Science Visualisation and Engaging Display Technologies

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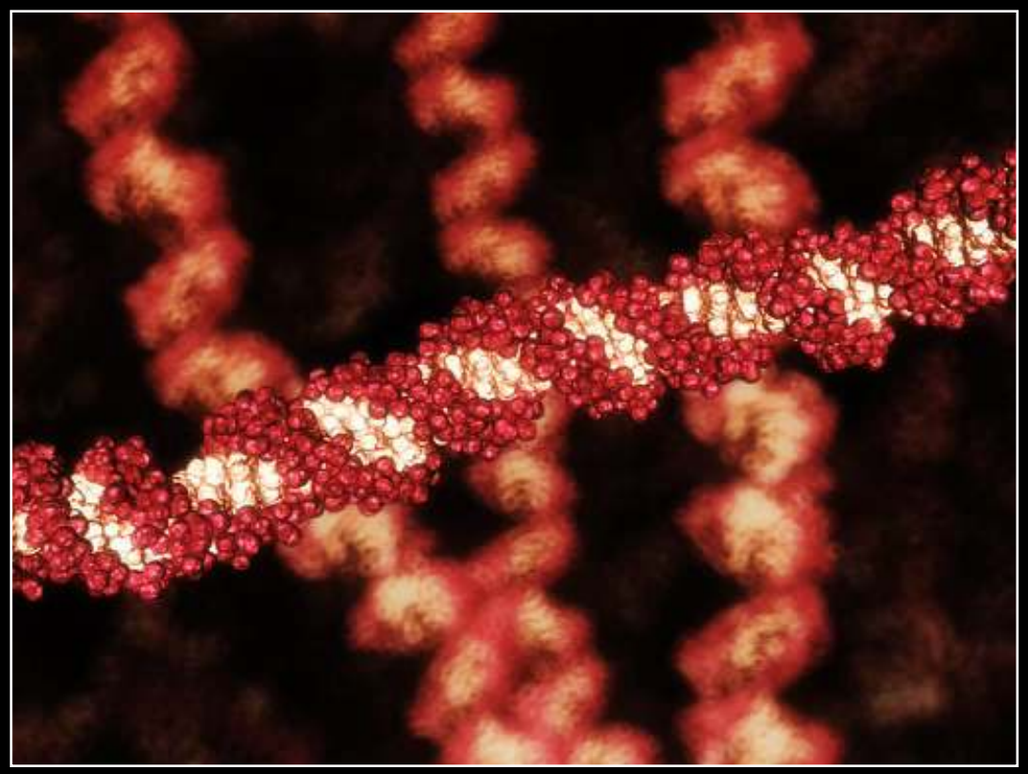
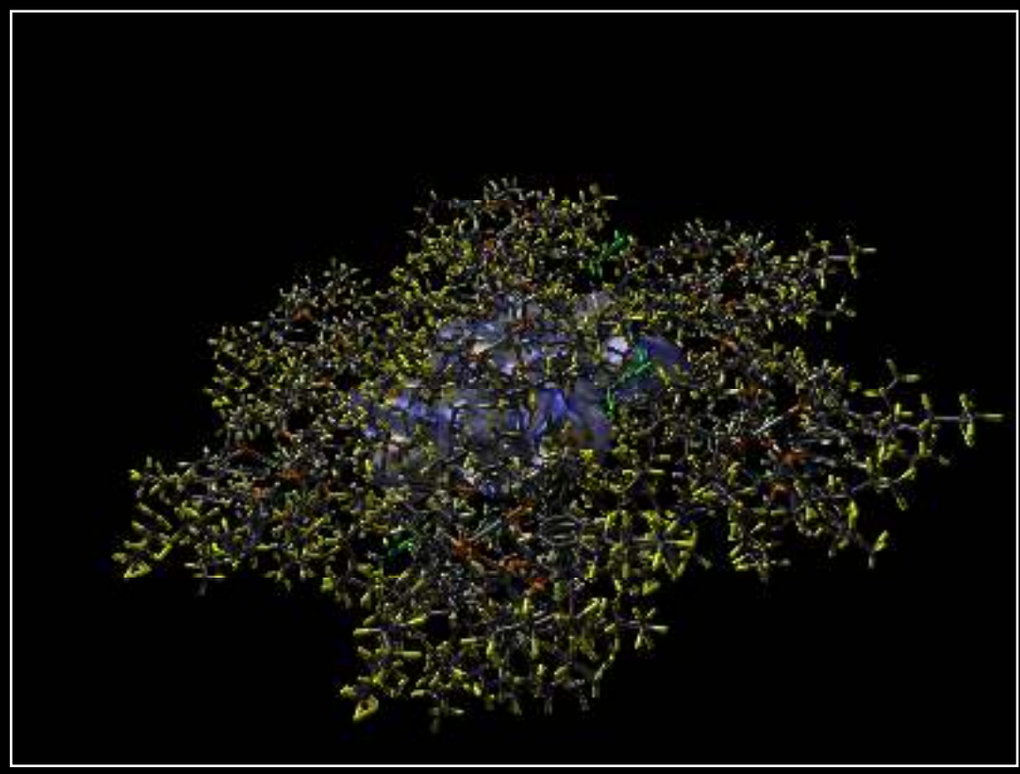
- Taste, smell, hearing.
- Tactile visualisation and rapid prototyping.
- Vision, the main method of visualising data.
- Characteristics of the human visual system.
  - Stereopsis
  - Peripheral vision
- Holography and glasses free stereoscopy.
- Stereoscopic demonstration.
- Dome demonstration (Optional).

Introduction - Visualisation

- Presenting information through the human senses, most notably our sense of vision.
- Goals
  - give researchers new insight into some process
  - provide insight faster than traditional methods
  - reveal errors in simulation or experimental data
- Distinction between illustrative visualisation and data visualisation.

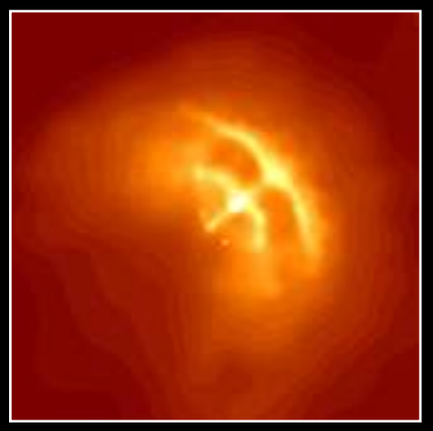


DNA (Courtesy Drew Berry)



The difficult senses

- Both the sense of taste and smell are rarely used.
- Taste in particular involved many components: chemicals, feel of the object being consumed, etc. Only likely to be achieved with direct brain stimulation.
- Many attempts have been made to engage the sense of the smell. Includes “canons” that can direct particular smells to an individual. Still very early days of research and the smells are largely crude in nature, representing strong smells.
- Hearing is more widely used for visualisation, the conversion of data into sounds is called sonification.
- In general there is only an imprecise mapping between data and sound, most commonly used in visualisation to support the sense of vision.



Vela pulsar

Event-based sonification of an EEG section of patient with generalized absence seizure.

Sense of touch

- The sense of touch is often used in data visualisation although usually for a narrow range of applications.
- Haptic devices allow one to feel datasets, the provide force feedback when solid objects are “touched”.
- Piezo-electric devices can give a degree of smoothness/roughness.
- Some applications use temperature ... feeling geological data.

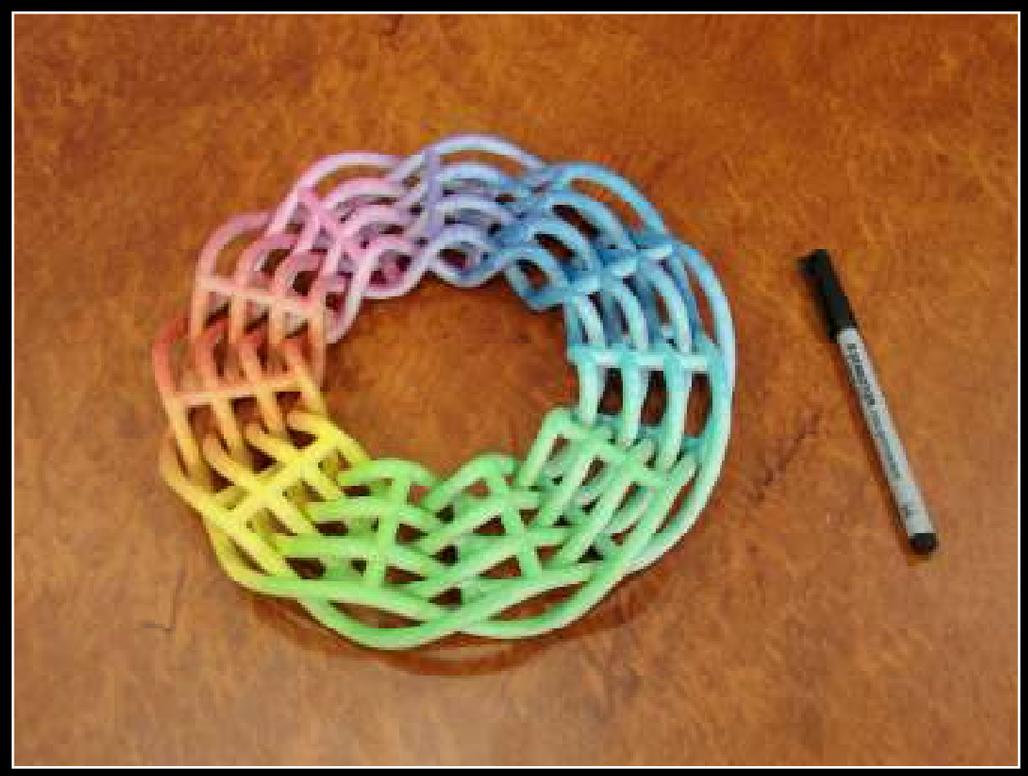
Rapid Prototyping

- One of my interests is the creation of solid models from data.
- A number of technologies exist by which objects can be manufactured automatically by a machine, essentially one "prints" and instead of getting a piece of paper one gets a 3D real object.
- We have been using the machines from Z-Corp. Capable of reasonably large objects (~25cm) and supports colour (4 colour glues, CMY and clear).
- Works like an inkjet printer but instead of squirting ink at a piece of paper it squirts a binding agent (glue) to a rising tank of powder.

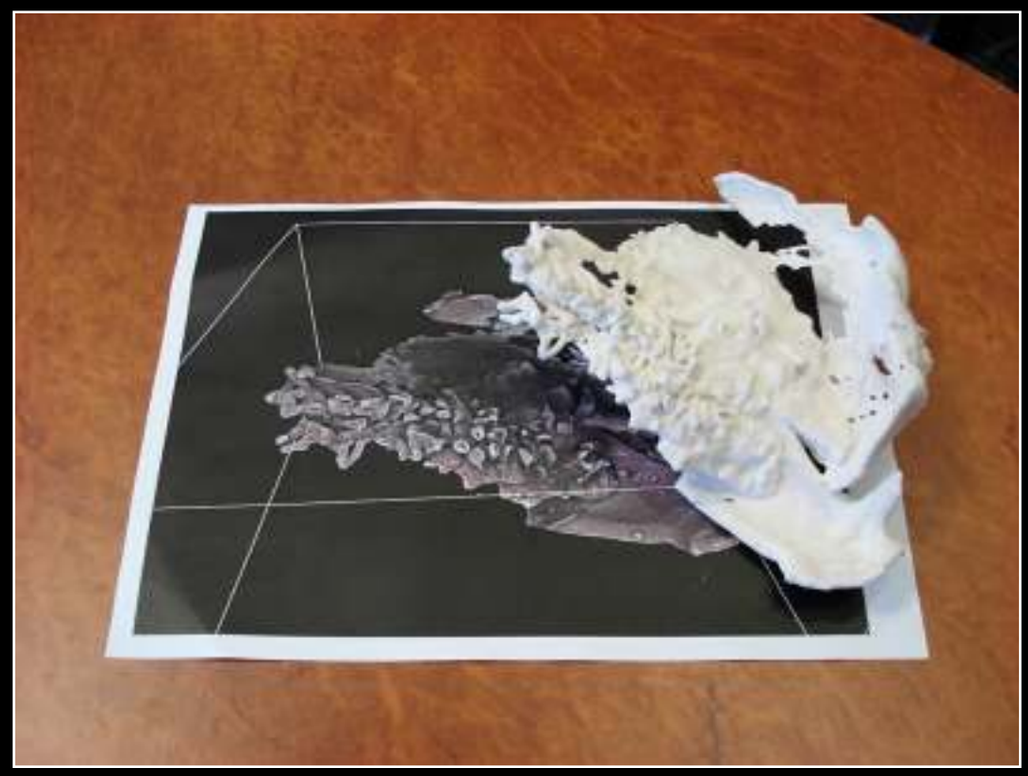
Examples

Miscellaneous examples from geology

Reconstructed rock face: Sirovision



Vision research mathematics



Placoderm fish vertebra

Crystal Engraving

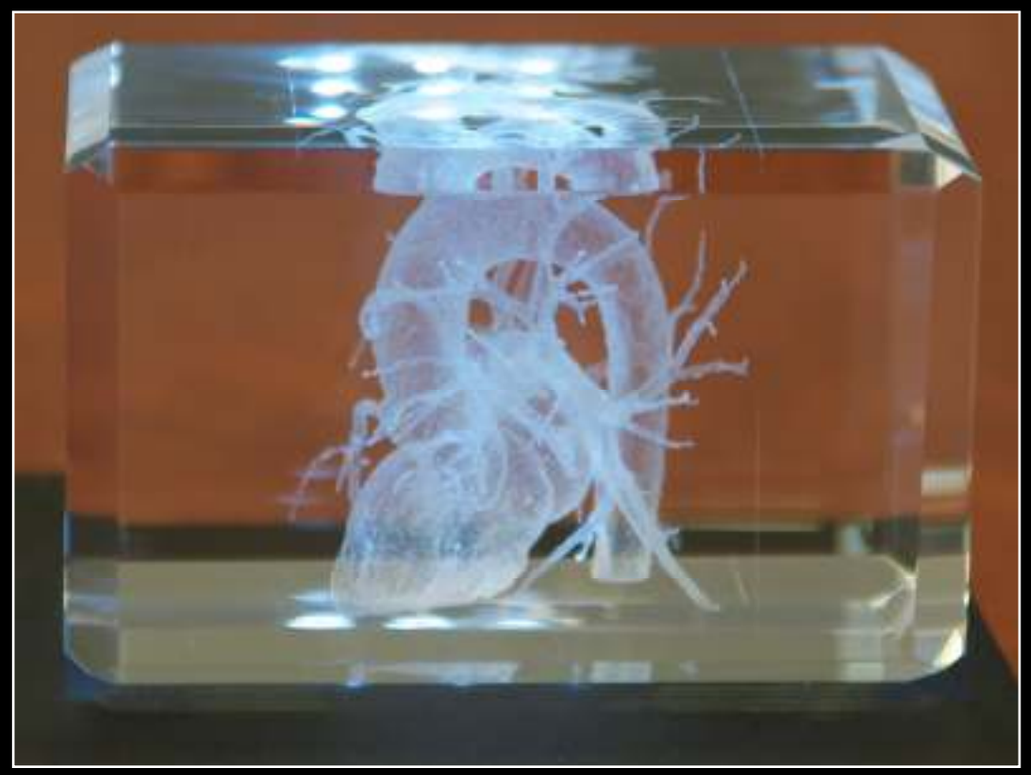
- While rapid prototyping can create single, structurally sound models, many datasets are disjoint.
- Another form of prototyping we have experimented with is crystal engraving.
- Laser focussed at a point in a block of crystal causes a "bubble" that then scatters impinging light.
- Successful examples include galaxy surveys and geological samples.

Examples

ASKAP telescope dish, point cloud from CAD model

Egyptian mummy, bone isosurface of CAT scan data

Lorenz attractor, derived from attractor equations



Human heart, segmentation of MRI data

Vision

- By far the main way data is visualised is through our sense of vision.
- Data is turned into images and series of images (movies) and presented on a digital display.
- Often standard display technologies are inadequate or inefficient at conveying the data.
- Visualisation therefore often uses novel technologies in order to
  - allow the researcher to get an improved appreciation of the data.
  - allow more engaging experiences for education and public outreach.
- Can can we maximise the use of the human visual system?

Features of the human visual system

- There are two main characteristics of the human visual system that are not engaged when viewing a standard 2D display.

- We have two eyes and this gives us the sense of depth we perceive in the real world.
- Our eyes have a very wide horizontal and vertical field of view.

- You can imagine there would be benefits from using these features of our visual system.

Peripheral Vision

- Our horizontal field of view is almost 180 degrees, vertical field of view is almost 120 degrees.
- Examples of environments that are able to utilise this can be found in the Science Centre: the iDome and the planetarium.
- When your peripheral vision is filled with virtual content then we get a strong sense of "being there".
- The visualisation laboratory at UWA provides researchers with the ability to view their data in the iDome. Particularly suited to times when they want to be on the inside of the data.
- Without the iDome researchers were continually panning to view the data across a range of angles.

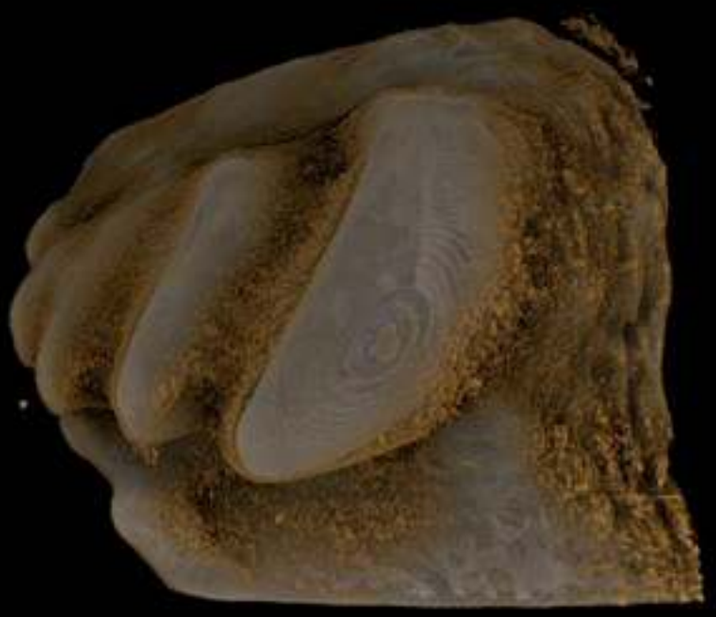
iDome examples

Stereopsis

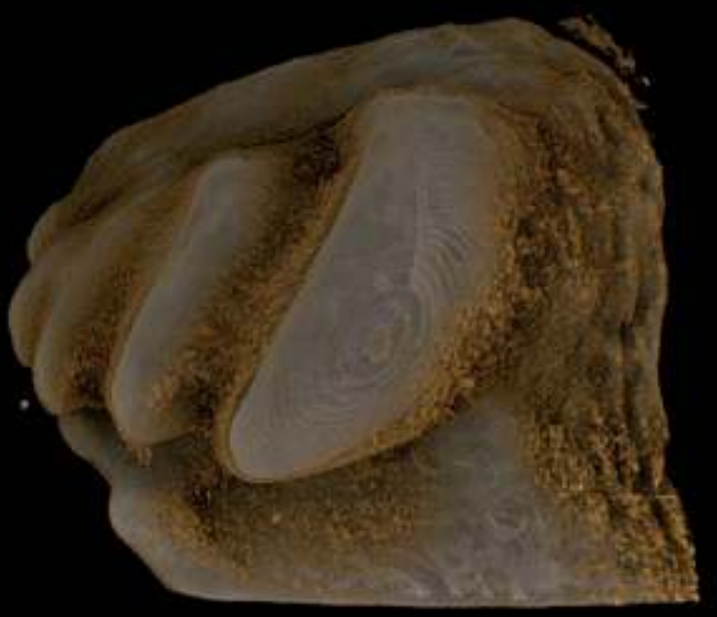
- Our visual cortex gets two slightly different views of the world from our horizontally offset eyes. This gives us the sense of depth we experience in the real world.
- On a standard computer display even through one may be looking at a 3D model, the image still appears flat.
- Is it possible to simulate this experience with computer graphics?
- Obviously yes, for example iMax3D. Indeed it has been possible for about 30 years, but until recently it has often been relatively expensive.
- Stereoscopic projection is perhaps the most commonly used tool for science visualisation. Particularly useful for geometrically complicated data relationships.

Technology

- The goal, irrespective of the technology, is to present images independently to each eye.
- That is, one image is created for the left eye, another image created for the right eye.
- There are at least 3 ways of achieving this:
  - Infitec
  - Shutter glasses
  - Polaroid
- The system discussed and demonstrated here is based upon polaroid filters.
- Glasses free stereoscopic viewing is now possible, although not used very often for visualisation because the resolution is relatively low.



Left eye image



Right eye image

Passive polaroid stereoscopic projection

- Two projectors each with a polaroid filter in front of the lens.
- The polaroid filters are at 90 degrees to each other.
- They match the angles of the polaroid glasses.
- Require a surface (front projector or rear projection) that doesn't destroy the polarisation of the light.
- Bottom line: Your left eye only sees the image from one projector, your right eye only sees the image from the other projector.

Holography (i-Lumograms)

- Aother area of exploration is holography. It is almost certain that holograms you have seen have been of real objects, a new technique is being developed to create holograms of virtual objects. Called “i-Lumograms”.
- Holograms of real objects are created by recording the interference pattern between light reflected off the object and a reference beam. The light field is reconstructed by diffraction when the hologram is illuminated by a light source identical to the reference beam.
- The light reflected off the object can be considered to be a large number of point sources, we can approximate this by rendering a large number of images of the object from different positions.
- Unlike conventional holograms the i-Lumograms have significantly better colour reproduction and are able to encode (limited) animation. Can be viewed simply with “reasonable’ monochromatic light.
- Down side is that the resolution is still not as good as “real” holograms.

Examples

Placoderm fish “teeth”, no animation but the parallax from different viewing positions is clear from the above

Geological sample, slight modification of the voxel transfer function between left and rightmost views.

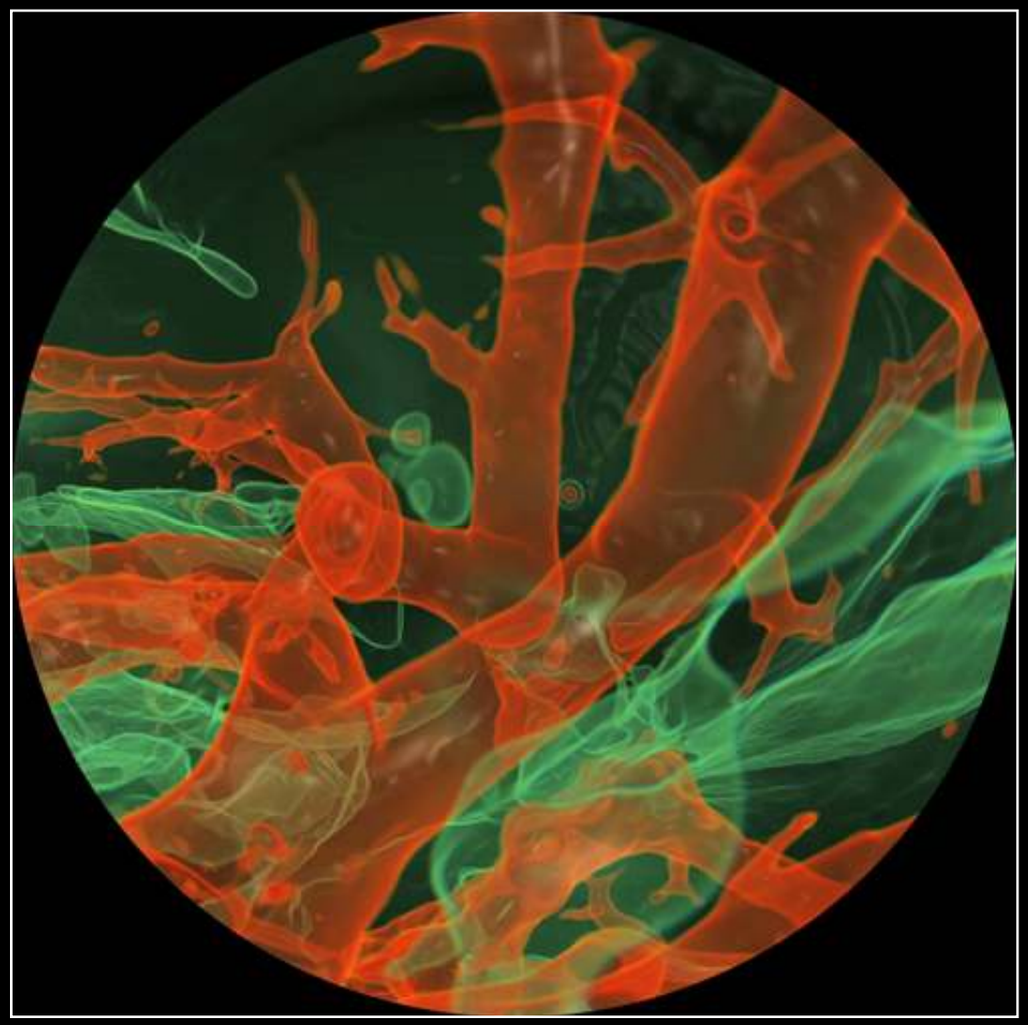
Stereoscopic demonstration

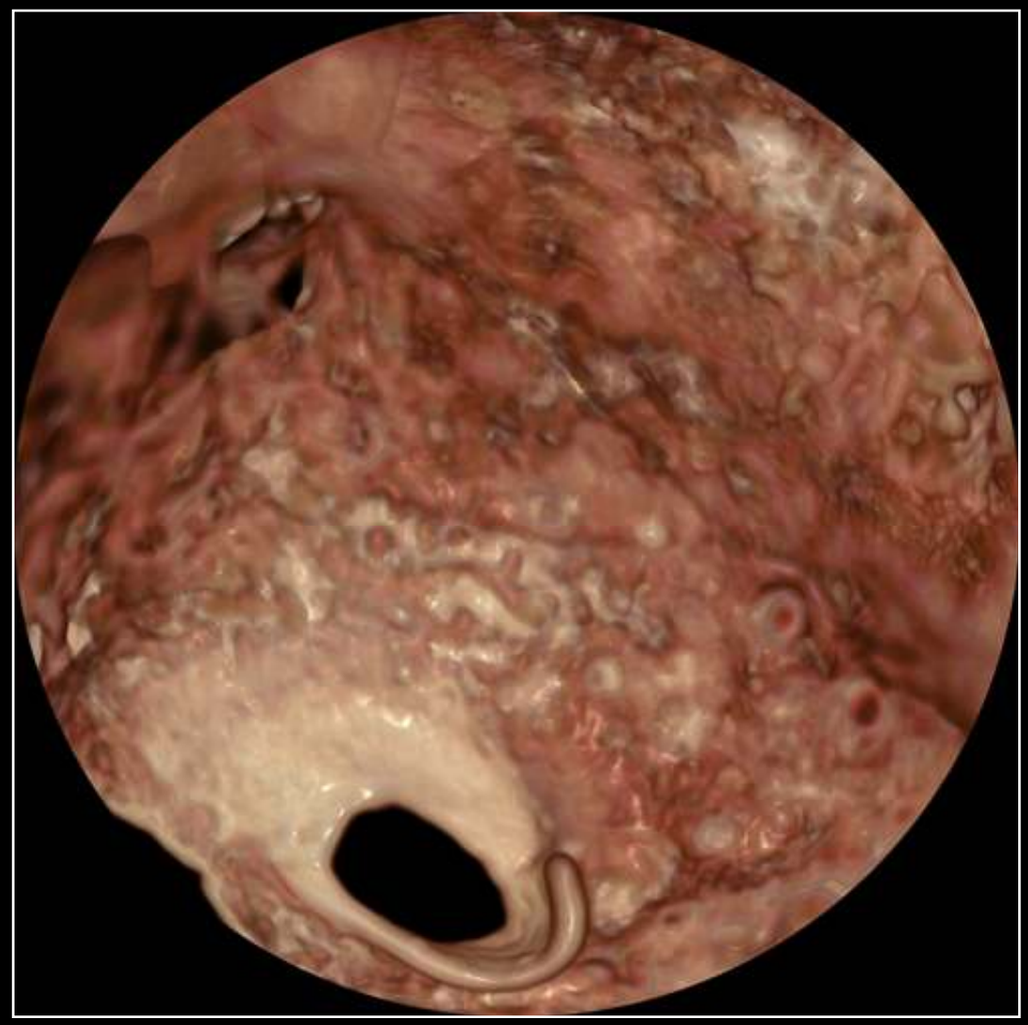
- Placoderm fish
- Sirovision reconstruction
- Geology
- Small nature photography
- Heritage
- 6dF galaxy survey
- SKA photographs
- Crystal explorer
- Antarctica

Planetarium demonstration

- Will present a recent short production by myself titled "Volume Visualisation Under the Dome".

- A selection of other short visualisation examples.





Questions?

More information can be found on my web site:

http://local.wasp.uwa.edu.au/~pbourke/