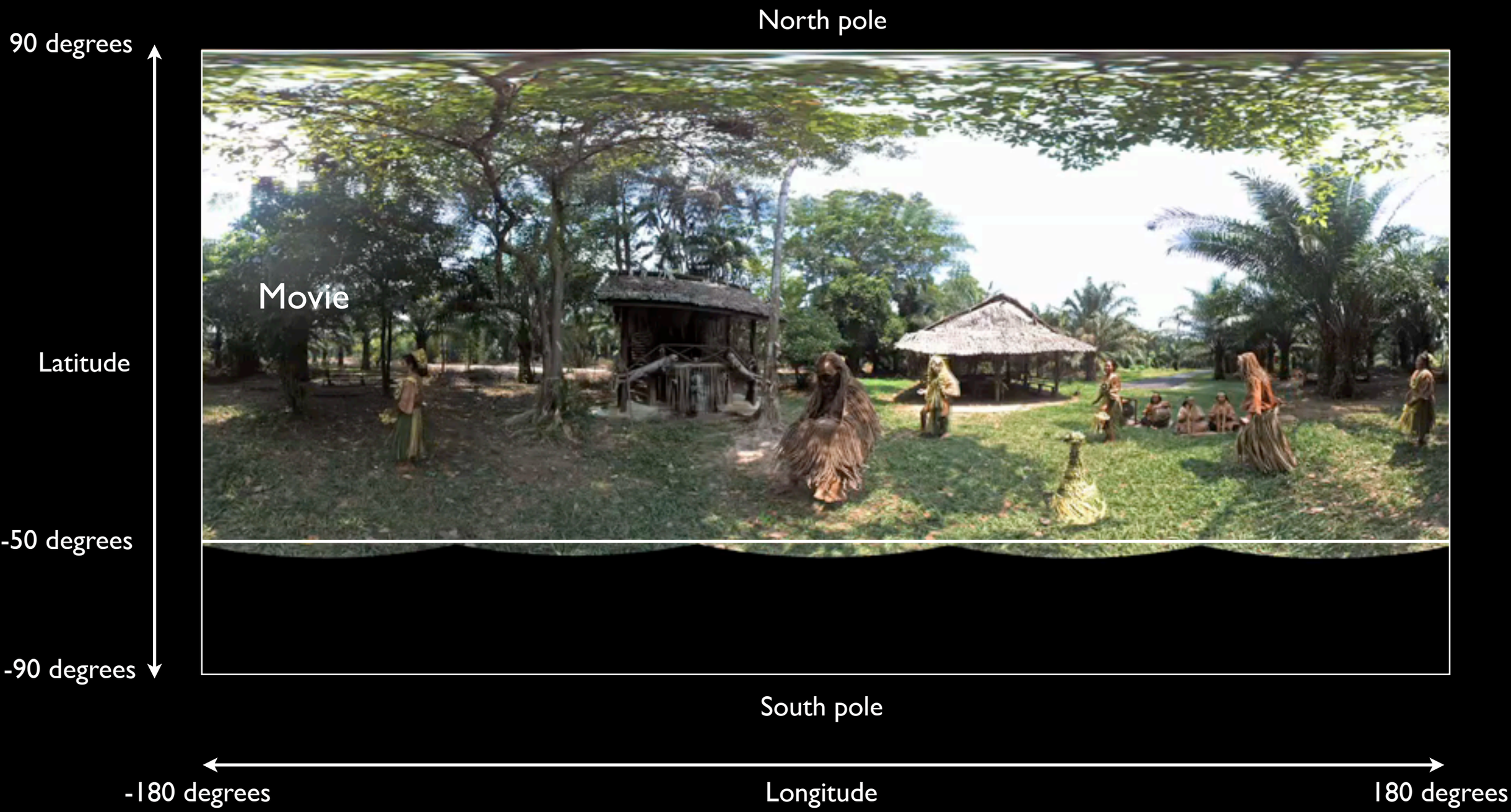
8000 x 4000 pixel video

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”.

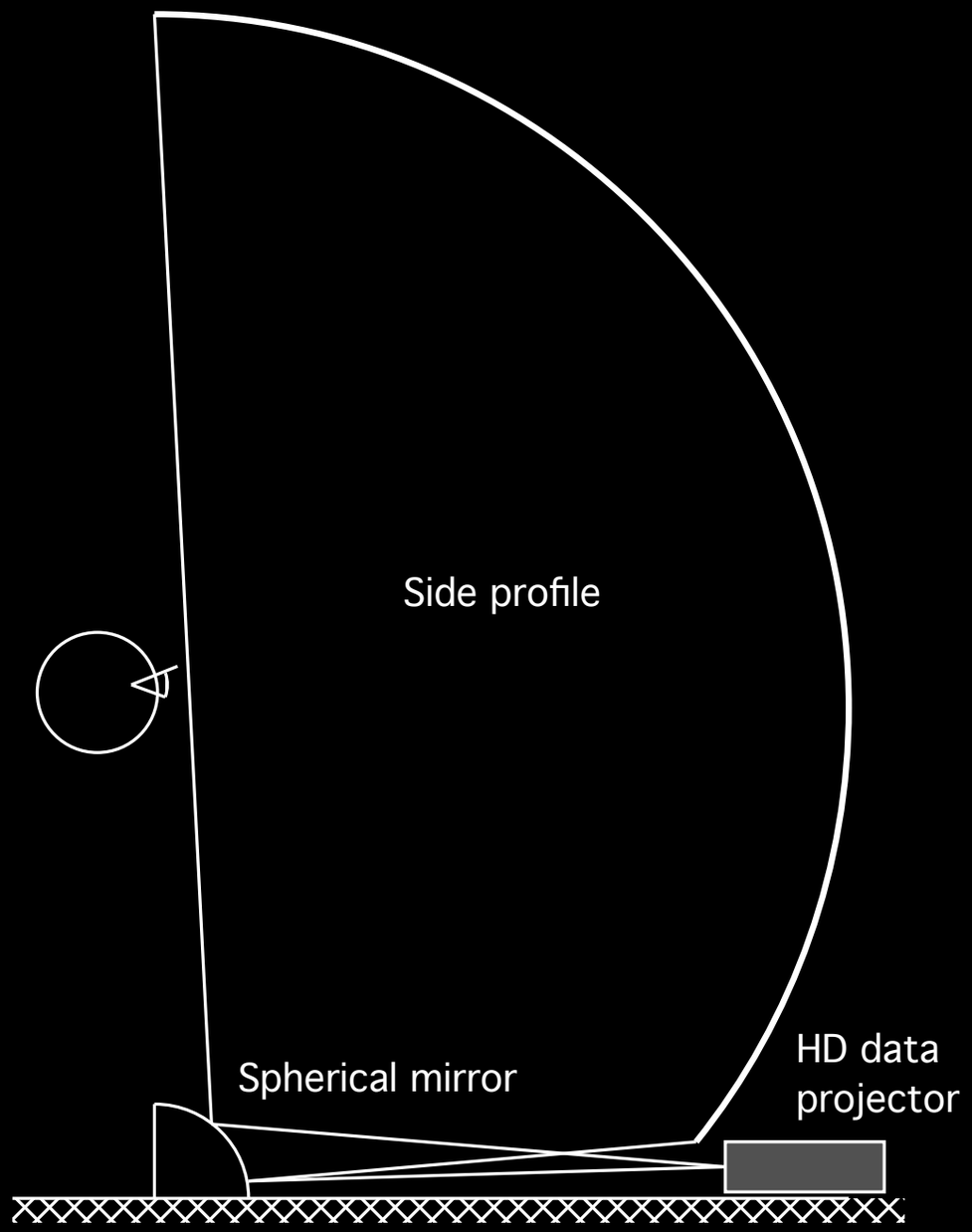
Spherical panorama

- 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.



Example: Ngintaka

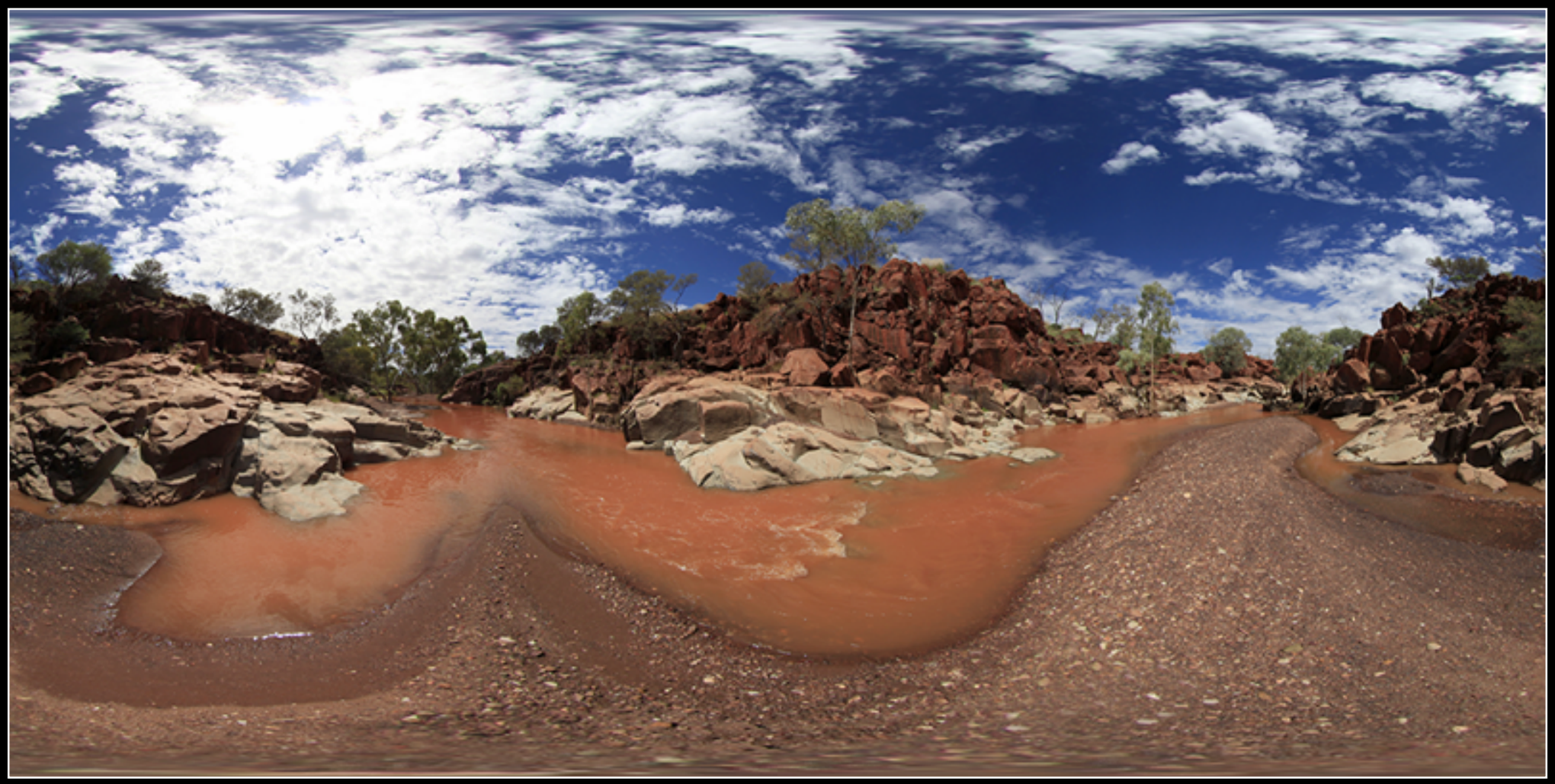
- Example of traditional story from indigenous Australians.
- Performed in a remote cave, the belly of Ngintaka (lizard).

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

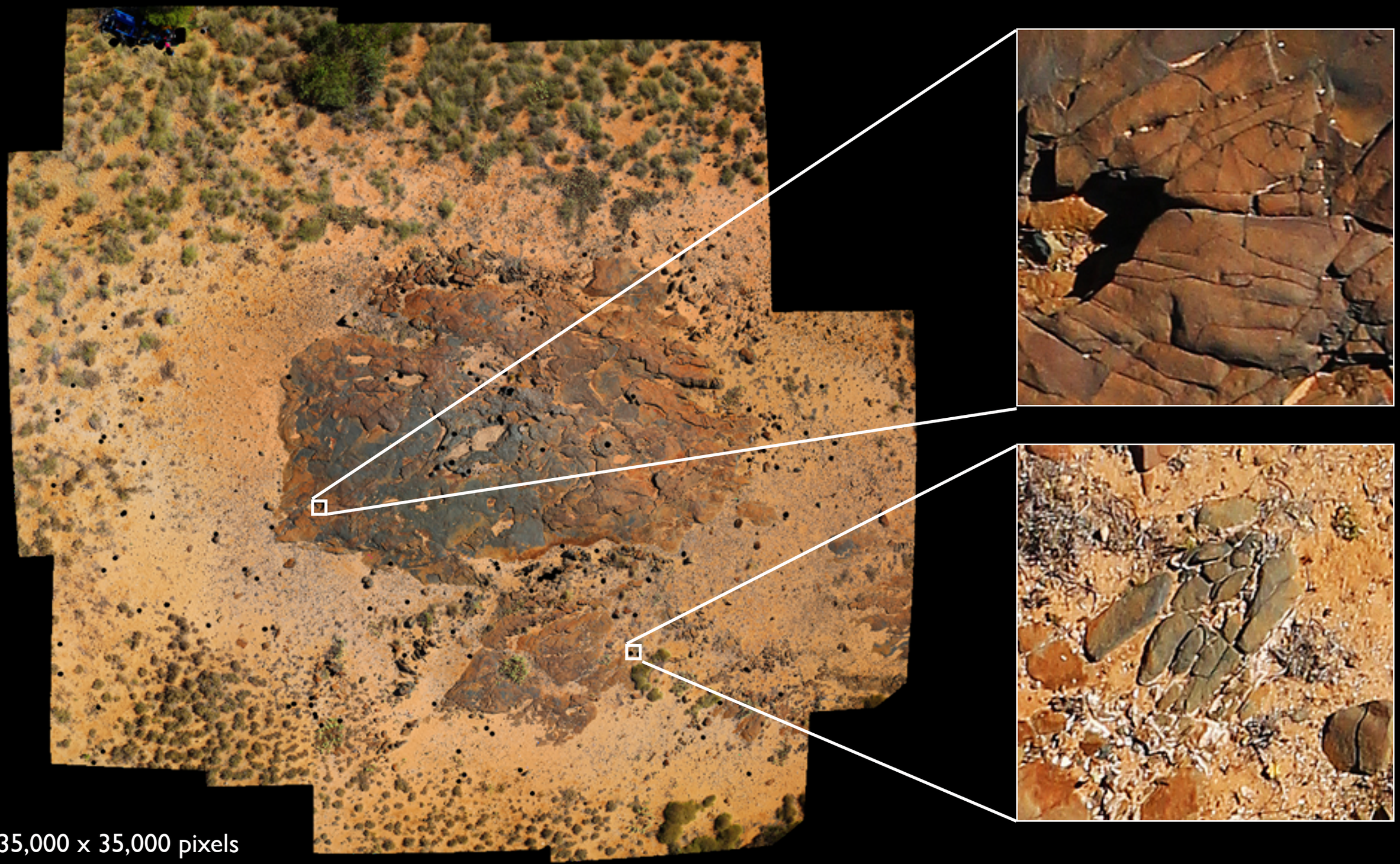
80,000 x 22,000 pixels

Wanmanna


Movie

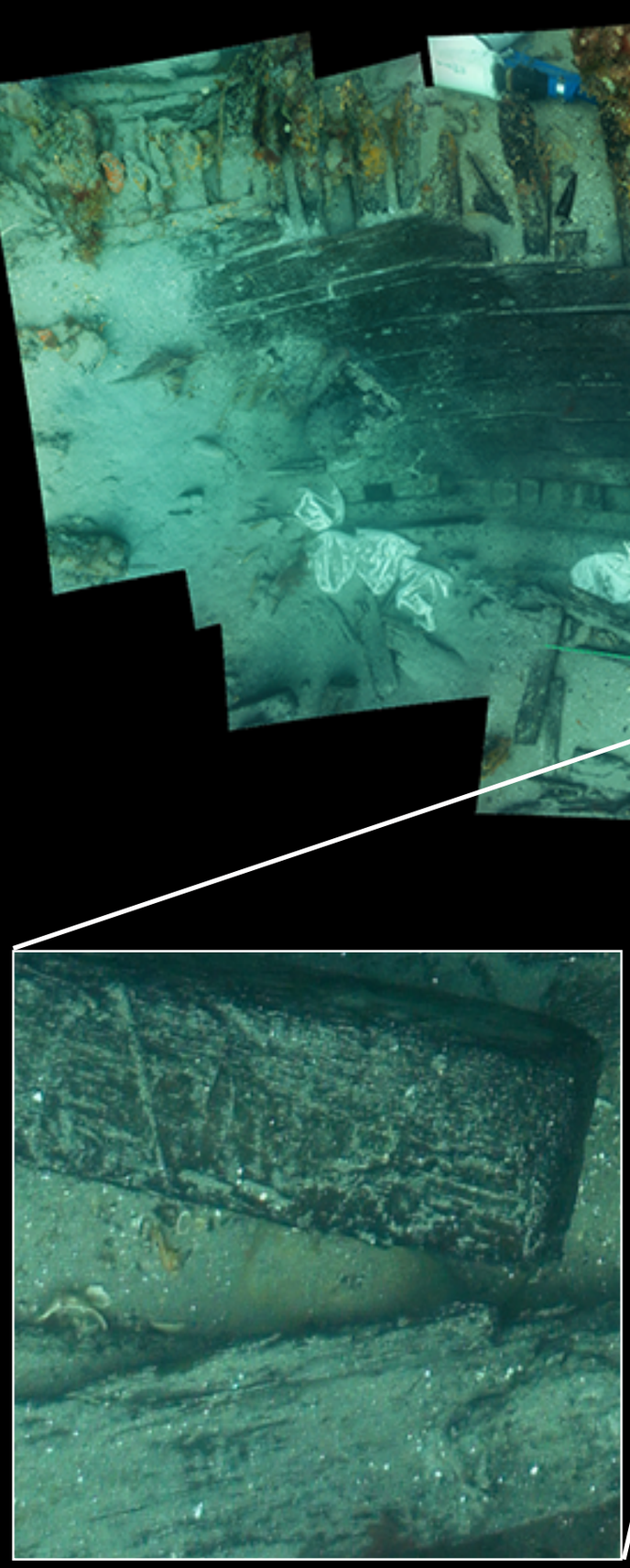
Gigapixel aerial image mosaicing

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



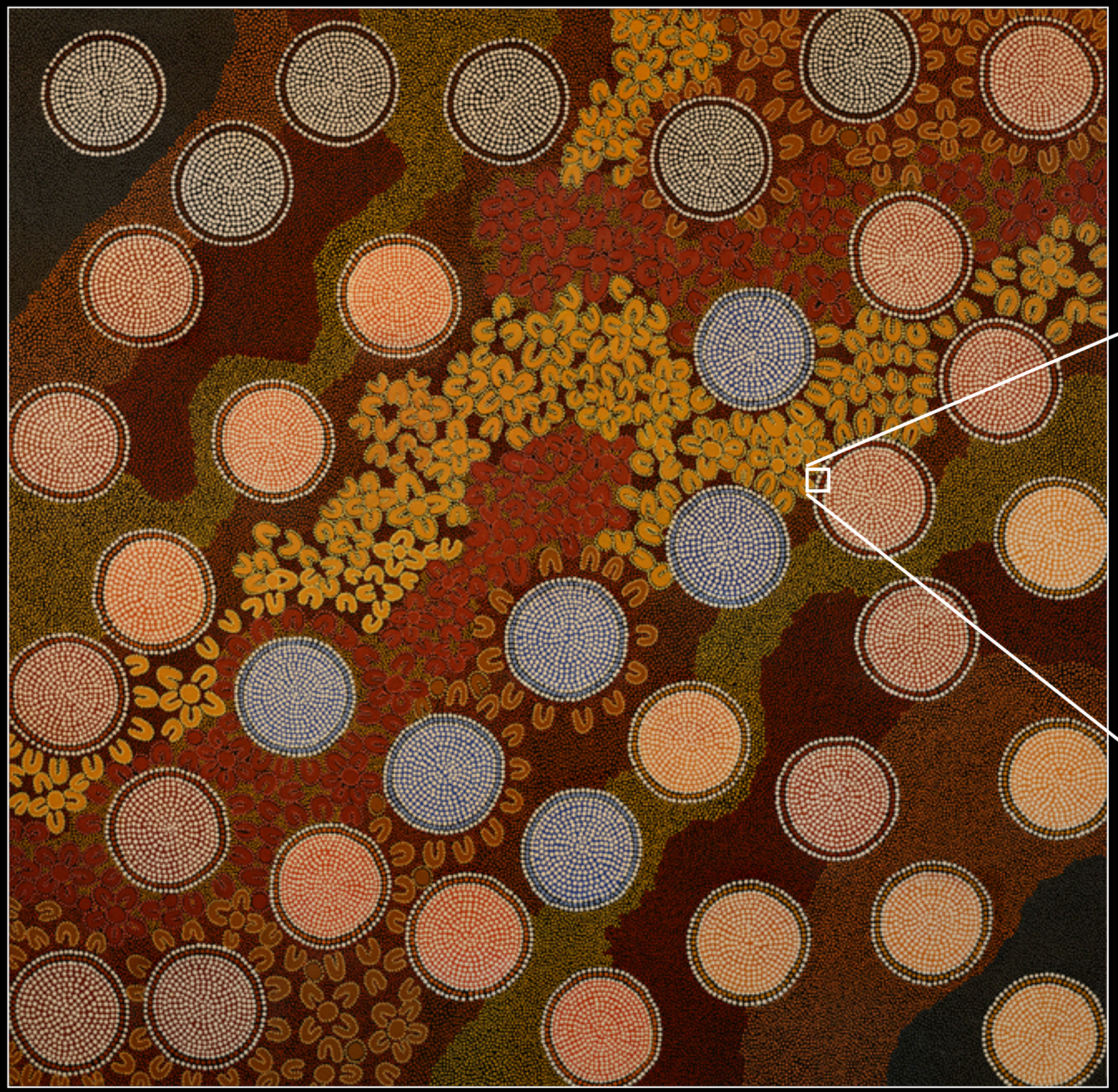
35,000 x 35,000 pixels

Gigapixel underwater mosaics



50,000 x 20,000 pixels

Picture scanning: Indigenous dot paintings



100,000 x 100,000 pixels

Rock art

55,000 x 7,000 pixels

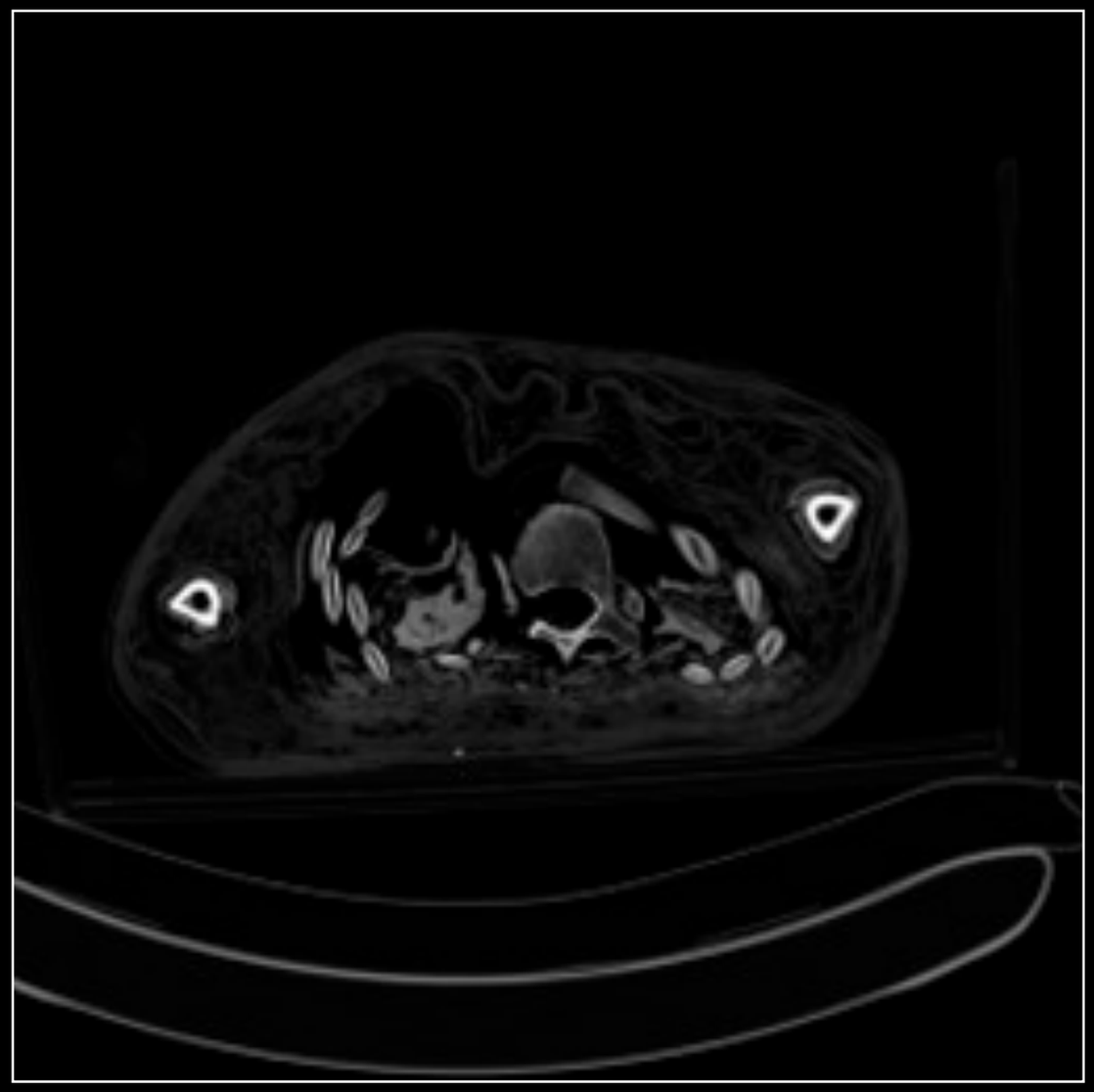
High definition volumetric scanning

- 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.



CT slices

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.

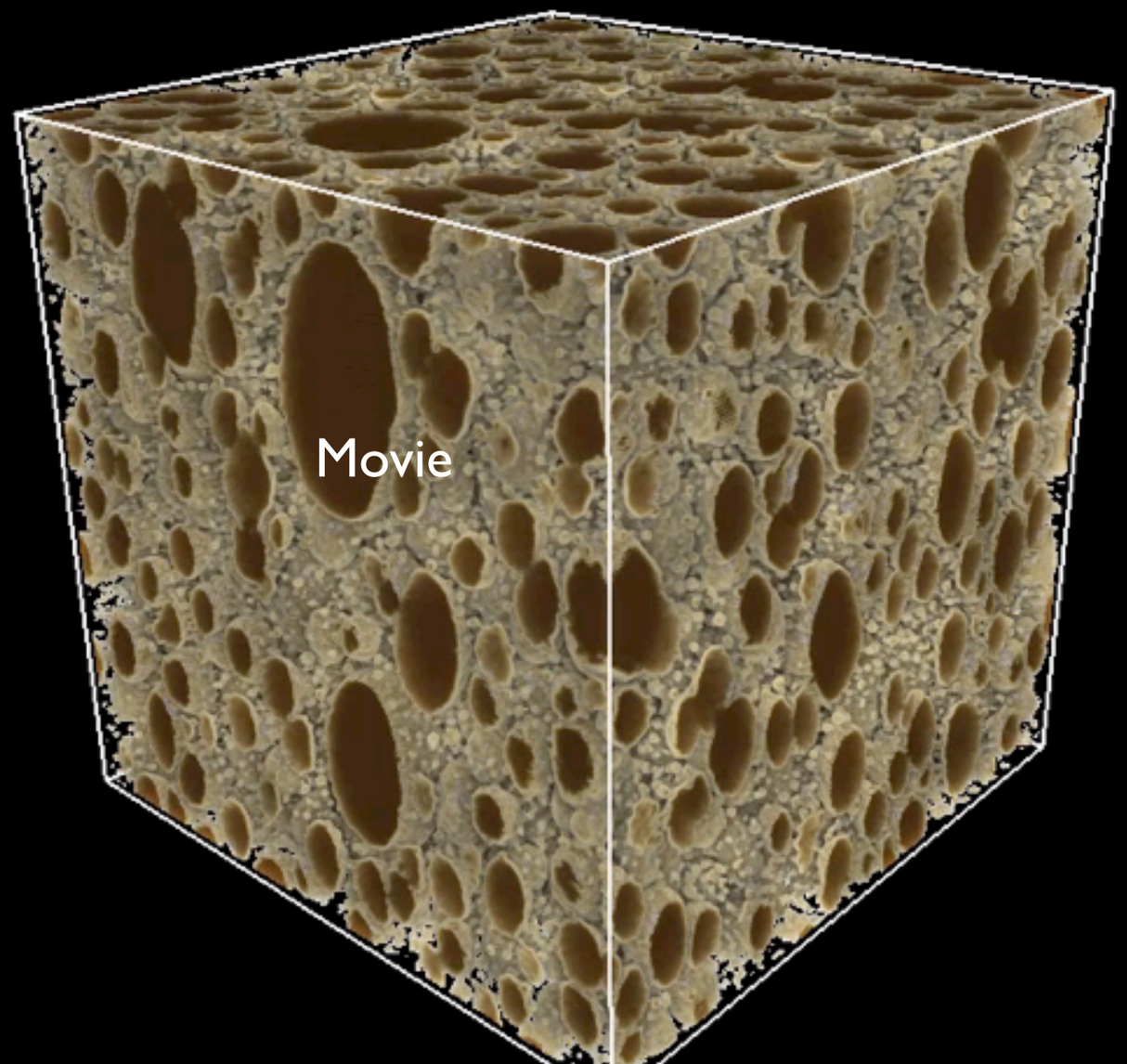
Volume visualisation

- 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.

Movie

Porosity

- Volume rendering can also be applied to small samples for forensic or materials testing.
- Example: a 1cm ^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.

Australian indigenous rock shelter

Motivation / Aims

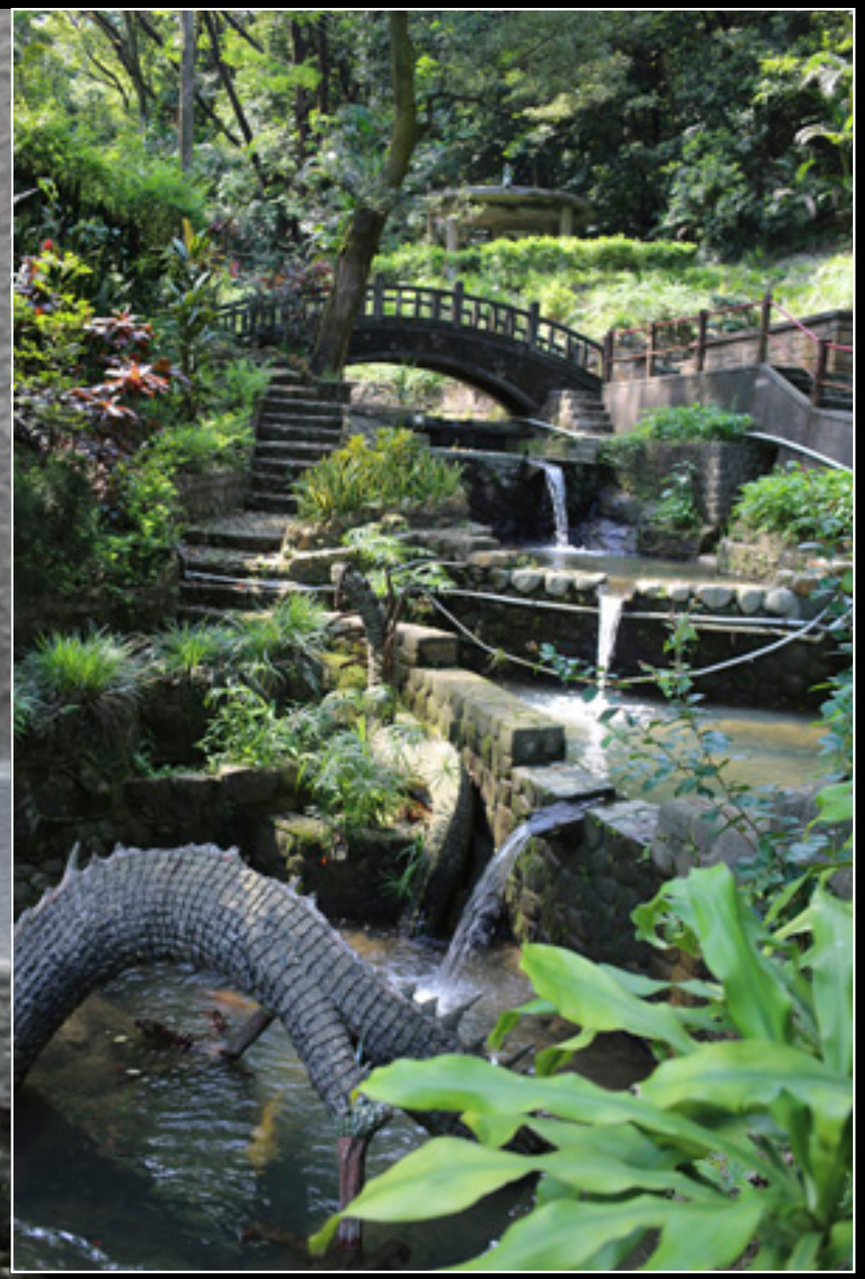
- Creating richer more informed digital records of archaeologically significant sites.
- Not content with “point clouds” which is usually the end point for other 3D scanning processes.
- Wish to avoid in-scene markers, many sites or objects preclude this.
- Want a highly automated process, some survey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

Movie

Coral building
Beacon Island

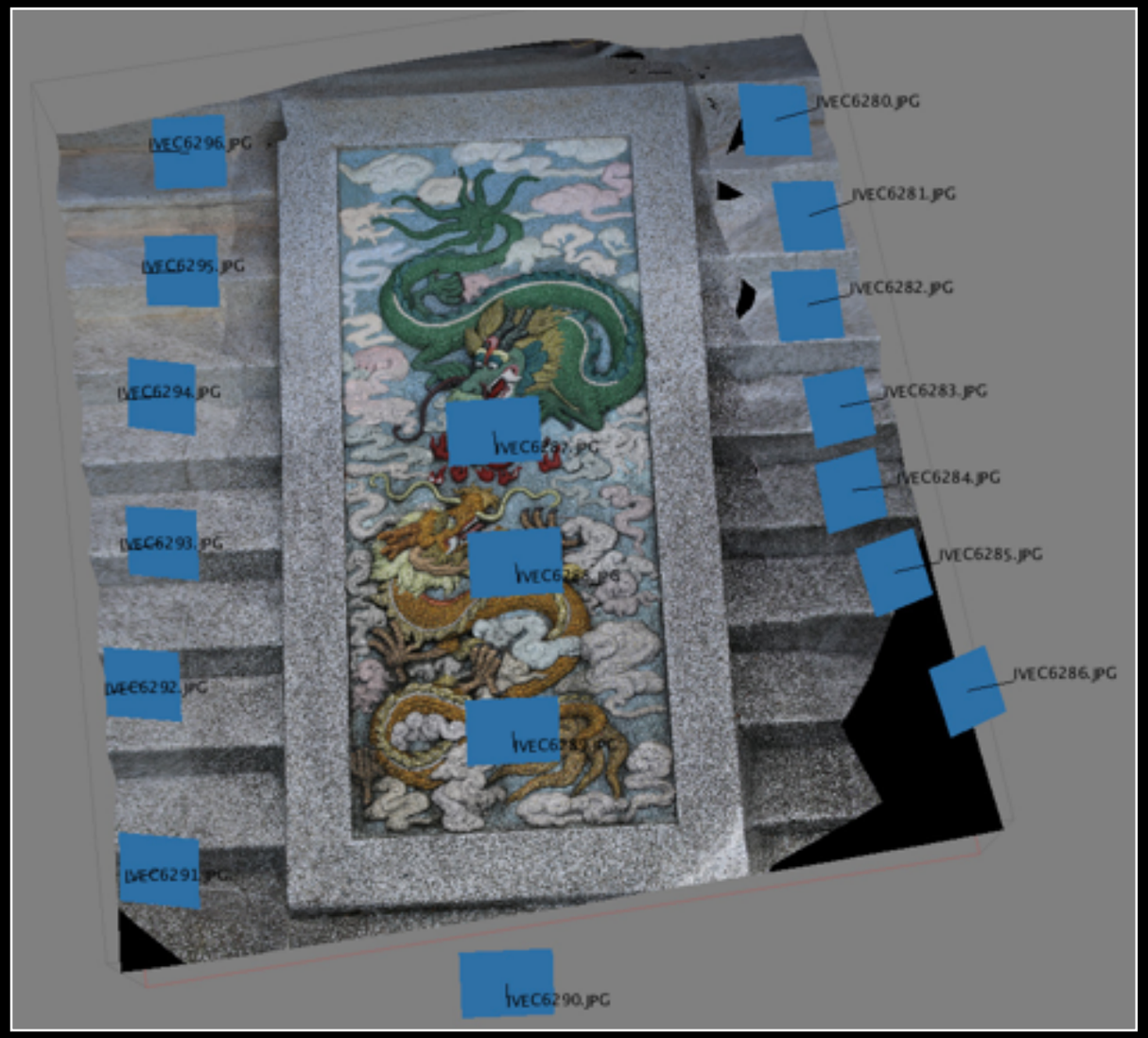
Dragon gardens - Hong Kong

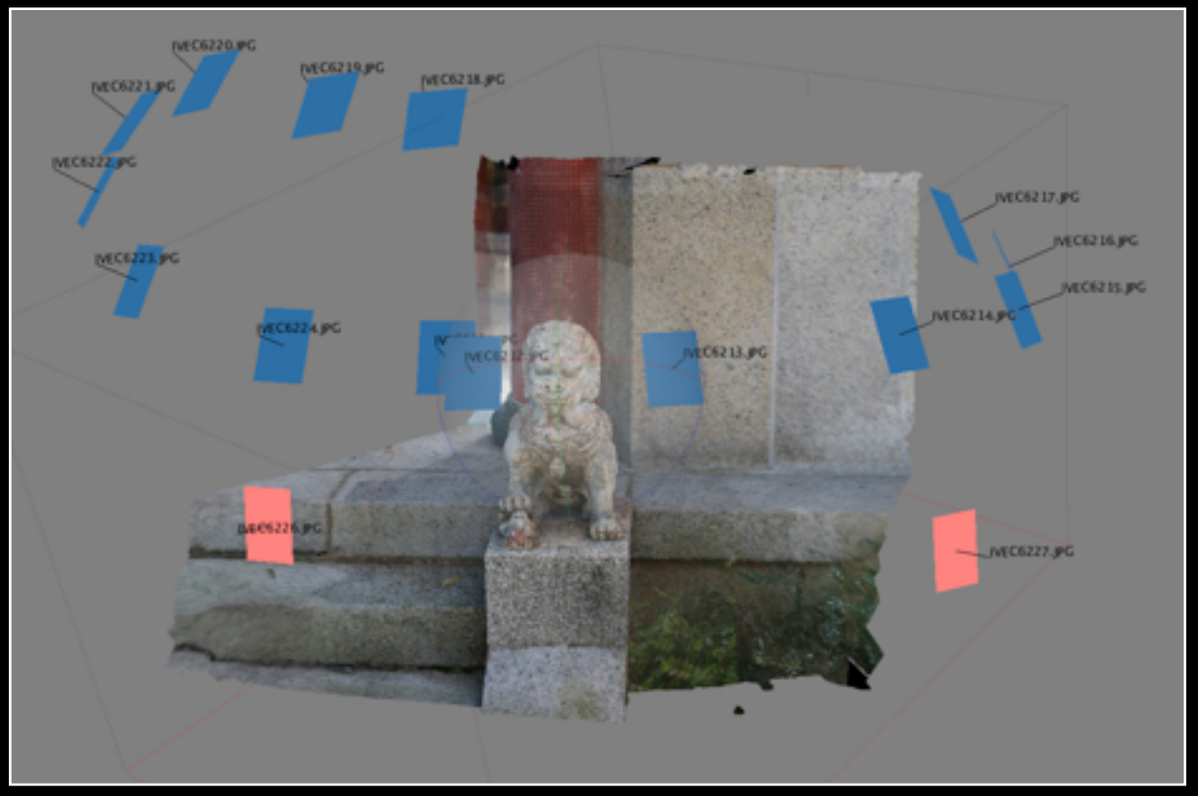
Movie



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.

Movie

3D

Movie

Repurposing for different applications

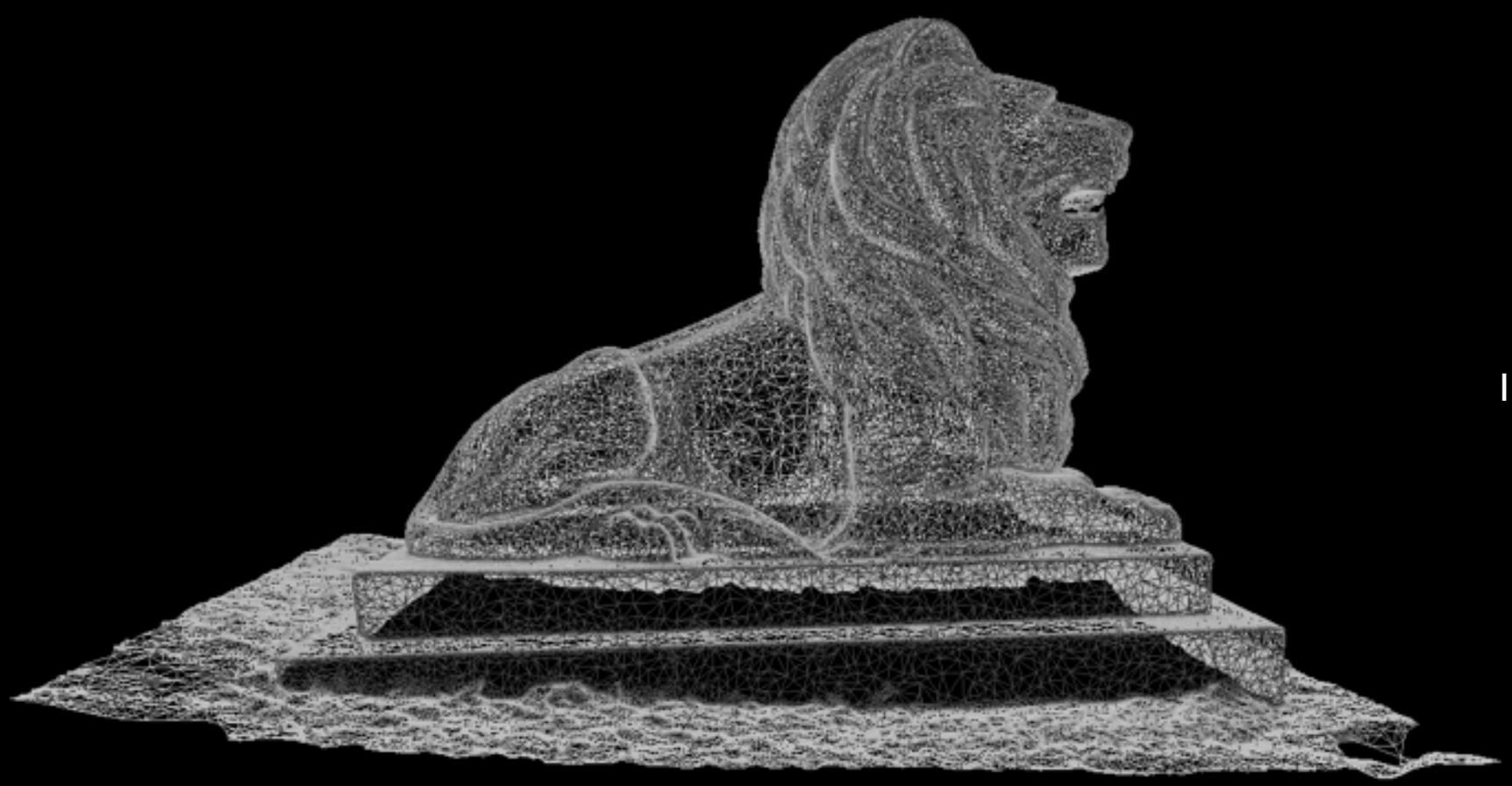
- Important to consider actual mesh resolution vs apparent mesh resolution.
- Texture resolution rather than geometric resolution.
- Requirements vary depending on the end application
  - Realtime environments require low geometric complexity and high texture detail
  - Analysis generally requires high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

	Geometric resolution	Texture resolution
Gaming	Low	High
Analysis	High	Don’t care
Education	Medium	High
Archive/heritage	High	High
Online	Low/Average	Low/average

1,000,000 triangles

100,00 triangles

1,000,000 triangles



100,00 triangles

Indigenous Australian artefacts

- Which one is the photograph and which is a 3D model?

Ngintaka - Indigenous Headress

Movie

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, searhcing and delivering these assets to researchers is not keeping pace with the capture.

Thank you

iVEC @UWA