Scientific Visualization

What is visualization?

- Vision is a powerful sensor system
- Uses a substantial part of the brain
- With vision we can see complex patterns and relationships in data

Visualization - *Transformation of data or information into IMAGES*.

Visualization

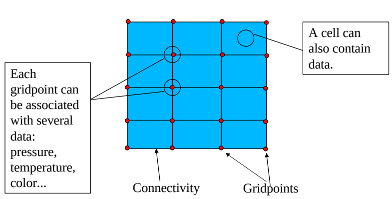
- Data can be generated from simulations and measurements (microscopes, satellites, ...).
- Generating the data is usually not the goal.
- Understanding is!
- Size and/or shear complexity of data could be a barrier for understanding.
- Multivariat data can be hard to interpret

- So why visualization?
  - Important both for exploration and understanding in the scientist's own work.
  - Visualization help researchers find errors in their simulations and experiments.
  - Researchers can see complex patterns and relationships in their data.
  - Conveys information and ideas efficiently among collaborators
  - Visualization helps educate funders and the public

Data

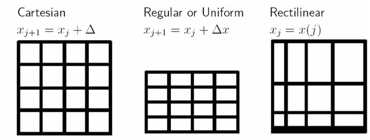
- What is data?
  - Consists of two things:
    - The grid/connectivity
    - The data
      - Can be several datapoints per gridpoint

Data



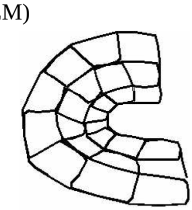
Data

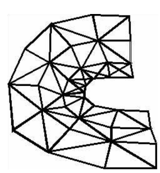
- Data can be 1-dimensional, 2, 3 or multidimensional.
- Can be timevariant
- Can have different topology
- Can be structured, or unstructured
- Think of an ordinary bitmap image:
  - 2 Dimensional, structured, 3 or 4 scalar values per gridpoint (RGBA)
- Structured:



Data

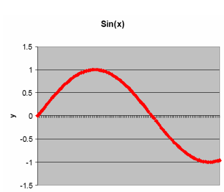
- Unstructured
- A common result from a material simulation (FEM)


Hexahedral


Tetrahedal

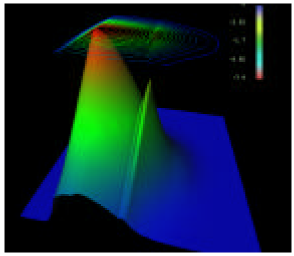
1D Visualization

- Y=f(x)
- Line charts
- Curve fitting
- Smoothing or approximation



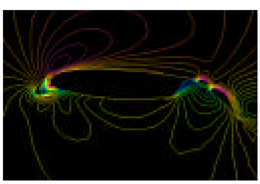
2D Visualization

- Scalar Data on a regular grid
  - Surface plot

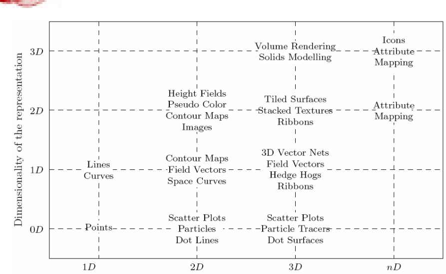


2D Visualization

- Contour Lines – f(x,y) = constant
- Heightlines on a map!

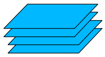


3D Visualization

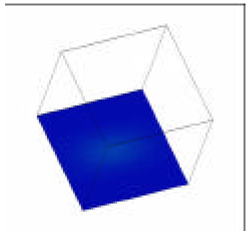


3D Visualization

- Assume we have data in 3 Dimensions
- Imagine bitmap images in a stack

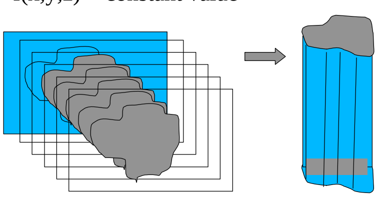


- Very common in medicine visualization, CT Scans
- How can we look ”into” that?
- One way is to look at one slide at a time:
  - Ortoslice

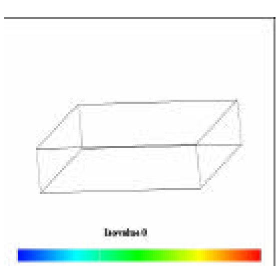


3D Visualization

- We could also use the heightline teqnique from maps (Isolines) in 3D, **Isosurface**
- f(x,y,z) = constant value

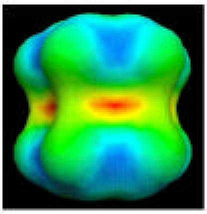
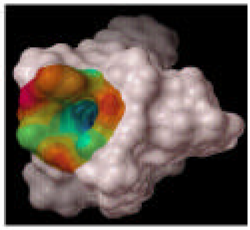


Isosurface



Isosurface

- Surface generated from one datapoint (density?)
- Color from another (temperature?)

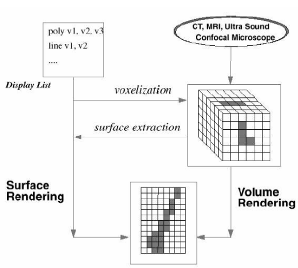



3D Visualization

- Another teqnique to visualize a 3D volume is volume rendering
- We want to handle volumetric objects
  - Gas, fire, smoke, clouds
  - Sampled data sets (MRI, CT
  - We want to be able to cut, sculp
    - Any operation that exposes the interior
  - Each datapoint is called a Voxel (volume element/compare with pixel (picture element))

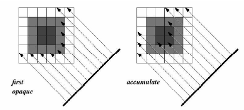
3D Visualization

- Comparison of surface and volume representation



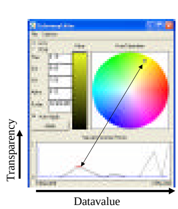
3D Visualization

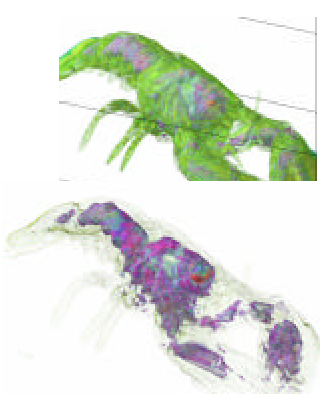
- How to render?
  - Raycasting
  - Cast rays from viewplane into the volume
  - Accumulate the values to the final color
  - Each voxel has a value and or a opacity associated to it



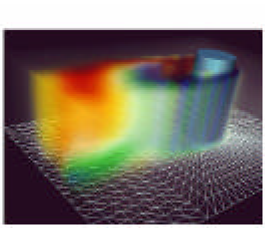
Transfer function

- Transfer function is a function that converts a value from one domain to another
- Assume we have a 128x128x128 volume =2097152 voxels. From a CT scan of a lobster
- Each voxel has a value from 0..255
- Assume we know that the values are corresponds to how much radiation is absorbed. 0 all radiation goes through, 255 no radiation goes through (led)
- Close to 255 should be the hardest parts of the shell (for humans it is the teeth) close to 0 should be air or perhaps water.
- Assume we know that bone are in the range of 200-230
- We would like to make everything outside the bone-range(l!) transparent, so we can only see the bone.
- We need a transfer function that handles this.



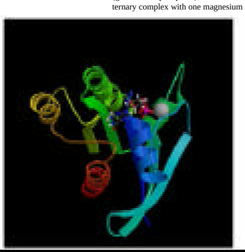


Volume rendering



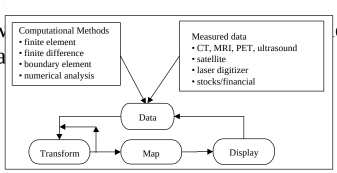
3D Visualization

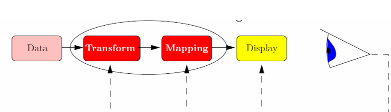
The Ras p21 protein is a central component in the cell-signalling system that transmits extra-cellular growth signals via cell membrane receptors, via a cascade of signalling molecules into the nucleus. It is present in many cell types, and several forms of cancer are associated with a mutated form of the protein, where it is locked in a growth-promoting state.
Ras p21 is an enzyme; it hydrolyzes GTP (guanosine triphosphate) to GDP (guanosine diphosphate); it is a GTPase. The protein exists in vivo as a ternary complex with one magnesium ion (Mg) and GDP (or GTP).



The visualization process

- How ... on
  usua...





Computational Steering

- In some cases a close connection between:

Data generation (simulation) ⟷ Data consuming (visualization)

- Is needed to:
  - Change parameters in realtime.
  - Steer/interact with the simulation.
  - Experience the simulation

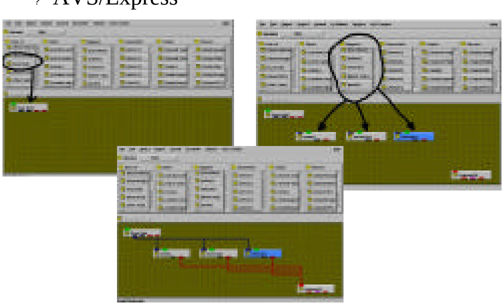
⇒ Computational steering.

Tools for visualization

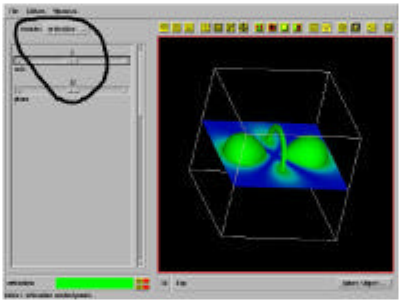
- Two examples,
- One commercial
  - AVS/Express
    - Visual Programming
    - +Fast prototyping
    - -Expensive
    - -No code
- One opensource
  - VTK
    - Traditional programming
    - -Slow prototyping
    - Easy to share
    - Cheap
    - Code available

Tools for visualization

- AVS/Express



Tools for visualization



Tools for visualization

- VTK – Visualization Toolkit
- OpenSource
- Large user community
- Hundreds of C++ classes for
  - Reading data
  - Filtering
  - Visualization algorithm
  - Rendering
  - Interaction
- Java+TCL language bindings

The end?