Engaging displays for Visualisation

Paul Bourke
iVEC @ University of Western Australia

iVEC @UWA

Visualisation: What is it?

- Presenting data in an informative (insightful) way using computer graphics.
- "Visualisation" is a term that is used in a large number of fields to refer to the general notion of using images/diagrams to give insight into underlying data or process.
- Aims of scientific data visualisation in research:
  - Allow researchers to learn something new about the data.
  - Allow researchers to more quickly understand the data.
  - Identify errors or unexpected effects in the data.
- Audience for science visualisation:
  - Used by scientists as part of their research.
  - Used by researchers to convey research outcomes to their peers
    eg: conferences, papers, seminars.
  - Used to educate a non expert audience
    eg: public education/outreach.
- Data sources:
  - Experimental data, for example 3D scanning, surveys, photogrammetry, etc.
  - Simulation data, for example finite element analysis, cosmology simulation, etc.
- Involves a combination of programming - algorithms - computer graphics - art.

Illustrative vs data visualisation

- Will draw a distinction between illustrative visualisation and data visualisation.

- Illustrative visualisation
  - Generally performed by an animator in conjunction with a domain expert.
  - Usually intended to convey insight into a process rather than necessarily being an accurate representation.

- Data visualisation
  - Based upon actual data, either from experiment or simulation.
  - Generally no scope for changing the underlying data, only how it is represented.

Example: Illustrative visualisation

Courtesy Drew Berry, WEHI

Example: Data visualisation (medical)

Courtesy Ajay Limaye, ANU

Example: Data visualisation (astronomy)

Galaxy formation simulation visualisation

Presentation to our brain

- Visualisation is largely concerned with the human visual system, that is, presenting information to our brain through our sense of sight.

- There are abilities of our visual system that are not normally engaged when using a standard flat panel display.

- Stereopsis.
  - Our brain receives two images from horizontally offset eyes.
  - Gives rise to the depth perception we experience in real life.

- Peripheral vision.
  - Our field of view is almost 180 degrees horizontally and 120 degrees vertically.
  - Gives us a sense of immersion, “being there”.

- Visual fidelity and dynamic range.
  - Eyes (mostly) have higher resolving power than displays, real world is continuous.

- Display technologies that leverage our visual system are useful in the visualisation process and have applications to public outreach and engaged learning.

Stereoscopic 3D

- Proposal: Exploring geometrically complicated datasets can be assisted if we use our sense of depth perception.
- Irrespective of the stereoscopic system used the goal is to present two correctly formed images independently to each eye.
- Technologies include shutter glasses, polaroid filters, Infitec.
- Glasses free systems are being developed but generally still low resolution and have viewing constraints.

Peripheral vision

- Many geometries have been used, eg: cubic rooms (CAVE), partial room (WEDGE), cylindrical displays (AVIE).
- Peripheral vision is credited with a sense of "being there", otherwise known as "presence".
- Ideal for placing a person inside the data rather than the traditional outside looking in.
- Often provides strong depth cues due to the visual system not seeing the frame.
- Another option is a hemispherical surface.
  UWA has an iDome, Perth has the Horizon Planetarium.

iDome at UWA

High resolution displays

- Standard resolution displays can be non-optimal for
  - High resolution images.
  - High density data.
- For high resolution images one is forever zooming in to see details (lose the context) or zooming out to see the context (lose the details). The "Google Earth" effect.
- For high density data there simply may not be enough pixels to differentiate the details in the data.
- A standard monitor may be HD resolution (1920x1080), images of resolutions 10,000x10,000 pixels (and much larger) are increasingly common.
- Three approaches
  - Tile a number of standard data projectors. Very hard to get high resolution and end up with a high cost of ownership system.
  - Tile a number of high resolution (4K) projectors. Costly, require lots of space.
  - Tile a number of commodity LCD panels.

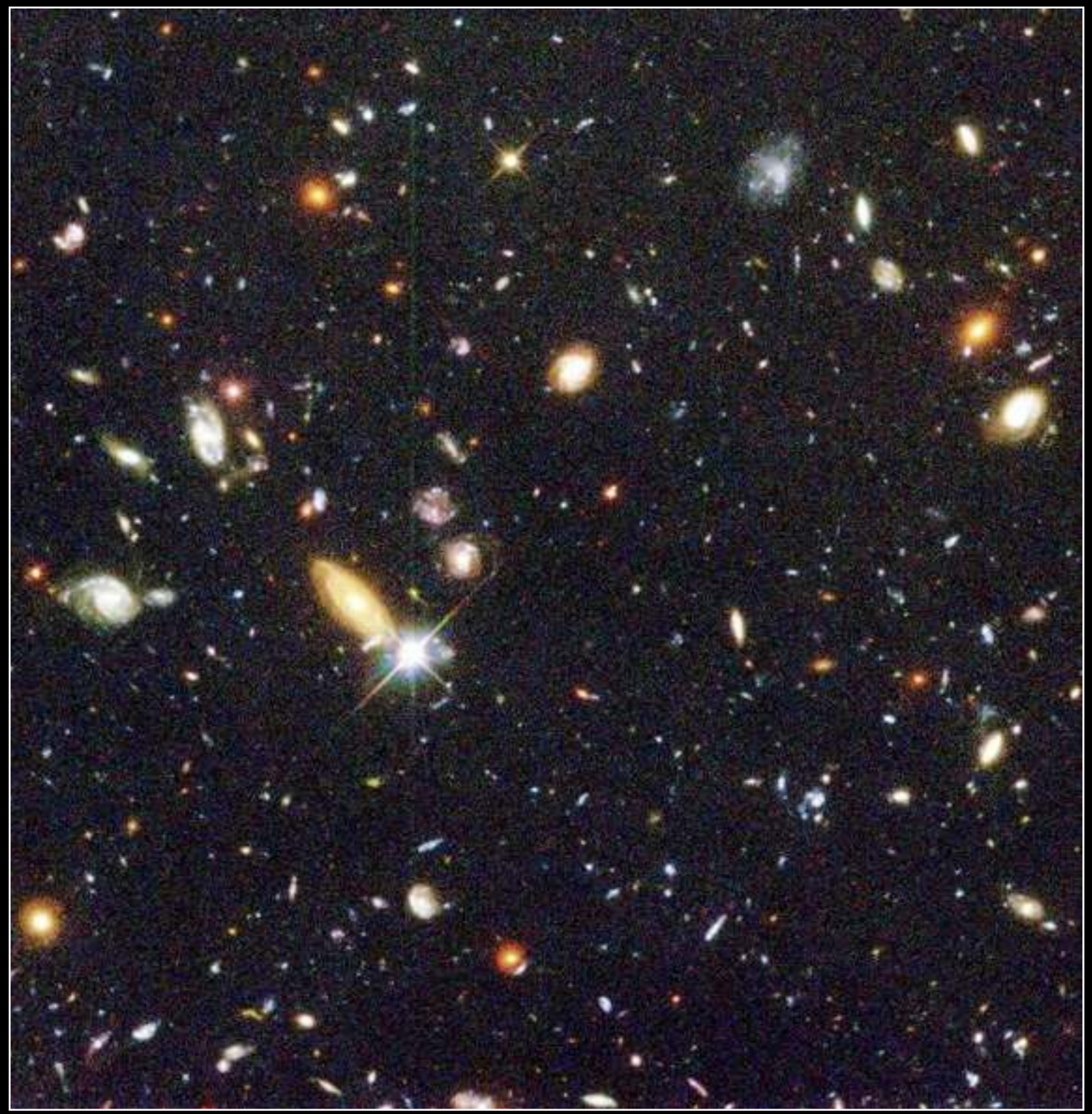
High resolution image data

- Tiled photography is a trend that spans a wide range of disciplines.
- Hubble space telescope - landscape - archaeology - microscopy.

100,000 x 80,000 pixels

6400 x 5120 pixels

Example: Hubble deep field



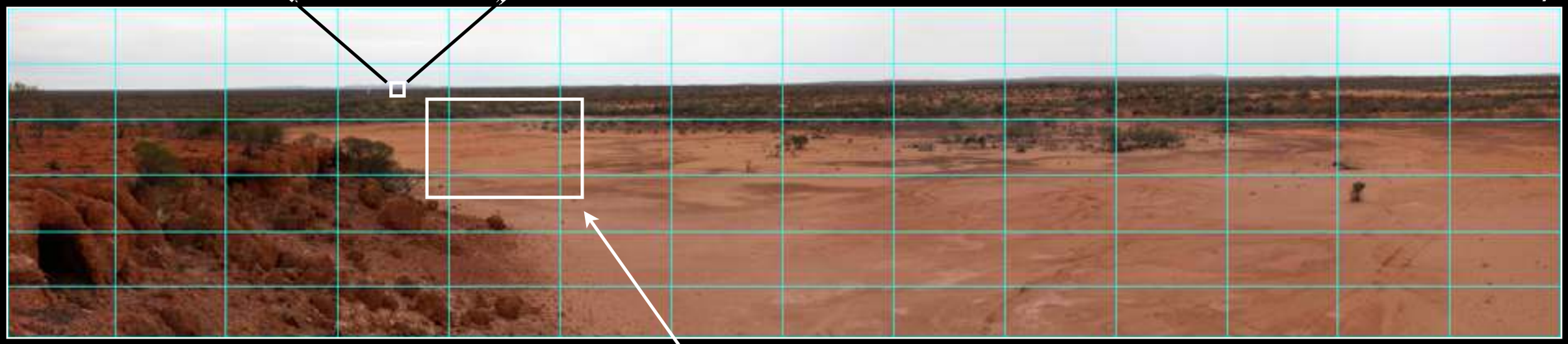
Hubble deep field, 340 images.

Example: ASKAP site

First ASKAP dish

Canon EOS 5D MkII camera
and gigapan mount

ASKAP site, Boolardy



21 MPixels, Canon EOS 5D Mk11

Total: 1.5 GPixels

Example: Microscopy

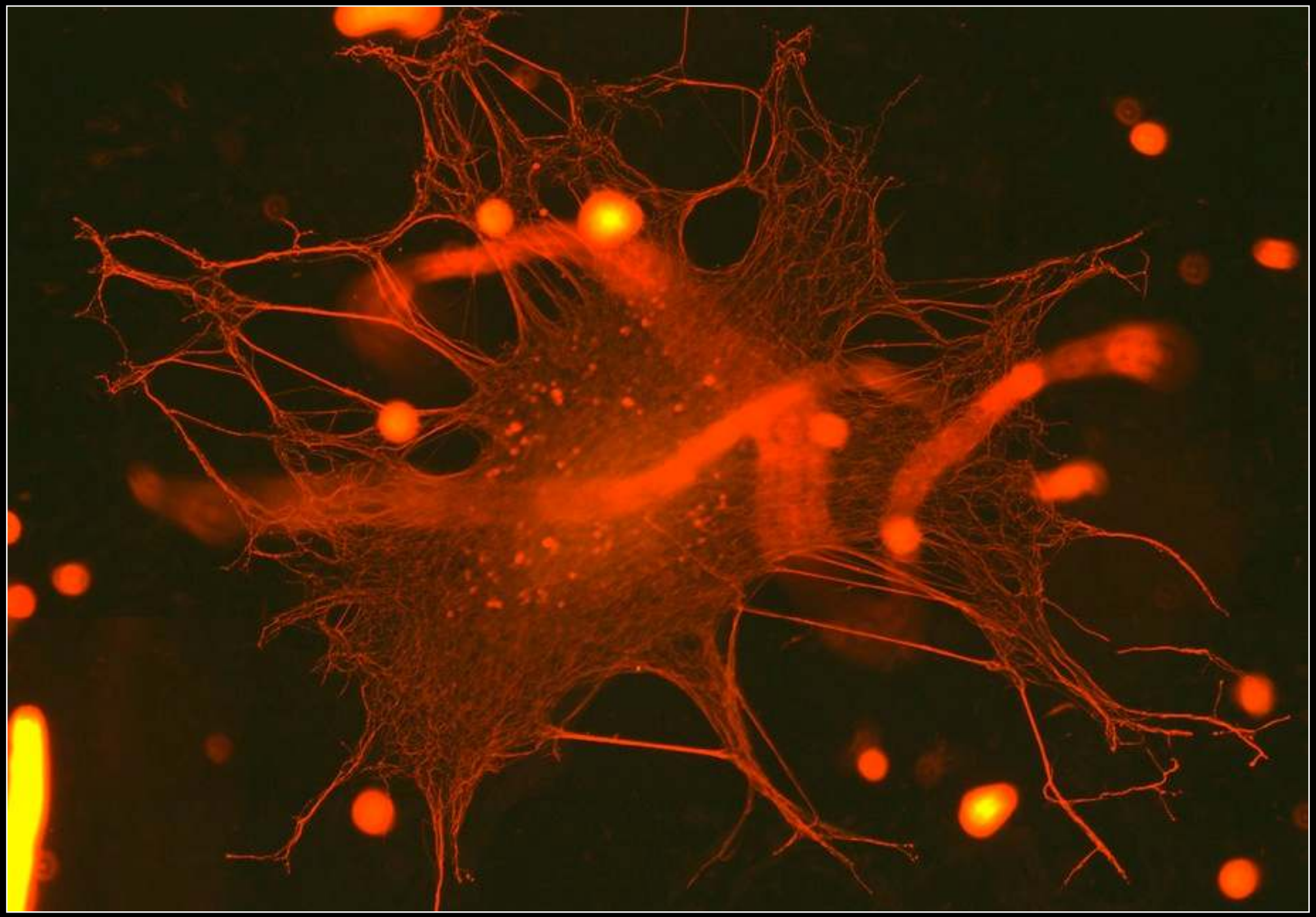


Image courtesy CMCA, UWA

11,000 x 8,000 pixels

Example: archaelogy

Left eye image

40,000 by 20,000 pixels

Hurleys darkroom, Mawsons hut (Antarctica), courtesy Peter Morse.

Holography

- The ultimate form of 3D display would be a hologram.
  Technology does not exist yet for (useful) realtime holography.

- Note that there are lots of technologies being proposed that use the word "hologram" and very few are holograms in the true sense of the word.

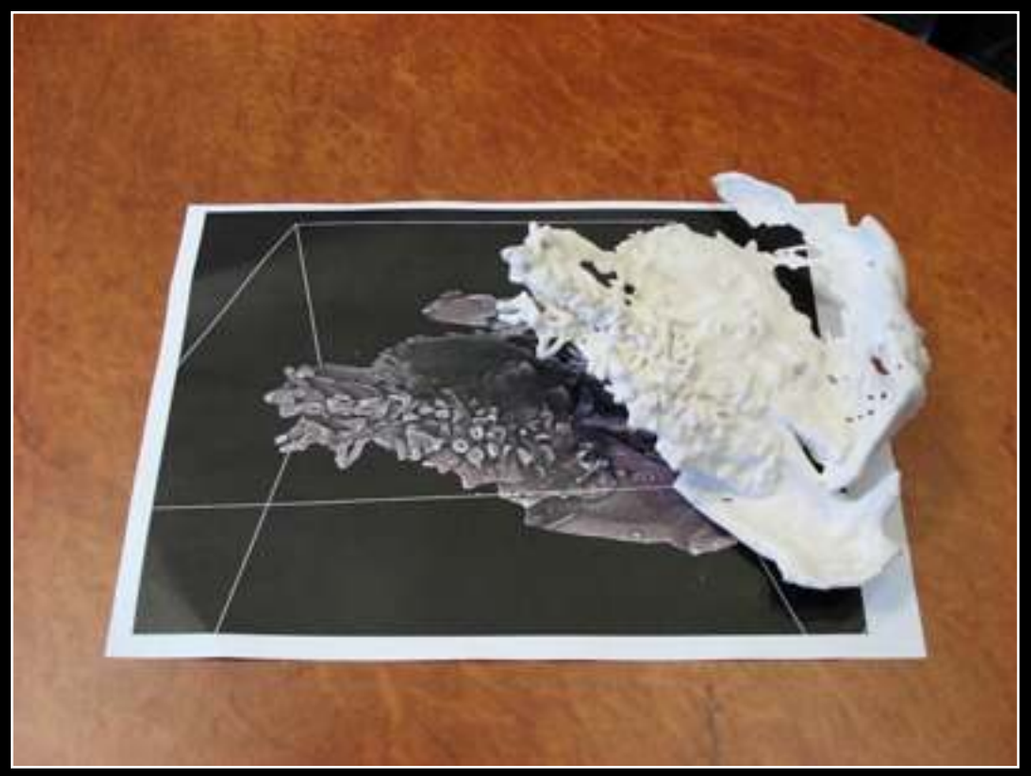
- A true hologram encodes the interference pattern of light from an object with a reference beam. Upon illumination of the hologram the light field is reconstructed by a process called diffraction.

- A discrete approximation to a hologram has been developed for printing and called a "holographic panoramagram".

Placoderm jaw and "teeth"

Tactile Visualisation - Rapid Prototyping

- A number of technologies exist that will allow one to automatically build a physical object from a computer model. Essentially 3D printing.
- Each technology has certain advantages and disadvantages. For example: degree of post production, strength of material, cost, colour fidelity, etc.
- Designed mainly for the mechanical engineering fields and component/product design. Also well established in the medical area for pre-surgery planning and implant design.
- Allows one to explore data in the same way as we explore objects in our everyday experience.



Live demonstrations.