Visualisation:

What is it?
What's it good for?

Paul Bourke

Outline

- Visualisation, what is it?
- Data types and characteristics.
- General techniques.
- Tools, technology leveraged.
- Exploiting characteristics of the human visual system.
- Challenges.

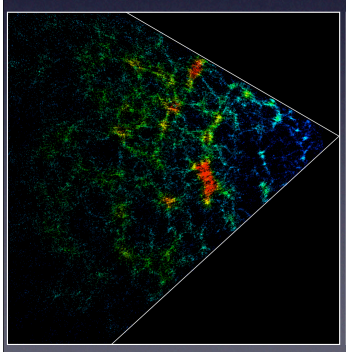
Visualisation: What is it?

- Possible definition: Gain insight to data using computer graphics.
- Distinction between data and illustrative visualistion.
  Illustrative visualisation: conveying a understanding of some principle without necessarily any real data being involved.
- Research orientated scientific visualisation
  - Finding relationships in datasets.
  - Faster understanding of relationships in datasets.
- Not uncommon outcome is data checking and verification.
  Errors are more obvious when seen graphically.
- Publication to peers or to a general audience.
- Public outreach, education.

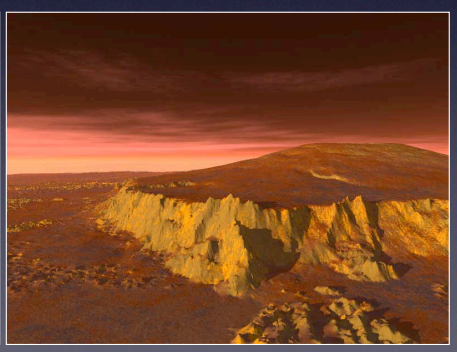
  Each of the above can have different requirements.

Data types/characteristics

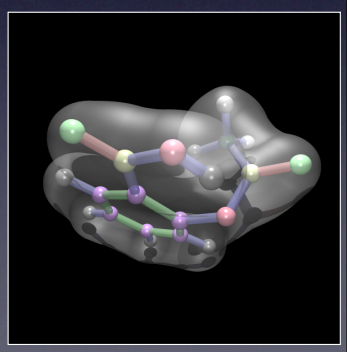
- Dimensionality, number of independent variables.
- Variable types: binary, scalar, vector. Discrete or continuous.
- Static vs dynamic data, single image vs movie, dynamic data vs camera animation.
- Geometric elements: Points, lines, surfaces, spheres, cylinders ...
- Data sampling, regular grid in 2D or 3D, or not.



Astronomy survey data



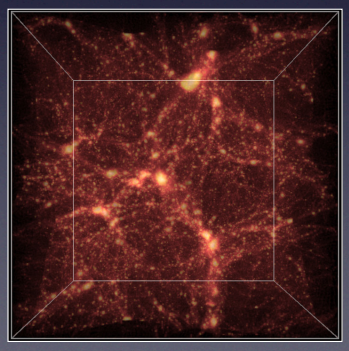
Terrain models



Molecules: sphere, tube, surface

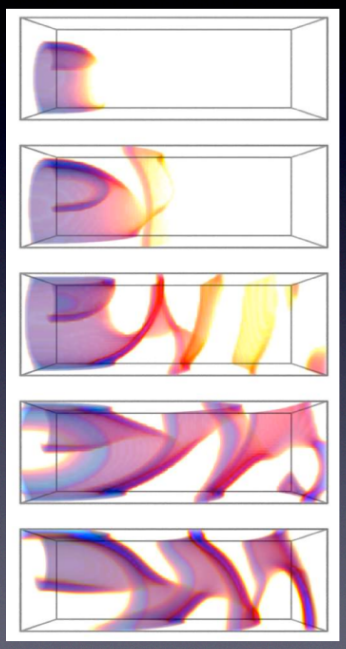
Data types/characteristics, continued ...

- Volumetric data. 3D pixels = voxel.
- Generally a scalar defined at every voxel but can be vector or even higher dimensional datatype.
- Not always a regular sampling, but usually is.
- Has always been a challenge, as hardware capabilities have increased so has the size of the volumes researchers want to visualise.



Cosmology volumetrics

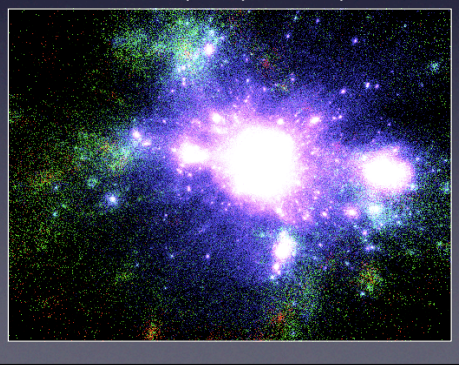
Velocity mapping - time varying

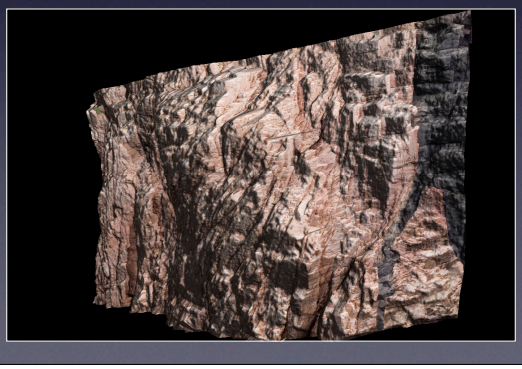


Data types/characteristics, continued ...

- Often need to deal with very large datasets.
- May be too large to fit into memory.
  - Common for animations.
  - Various strategies to deal with this, tend to be highly application dependent.
- May be too much data to transfer to graphics card for interactive frame rates.
  Techniques for dealing with this: Pre-culling, scenegraphs ....

5 million points per time step

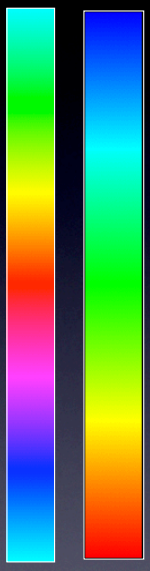




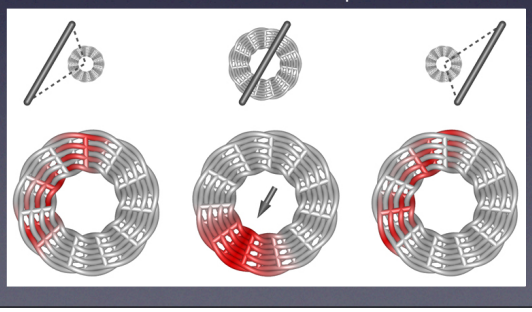
General techniques/characteristics

- Mapping data variables to geometry.
  Sometimes a clear one-to-one correspondence, sometimes not.
- Mapping mathematics or abstract relationships to geometry.
- Mapping variables to colour, transparency, glyphs.
  - Discrete of continuous ramps.
  - Circular or unidirectional.
  - Consideration of the capabilities of the vision system and viewer variation.
  - Not always in RGB space: HSV, YUV, ...
- Representation of data in different topologies or coordinate systems.

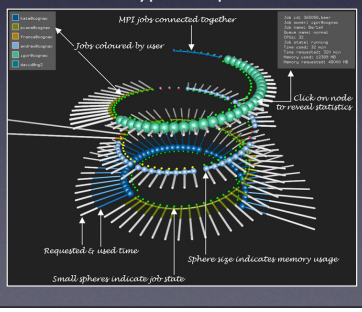
Colour ramps



Abstract mathematical model representation

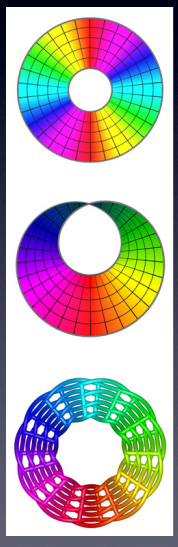


Glyph example

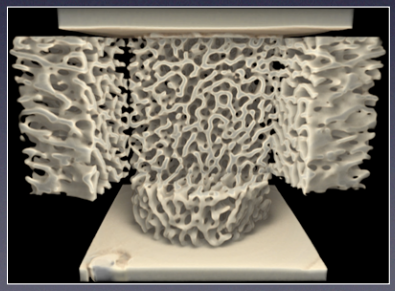


General techniques, continued ...

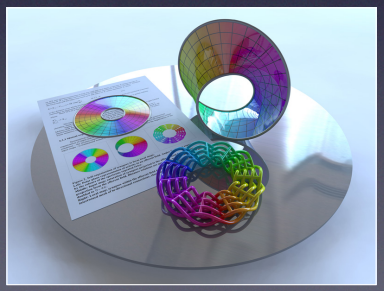
- Slicing/cutaway to see inside data, as well the use of transparency.
- Rendering quality: Simple lighting models for realtime APIs, to more complete light simulations for raytracing/radiosity.
- FIle format conversion. Occupies a significant amount of time, lots of data formats and formats.



Drishti

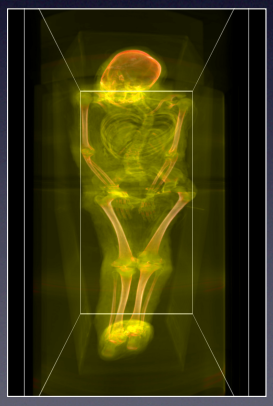


Environment maps and radiosity



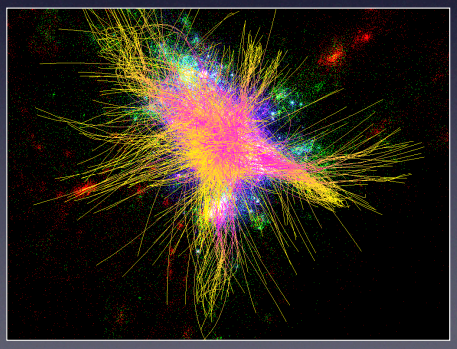
General techniques, continued ...

- Dimension reduction: projections, contours, isosurfaces.
- Realtime/interactive vs precomputed.
  Various methods exist to interactively explore datasets with precomputed elements.
- General visualisation software: OpenDX, VTK, AVS Express, IRIS Explorer...
- Discipline specific software: APS++, RasMol, Vis5D, VMD, ...



Direct rendering

Isosurfaces



Tools and technologies

- Computer science algorithms, data structures, data bases, ...
- Computer graphics and rendering techniques.
- GPU for realtime interaction/exploration.
- APIs: OpenGL, DirectX/3D
- Hardware assistance: 3D input devices, haptics, data gloves, ...
- Specialist projection hardware: stereoscopy, high definition displays, ...
- Artistic input for visual appeal.

Exploiting the human visual system

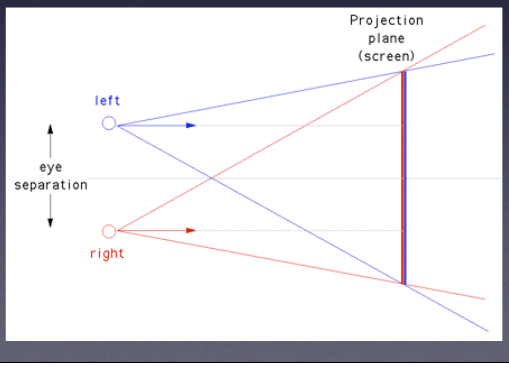
- Depth cues: perspective, motion cues, shadows, surface properties, light shading.
- Stereoscopy, depth from parallax from our two eyes.
- Peripheral vision, sense of immersion.
- Resolution of our visual system. Plxel limits of displays.

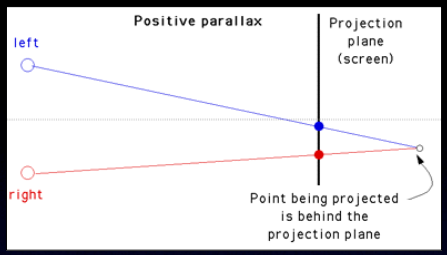
Other senses

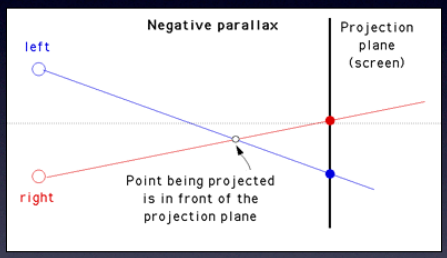
- Tactile: force feedback and 3D printing.
- Sonification: turning data into sounds. A less precise sense so generally in support of visuals.

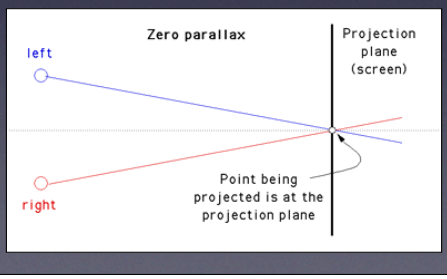
Stereoscopy

- Both IVEC & WASP have stereoscopic projection systems.
- Proven usefulness for visualisation of multidimensional data.
  - finding new relationships.
  - Appreciating relationships faster.
  - Engaging for exhibition and public education.



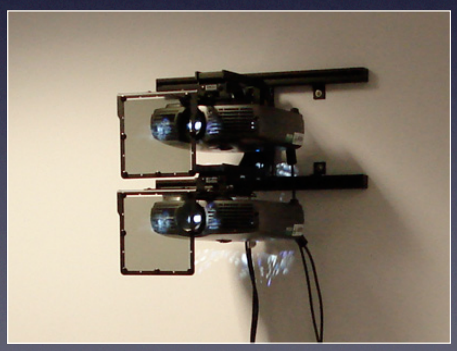






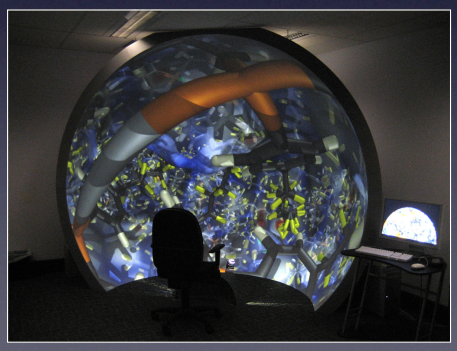
Stereoscopy, continued ...

- Irrespective of what stereoscopic technology is used the underlying requirement is that correctly formed left and right images are independently presented to each eye.
- Technologies: Active (usually monitors), passive (WASP), Infitec (IVEC), autostereoscopic.
- Autostereoscopic sounds interesting but still has problems in terms of resolution and viewing positions.



Peripheral Vision

- iDome, an experimental environment based upon a dome. A whole hemisphere is visible.
- Target visualisation problems where it may be useful to be inside the model, a situation that is often difficult for stereoscopic viewing.
- The alternatives
  - panning around on a flat display, this looses the sense of the relationship to the whole.
  - applying projections (eg: fisheye, spherical, ultra wide angle) on a flat screen, this distorts the geometry.



Challenges

- Datasets are growing in spatial and temporal resolution
  - data acquisition devices are improving.
  - computing advances allow bigger simulations.
- Expectations of realtime interactive graphics and performance increases on commodity hardware.
- Improved projection hardware to support/represent higher resolution imagery.
- Expectation of desktop solutions rather than going to special laboratories with high end or specialised infrastructure.
- Higher visual quality, competing with Hollywood for visual accuity.