High resolution imaging: Capture, storage and access

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- Motivation - Definition - Solution.
- Examples from a wide range of disciplines.
- Two fundamental techniques.

  - Single camera position, panorama.

  - Multiple camera positions, mosaic.
- Challenges - Summary.
- The Future.

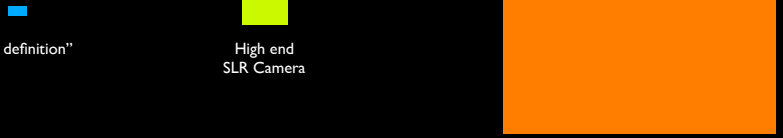
1,200,000 pixel mosaic from UAV
Courtesy Centre for Rock Art Research + Management

Motivation

- Capture the detail as well as the context in a single image.
- Result in richer research assets than separate distant and closeup images.
- In the context of remote locations access may be problematic/expensive, goal is to capture as high a value recording as possible.
- For destructive processes one only gets one chance, again, record at as high a resolution possible to maximise future research outcomes.

Definition

- Will define a “high resolution image” as one with dimensions greater that 30,000 pixels.
- Above 30,000 pixels
  - many/most standard file formats become unavailable.
  - standard brute force (memory based) viewing becomes increasingly problematic.
- Often defined as 1Gigapixel = 30,000+ x 30,000+.



“High definition”

High end SLR Camera

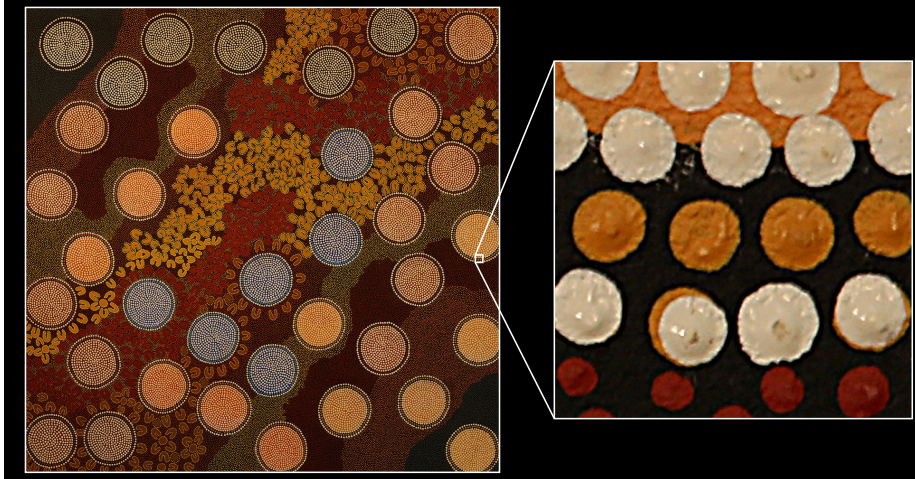
1 Gigapixel

Capture solution

- One cannot purchase an arbitrarily high resolution photographic sensor.
- Solution is to capture a number of overlapping images, usually but not always in a regular grid pattern, and stitch/blend together for a higher resolution composite.
- Scalable - resolution is largely determined by the field of view of the lens. The narrower the FOV the more images captured and the higher the resulting resolution.
- Not a new idea with existing applications across a wide range of disciplines.
- We are applying to heritage and archaeology where it still relatively new.
  Generally operating in the 1 Gigapixel to 10 Gigapixel range.
  High end SLR camera is typically 0.02 Gigapixels.
  HD is 0.002 Gigapixels.

Example: Indigenous dot painting (Forensics)

- Resolving, with a hand held camera, features not visible to the human eye.



Margaret Whitehut, Yamaji Art 60,000 x 60,000 pixels

Example: Google Art project

- Example of unexpected outcomes but made possible given the imaging resolution.
- Study by geologists of similar fault structures and physics in paint as occur on Earth.

Reference to painting and google art

Example: Hurleys darkroom, Antarctica (Heritage)

- Example of maximising capture in rare opportunities.
- Armchair exploration vs visiting challenging environments.

40,000 by 20,000 pixels

Hurleys darkroom, Mawsons hut (Antarctica)
Courtesy Peter Morse

Example: Beacon Island (Heritage)

Beacon Island

120,000 x 15,000 pixels

Example: Microscopy

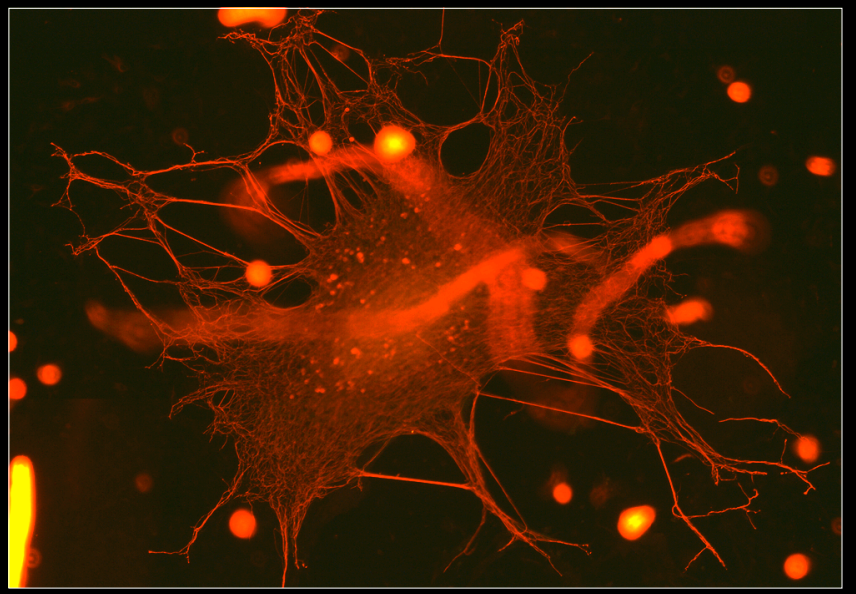
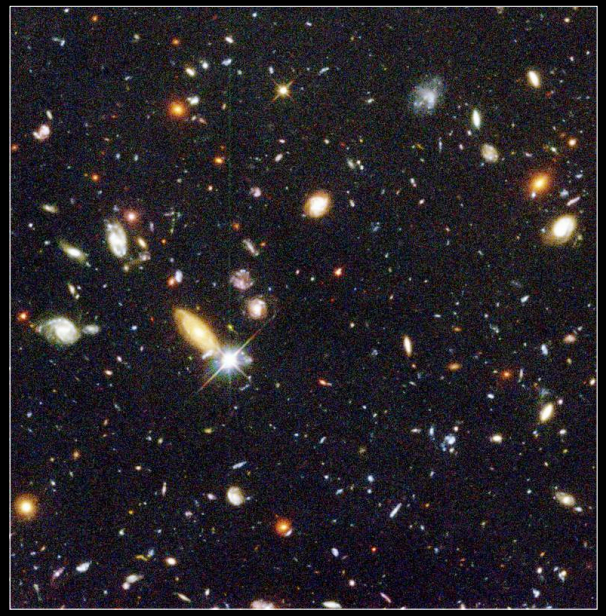


Image courtesy CMCA, UWA

31,000 x 26,000 pixels

Example: Hubble Space Telescope



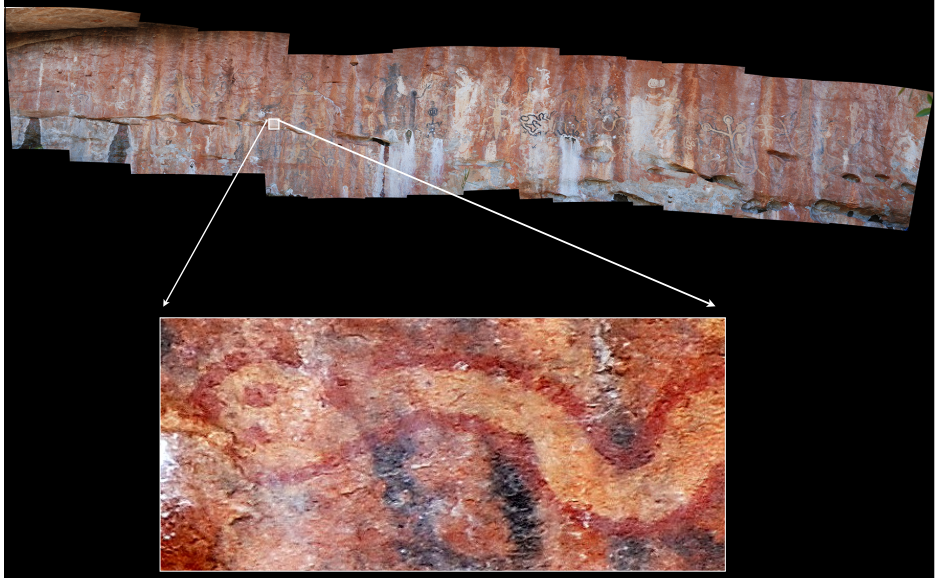
Hubble deep field
340 image composite

Example: Rock art recording

Wanmanna, Archaeology, UWA

Movie

Example: Rock art

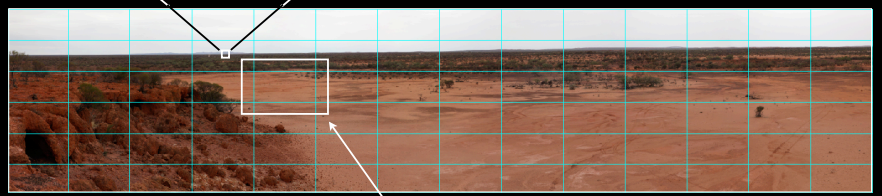


Movie

Example: ASKAP site

First ASKAP dish

ASKAP site, Boolardy



21 MPixels, Canon EOS 5D Mk11

Total: 2.5 GPixels

Techniques

- Basic idea is to take a number of photographs, each overlapping with its neighbours.
- Generally using a motorised rig to automate the process.
- Feature points betweens pairs of images derived across the overlap region.
- Images spatially aligned based upon those feature points.
- Overlap region blended between image pairs.
- The simplicity is what is driving the increased appearance of such images.
- Two main categories:

  - Stationary camera, panorama style.

  - Moving camera, mosaic style (suited to largely flat objects).

Panorama: stationary camera

- The final resolution is largely dependent on the field of view of the lens. The narrower the lens the more photographs and the higher the final resolution.
- Use approximately 1/3 image overlap.

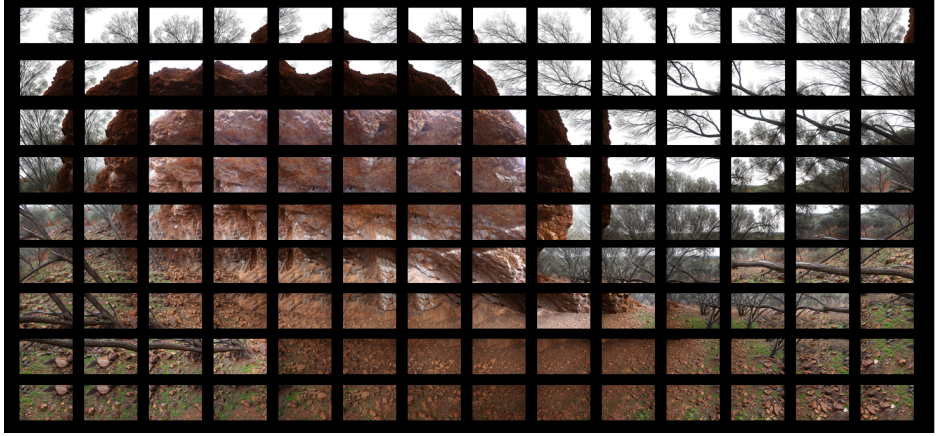
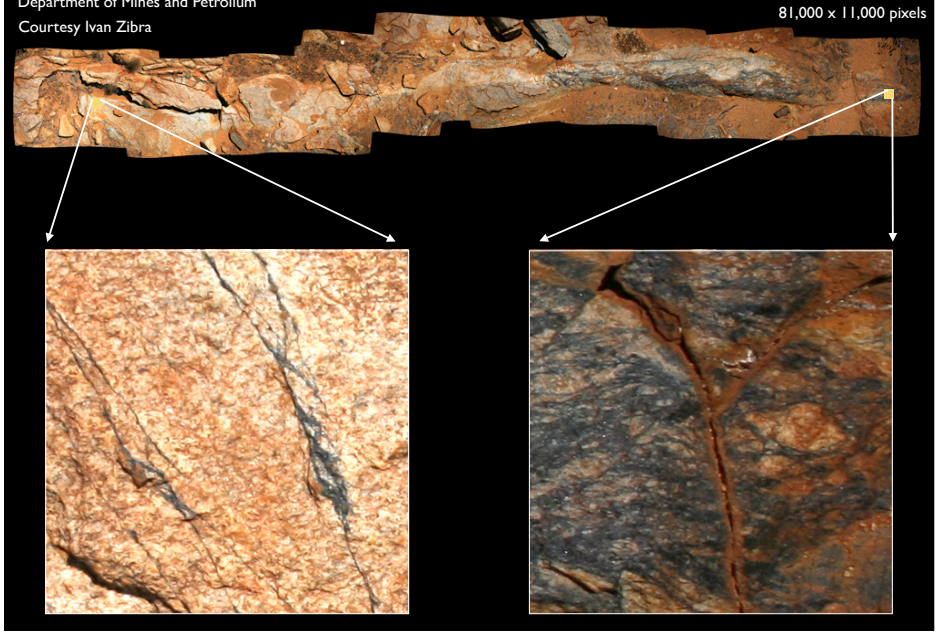


Image mosaics

Department of Mines and Petrolium
Courtesy Ivan Zibra

81,000 x 11,000 pixels



Gigapixel mosaics

- For panorama style the camera is arranged to rotate about it's so called "nodal" point.
- Stitching can be perfect.

- Mosaics refer to a camera that moves, typically across a largely 2D object.
- For fundamental reasons the stitching/blending cannot be perfect across all depths. Thus better for surfaces with minimal depth variation.

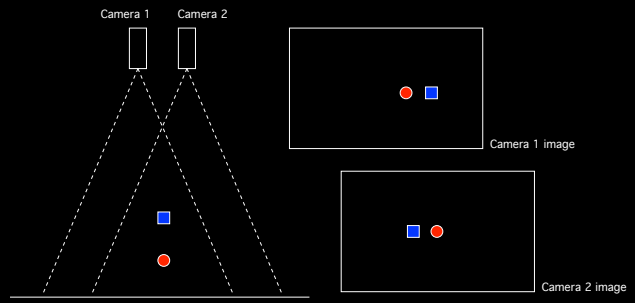
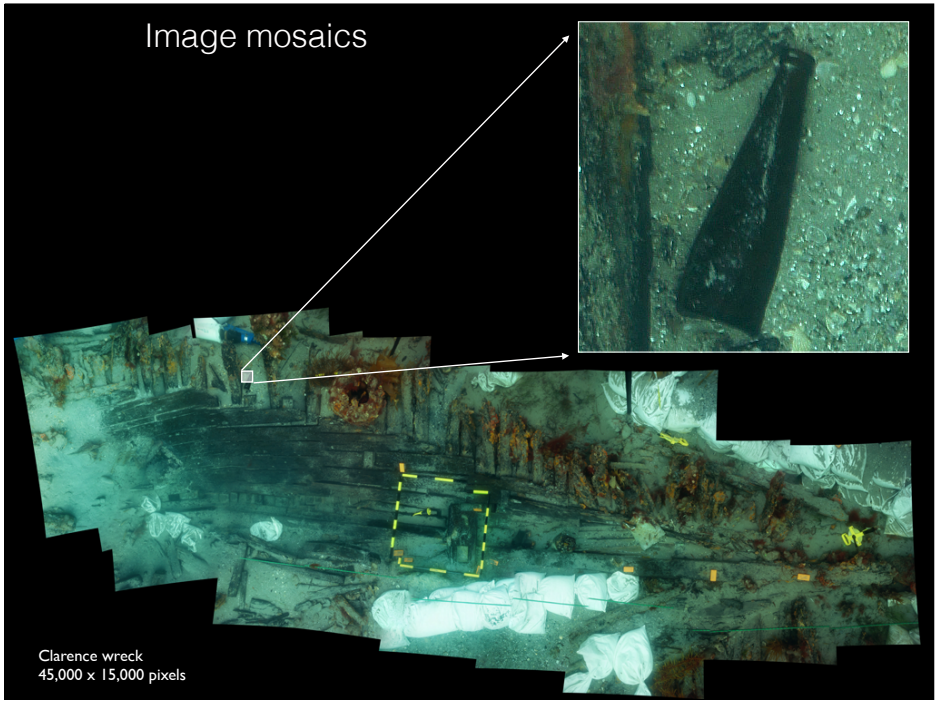
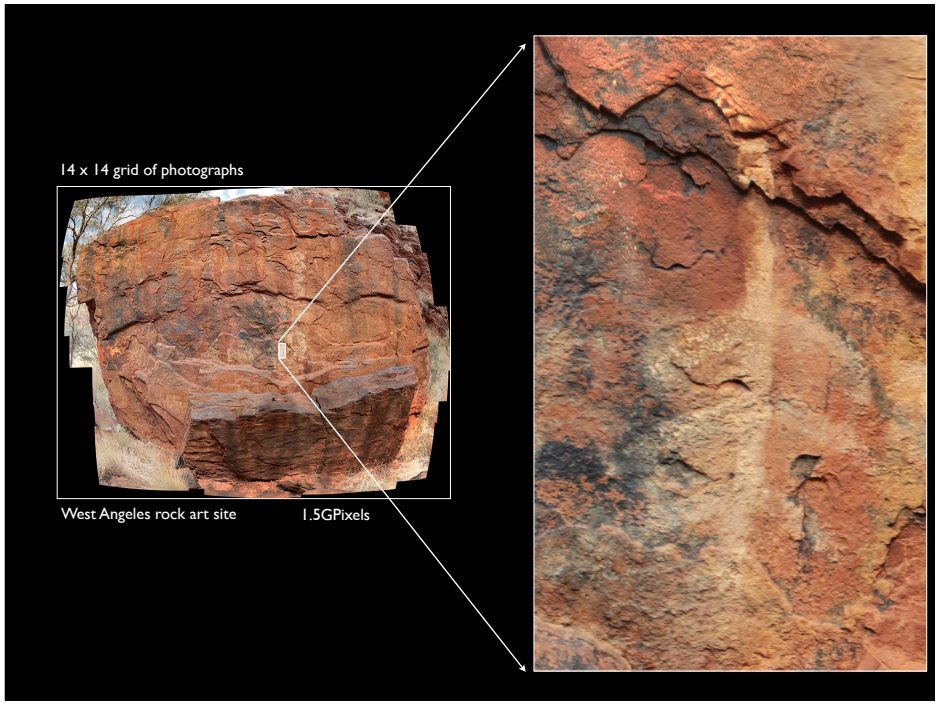
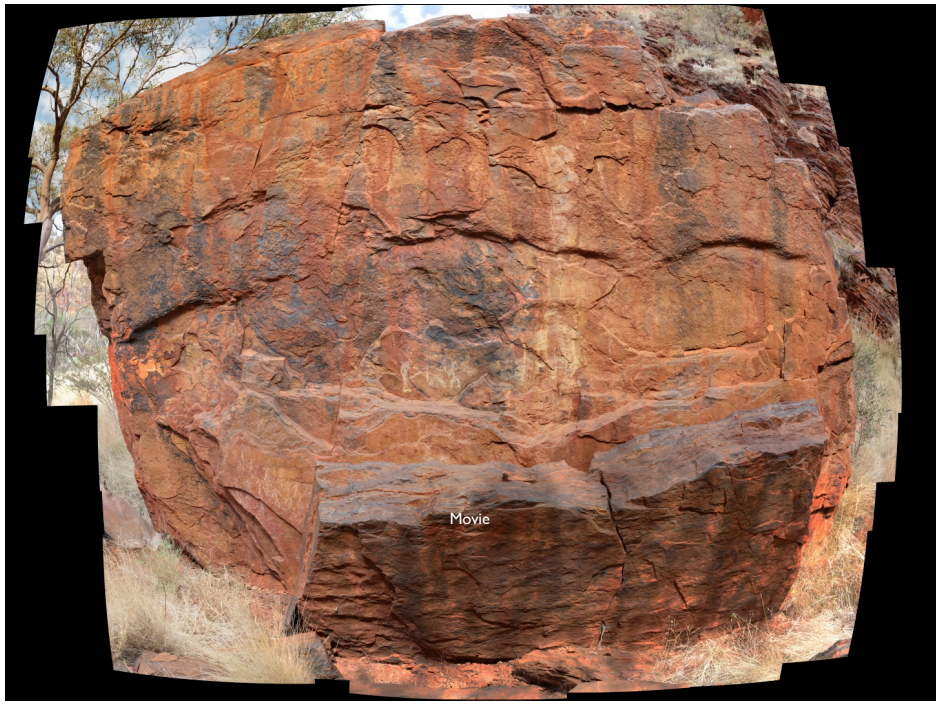


Image mosaics





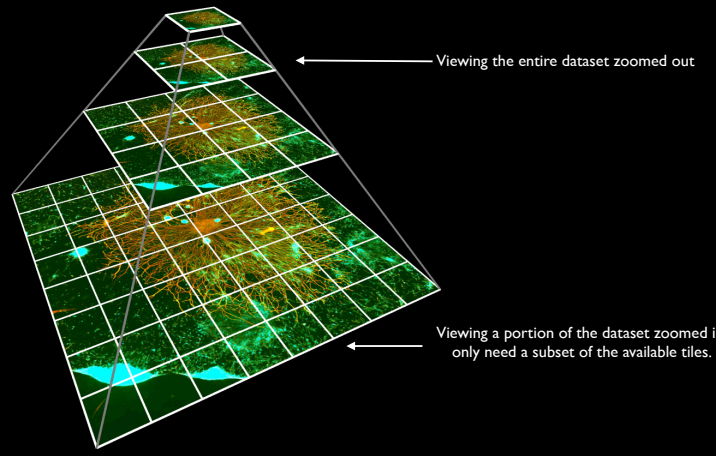


Challenges

- These are “just images” so one might expect it to be a solved space.
  Capture yes. Data storage, management and distribution ... not so!
- Most standard image formats are limited to 2^15 (32768) pixels maximum width or height. Some are lazier and limit to 32,000 or even 30,000 pixels.
- Many formats are limited to 2GB maximum file size, others 4GB ... a legacy of past file system limitations.
- Candidate file formats such as:
  TIFF, Pyramidal tiff, bigtiff - JPEG 2000 - Photoshop large image format - ...
  Generally poorly supported by storage and analysis software.
- The vast majority of software expect to read the whole image into RAM.
  Increasingly inefficient, one can now readily capture images requiring 10’s GBytes.
  Problems with databases that try to create thumbnail images, for example.
- There are very few standards based hierarchical or progressive image formats.
  JPEG 2000 Wavelet support, Pyramidal TIFF.
- Even fewer standards for online delivery and poorly supported.
  Lots of options but largely bespoke with corresponding lack of support.

Pyramidal TIFF

- The tiles visible depends on where in the image one is exploring and the zoom level.
- A scalable solution: principle is only load/transfer/display what is visible.
- Remarkably poorly supported.



Online

- Best online options at the moment are ad-hoc/bespoke image hierarchies supported by Javascript - Canvas - ...

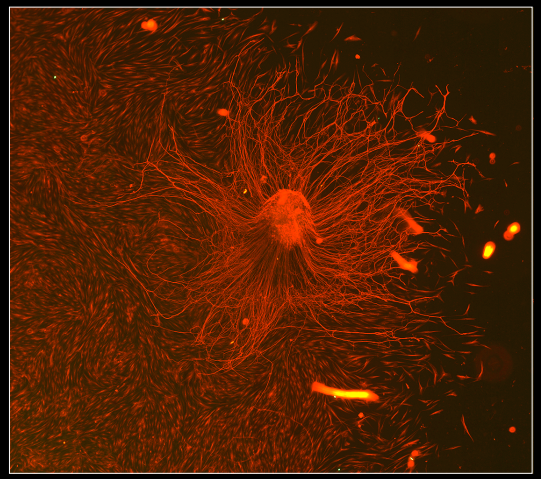
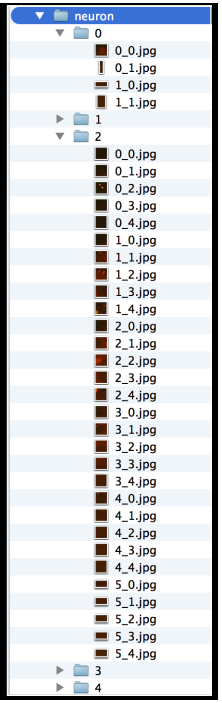
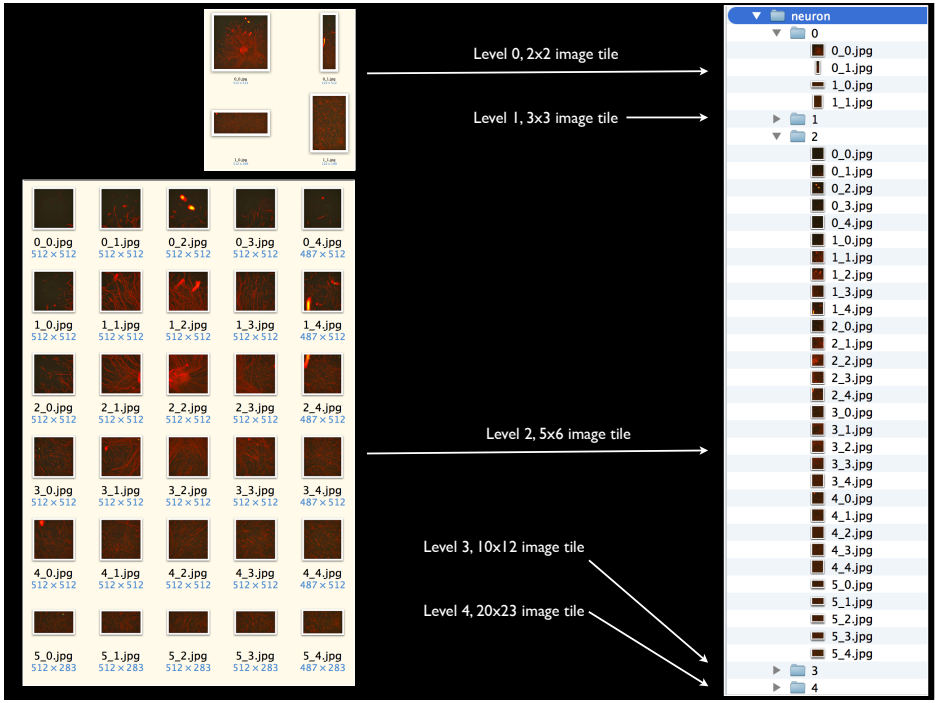


Image courtesy CMCA, UWA Rat neuron



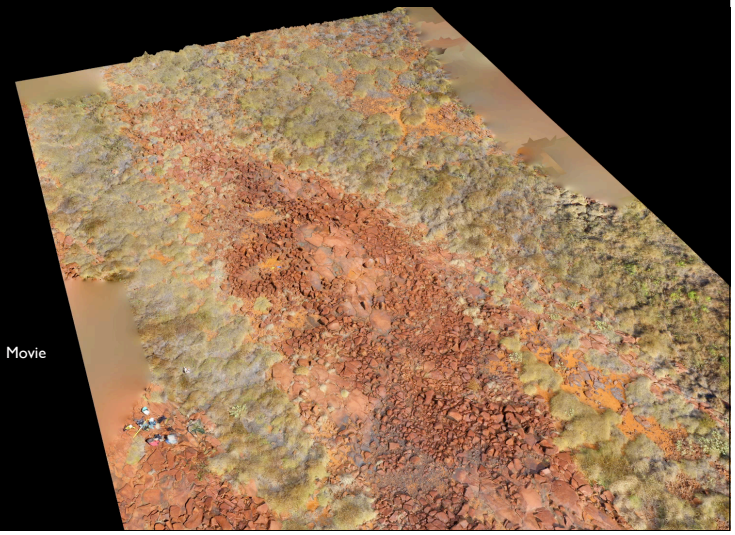


Summary

- High resolution, up to many Gigapixels, are increasingly easy to capture.
- Finding application across a number of disciplines as a means of capturing valuable digital assets.
- Software tools for displaying, storing, managing, searching these images are not meeting research requirements.

Future ... gets even more exciting

- Photographic data is being used to reconstruct 3D models.
- Hierarchical data structures also being used here.



Future ... and extended to video

- ... and it's about to get worse (better).
- High resolution filming is increasingly available and yielding valuable digital assets, in this case cultural heritage.

Ngintaka cave, Northern Territories

8000 x 4000 pixels = 15 x HD video

Questions