Visualization and Nonphotorealistic Rendering

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Project 4 Competition

Top 4 Artifacts get an IPod Touch!

Artifact can be movie/image/anything else...

(decided by vote of TAs + Graphics Lab)

Thank you AMD...

AMD

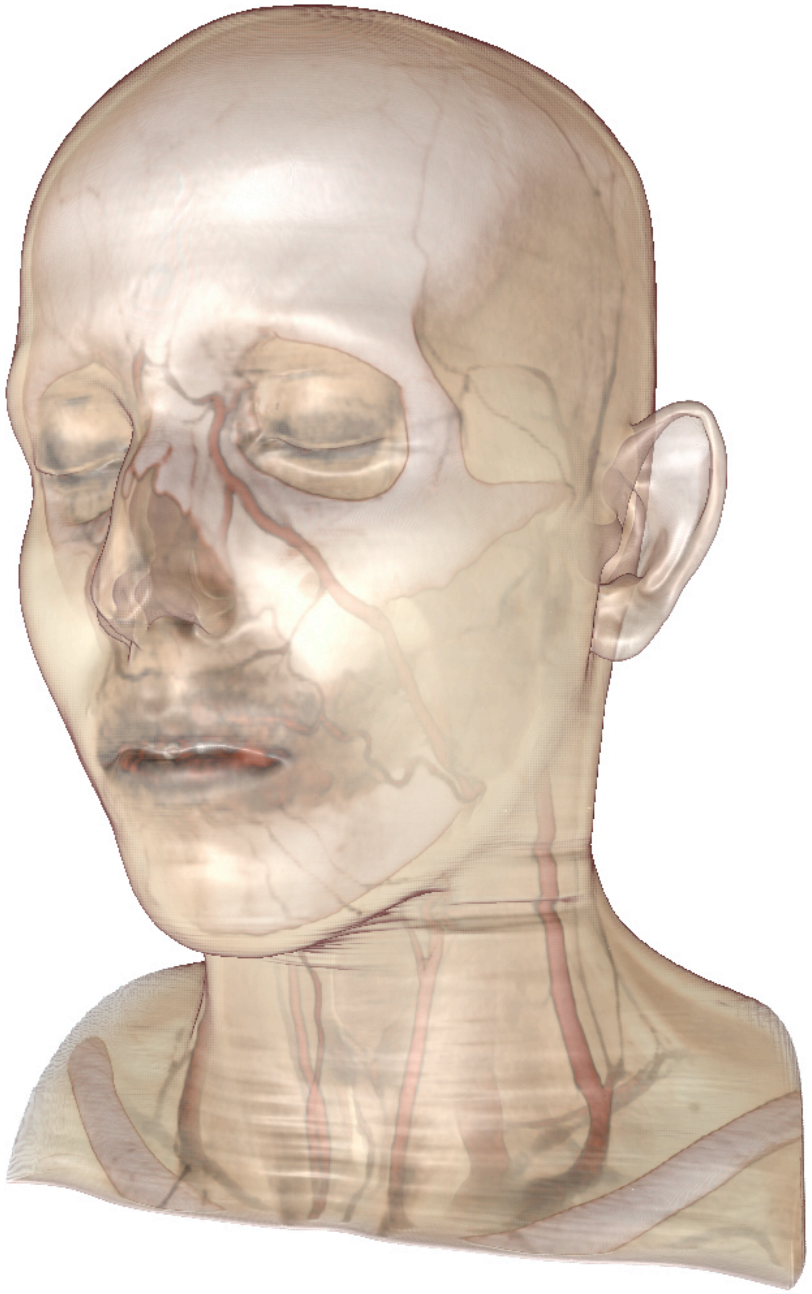
Outline

- Visualization
- Non-photorealistic Rendering
- Cutaway Illustration
- Contour Drawing
- Good photographs.
- Map Drawing
- Painting

Outline

- **Visualization**
- Non-photorealistic Rendering
- Cutaway Illustration
- Contour Drawing
- Good photographs.
- Map Drawing
- Painting

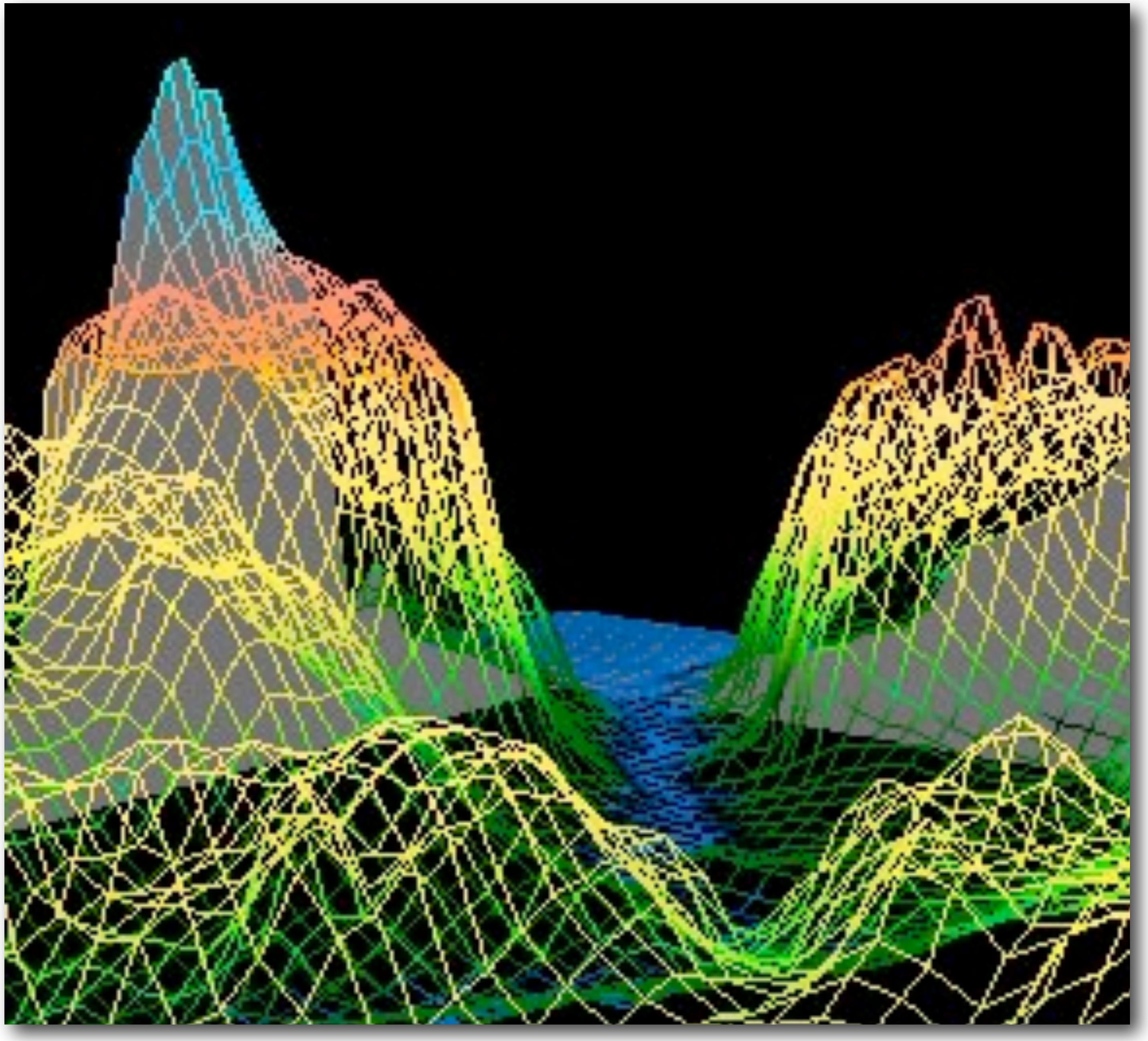
Visualization



http://medvis.vrvis.at/fileadmin/hvr/images/headlarge.jpg

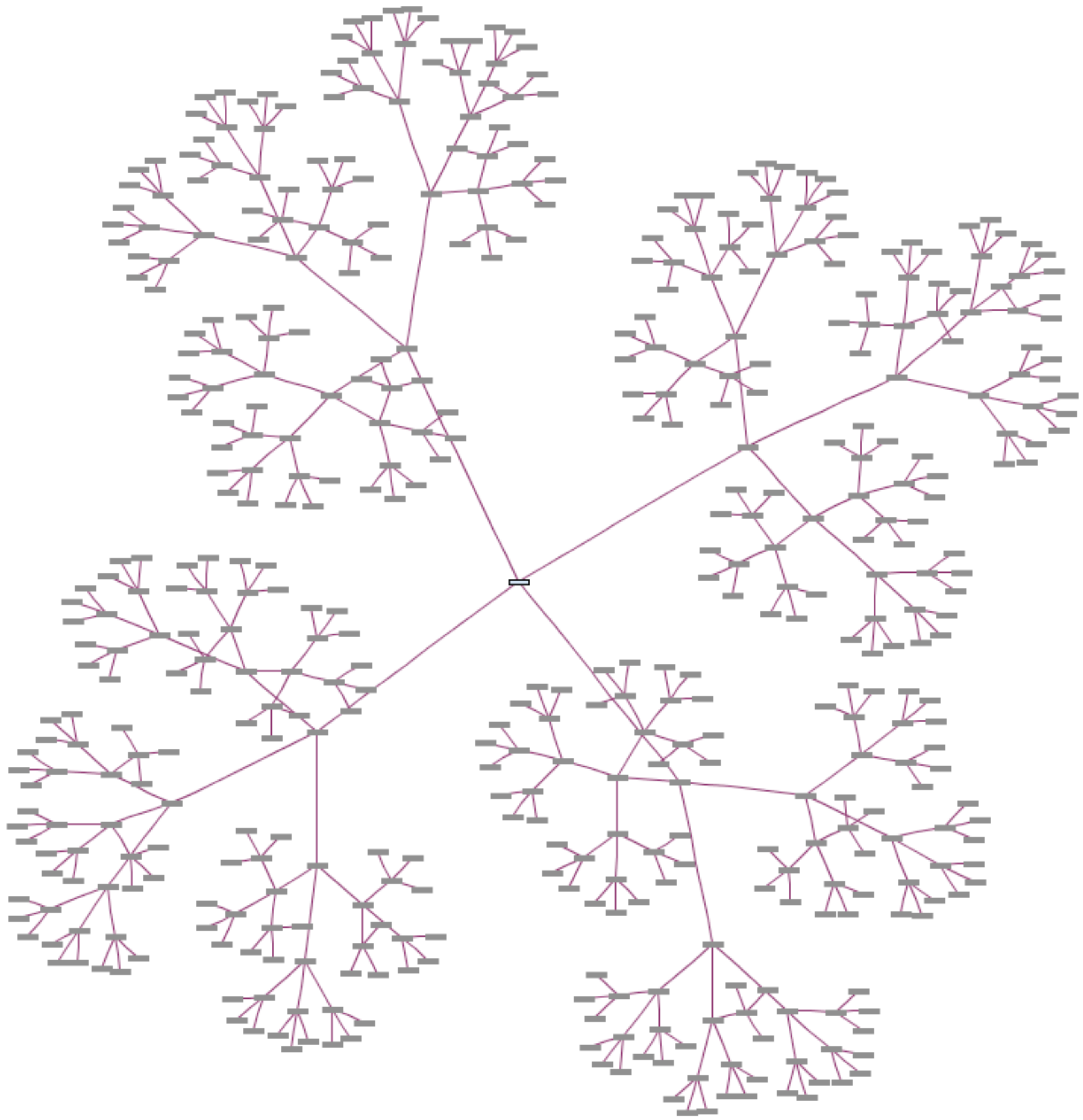
- Goal: Use computer graphics to understand data.
- For virtual every data type there is a corresponding visualization.
  - The importance of graphics!

Numerical Data



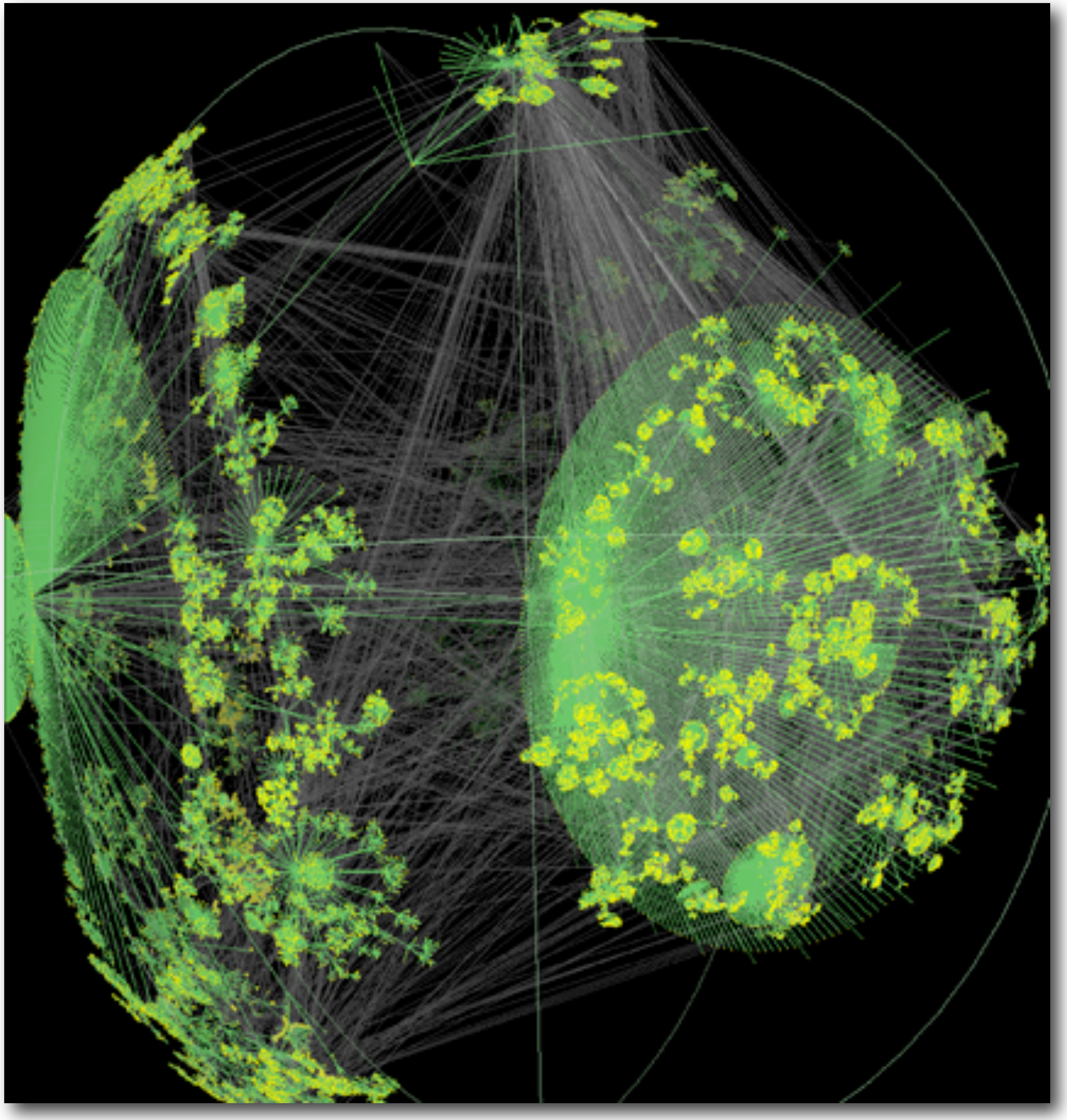
http://www.manifold.net/news/fly_through.jpg

Graphs



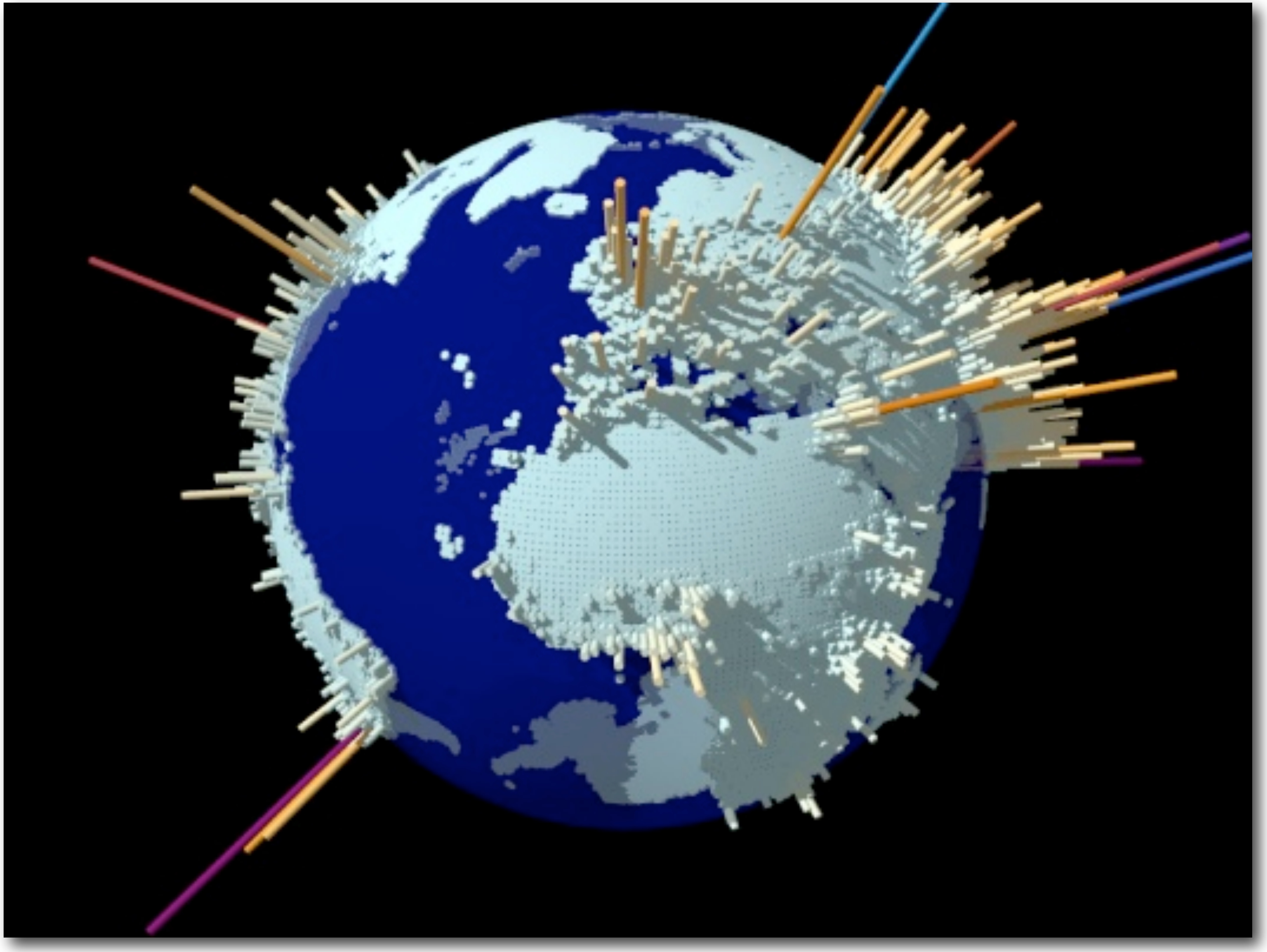
http://www.wandora.org/wandora/wiki/images/Tree_graph_example.gif

Graphs



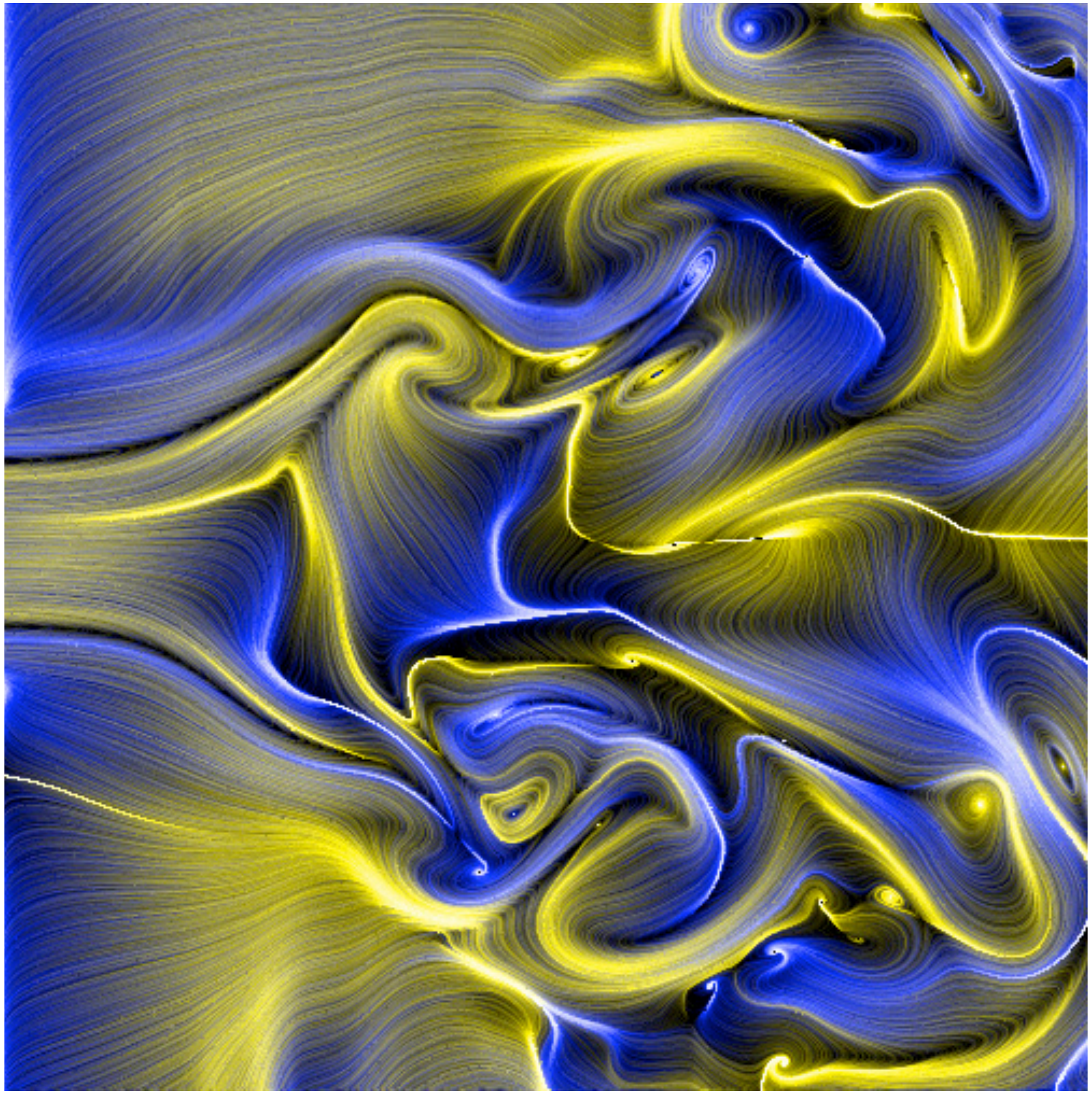
http://www.designinginteractions.com/chapters/7

Geographic Data



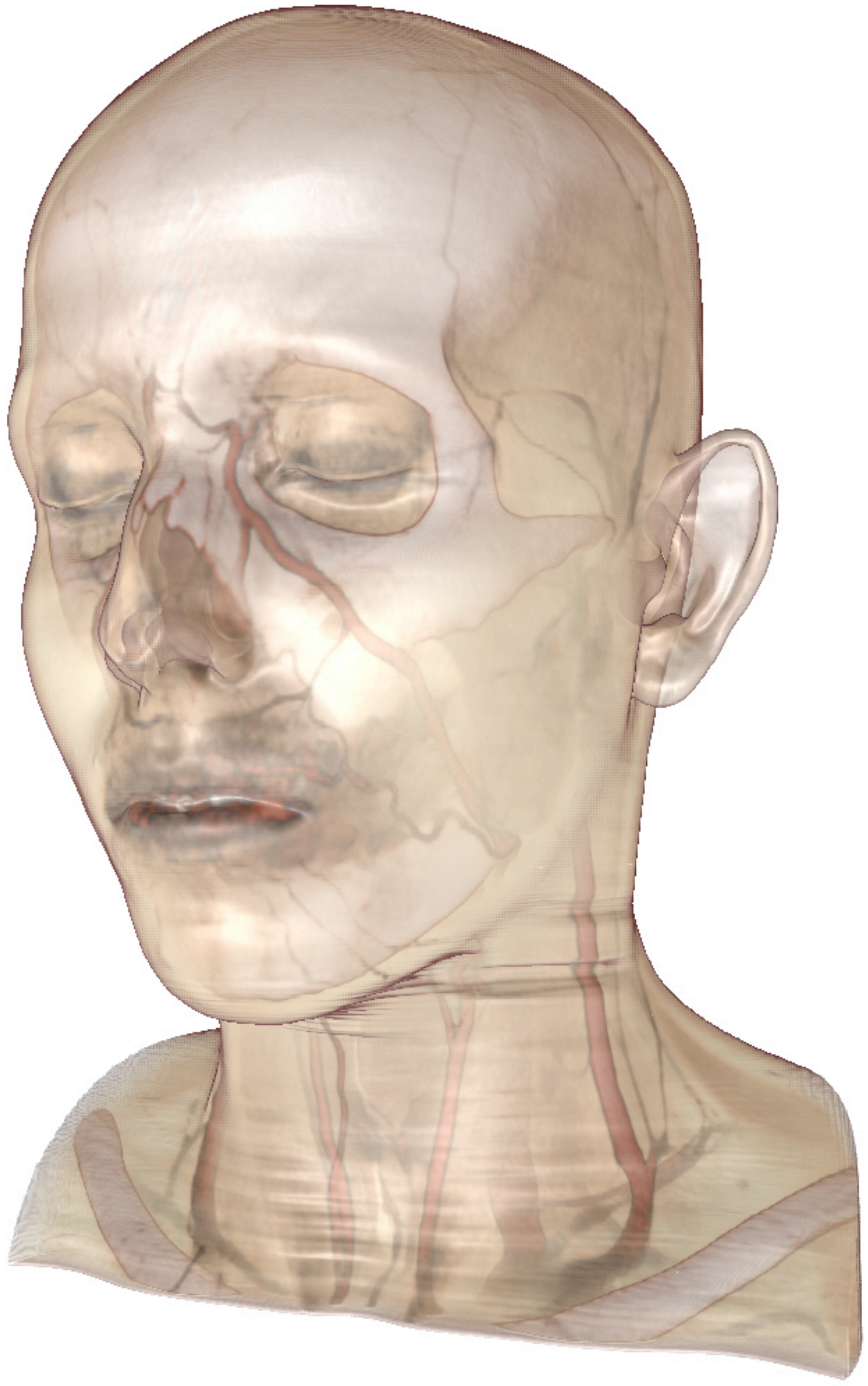
http://flowingdata.com/wp-content/plugins/yet-another-photoblog/cache/g_econ.6zhzwniskpgcwwgs00okoco4s.7dm680981og04ocskgcsckco4.th.jpeg

Flow Visualization



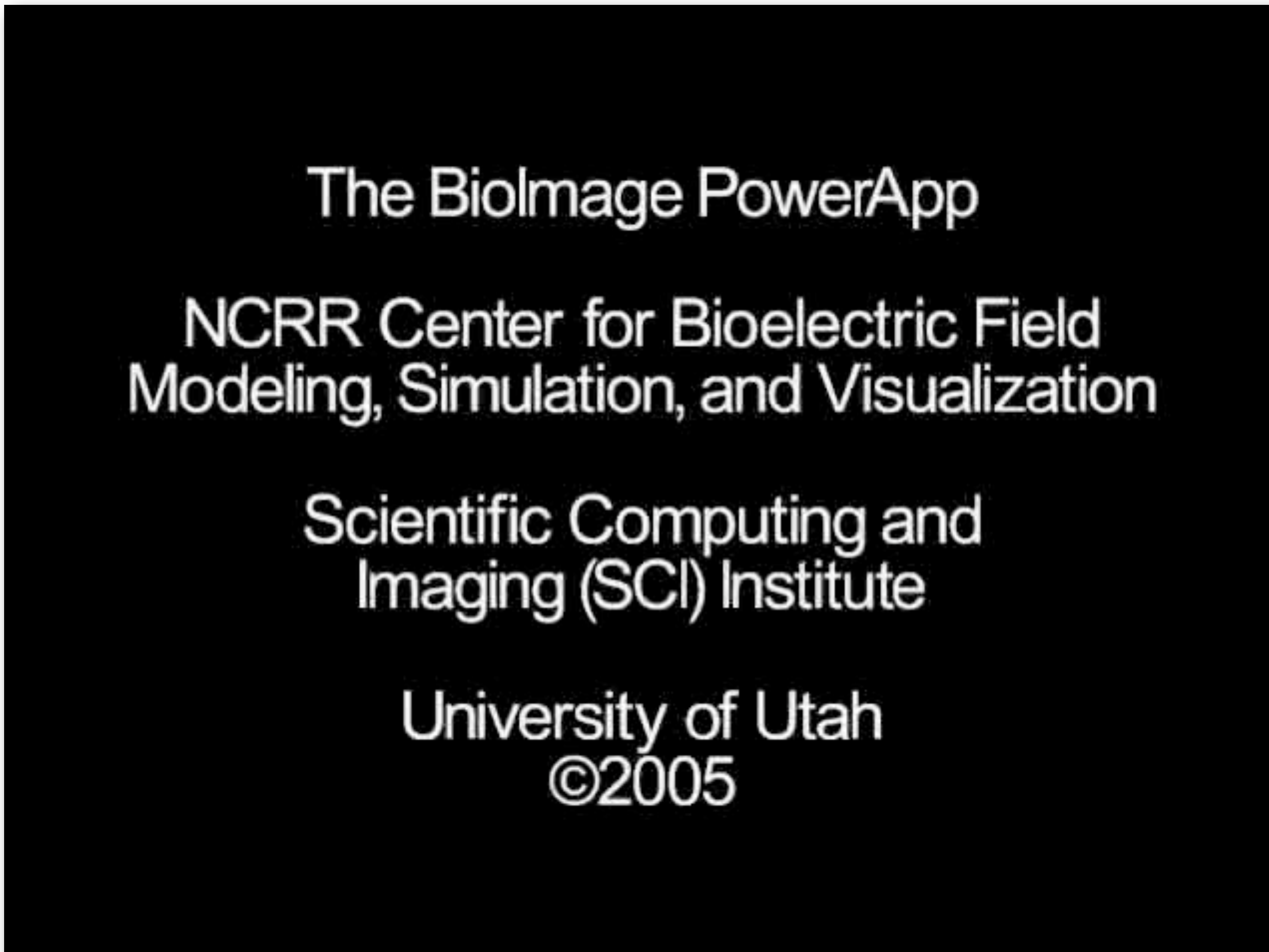
http://www.faculty.iu-bremen.de/llinsen/publications/ParkYuHotzKreylosLinsenHamann06.jpg

3D Volume Data



http://medvis.vrvis.at/fileadmin/hvr/images/headlarge.jpg

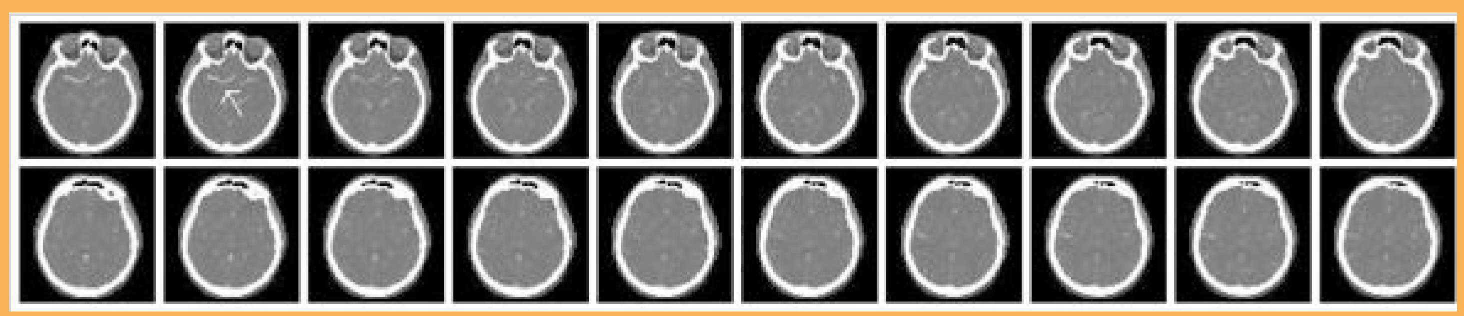
Example


The BioImage PowerApp
NCRR Center for Bioelectric Field
Modeling, Simulation, and Visualization
Scientific Computing and
Imaging (SCI) Institute
University of Utah
©2005

Volume Rendering

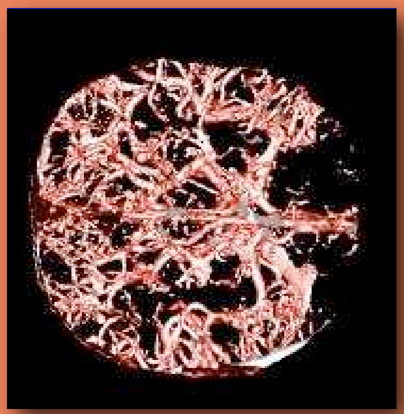
- Visualize Large dataset for scientific / medical application.
- Generally do not start with a 3D model.

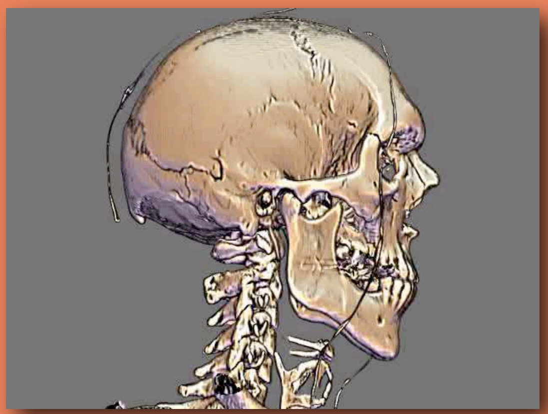
INPUT



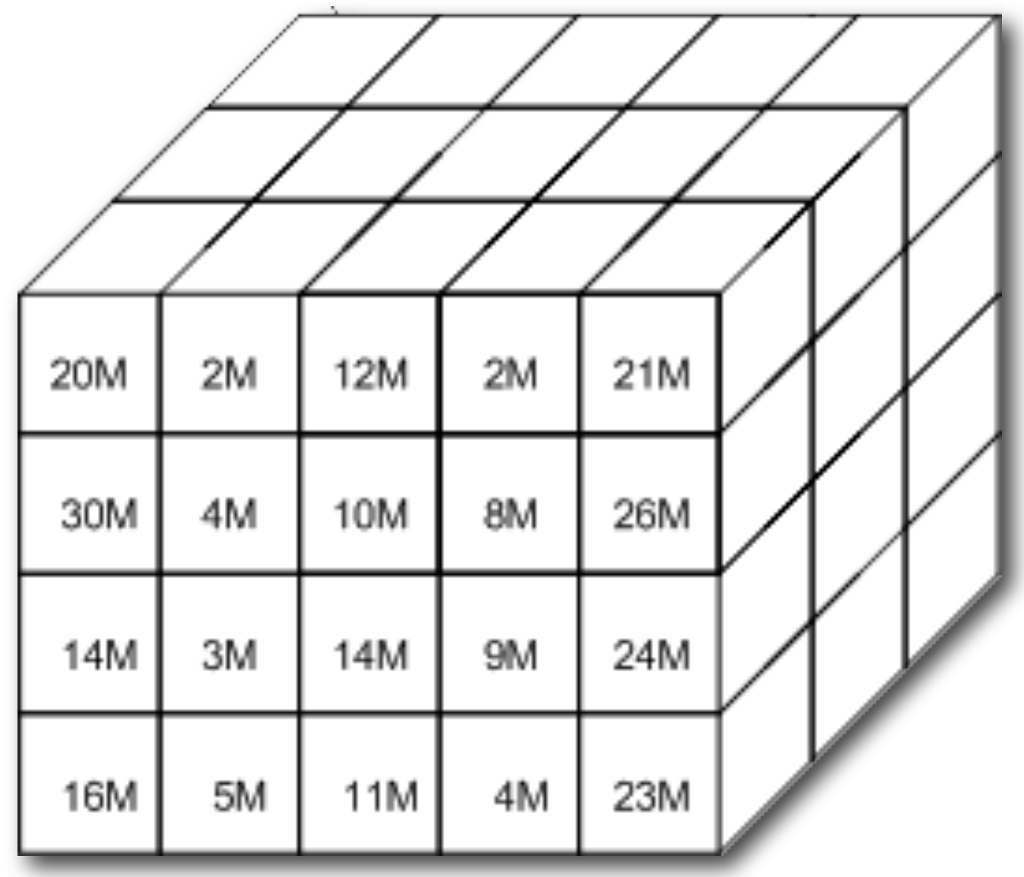
CT Scan - White means higher radiodensity.

OUTPUT





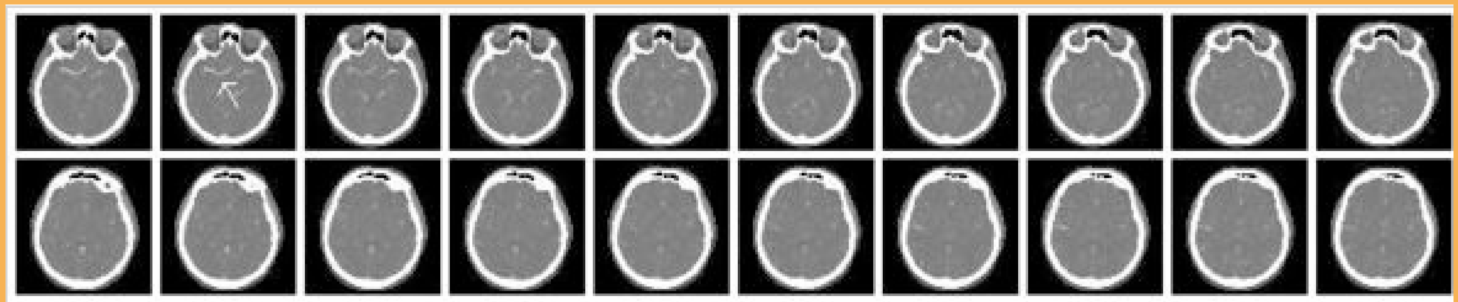
Data Format



- A cube of density values.

Large Datasets

INPUT

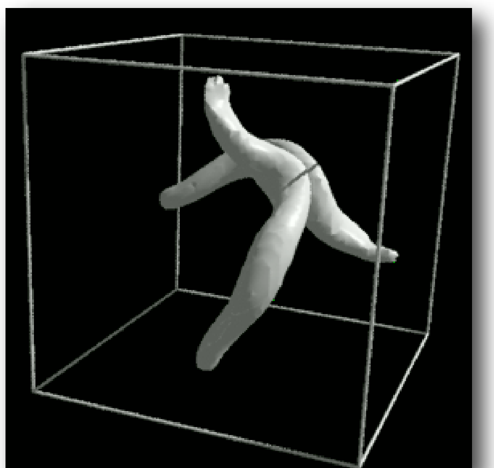


CT Scan - White means higher radiodensity.

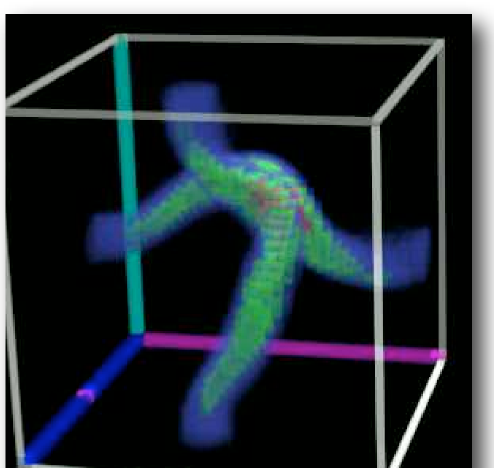
OUTPUT

- CT or MRI:
  - e.g. 512×512×200 ≈ 50MB
- Visible Human:
  - 512×512×1734 ≈ 433MB

Two Options

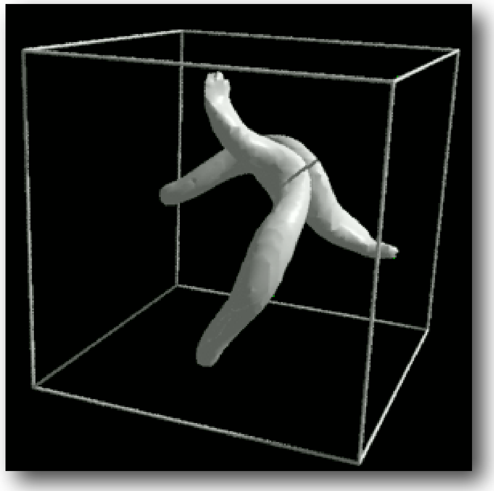


- Surface Rendering

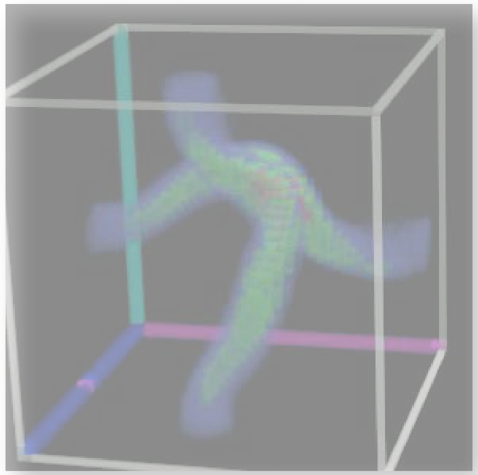


- Volume Rendering

Two Options

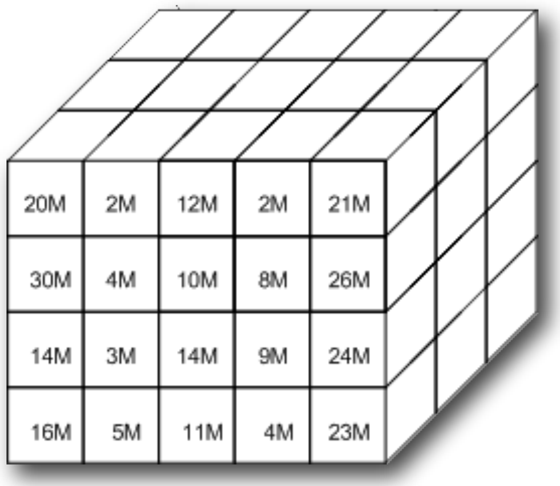


- **Surface Rendering**

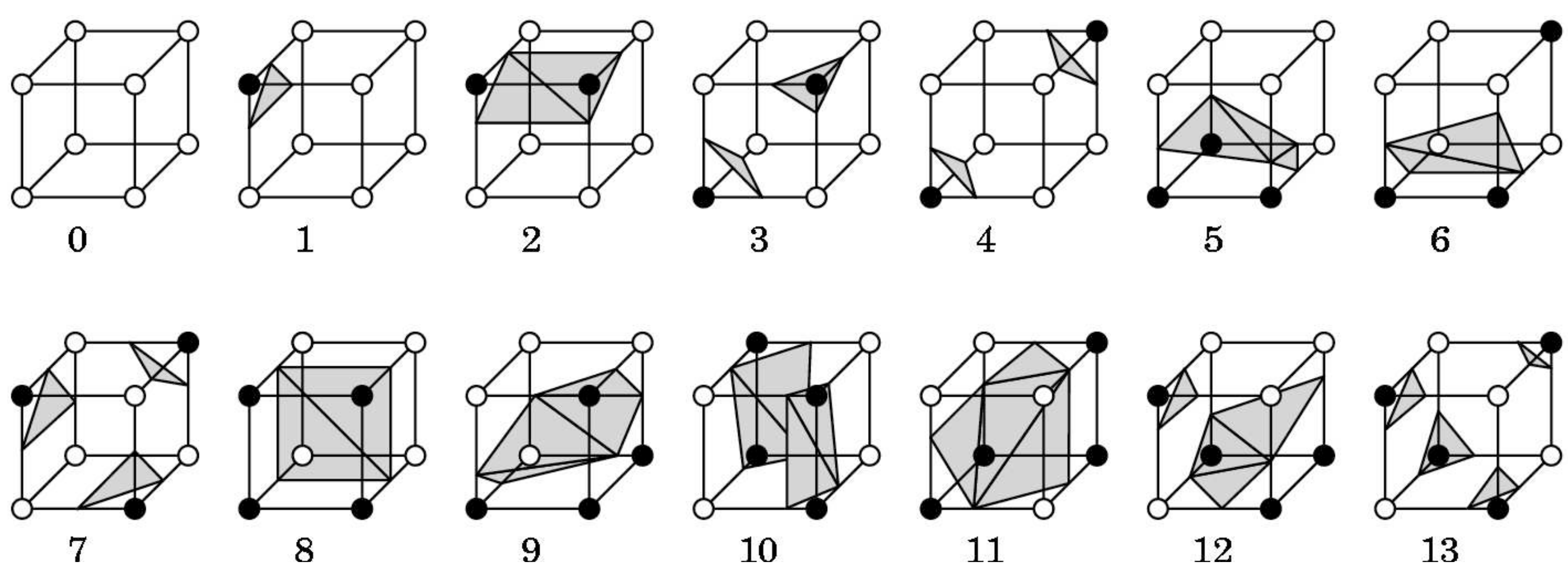


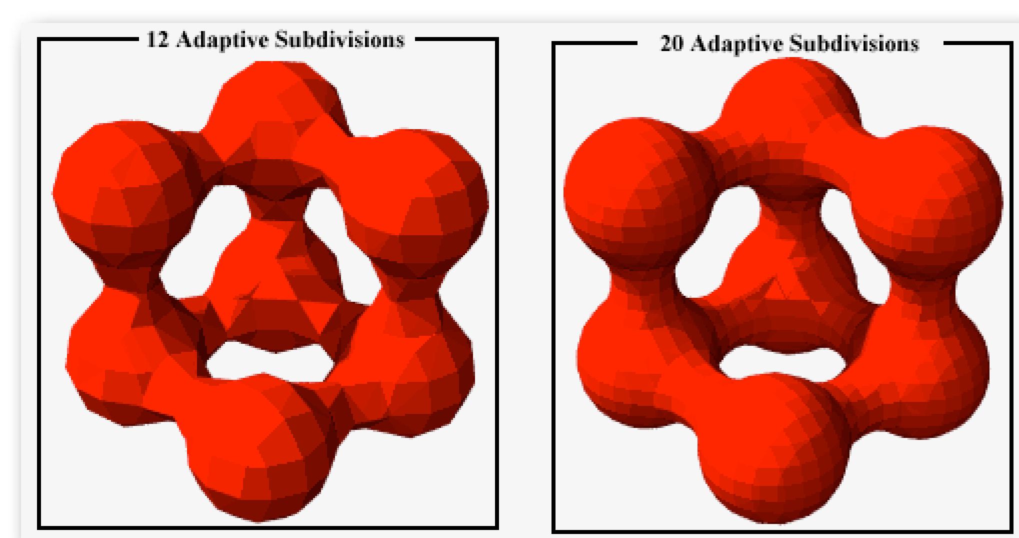
- Volume Rendering

Surface Rendering



- Threshold volume data.
- Then run our favorite algorithm....
- Hint: rhymes with “starching dudes”





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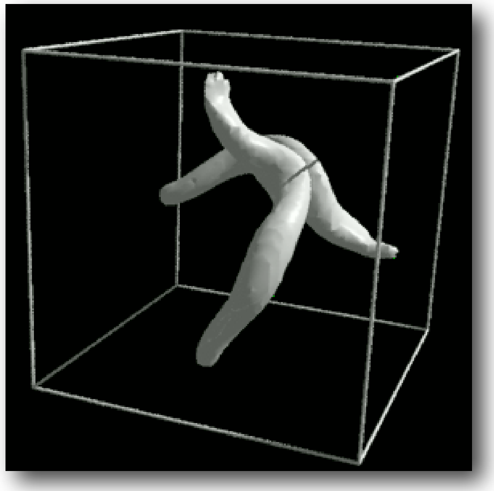
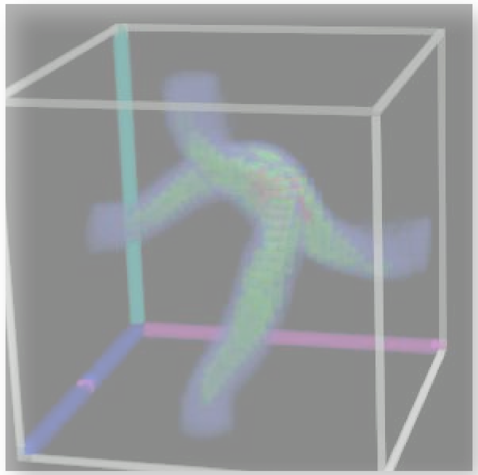
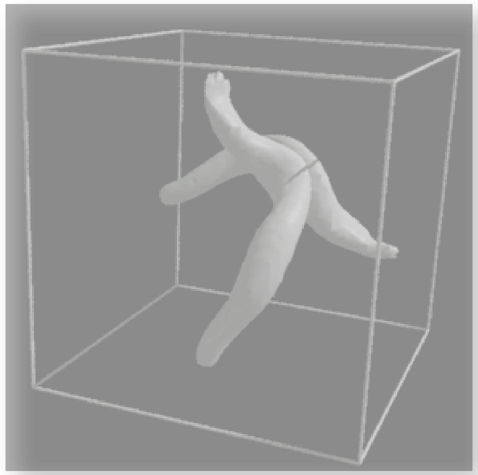


- **Surface Rendering**



- Volume Rendering

Two Options



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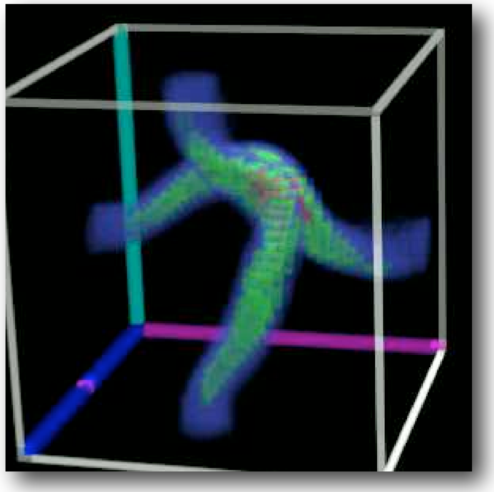
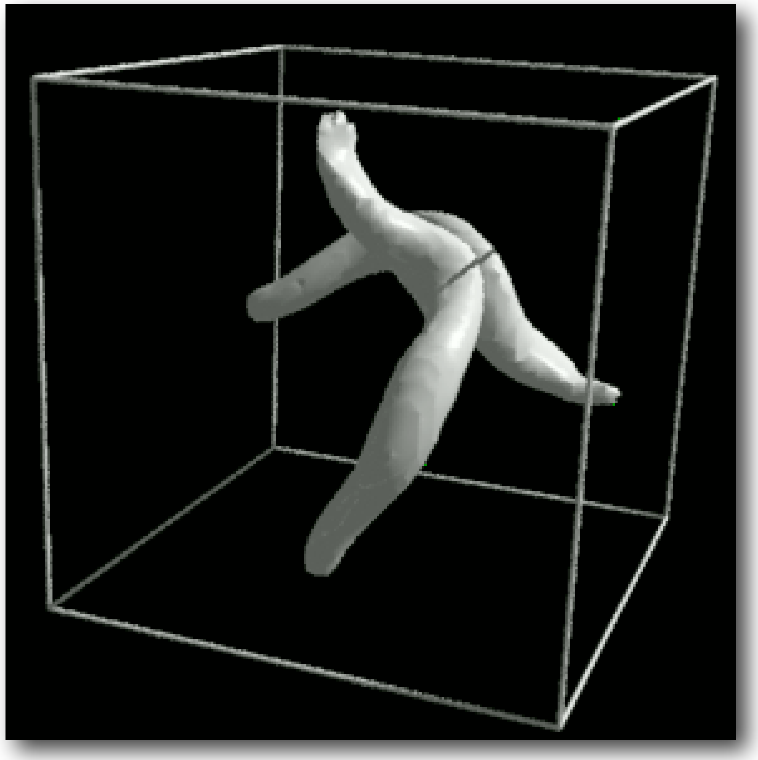


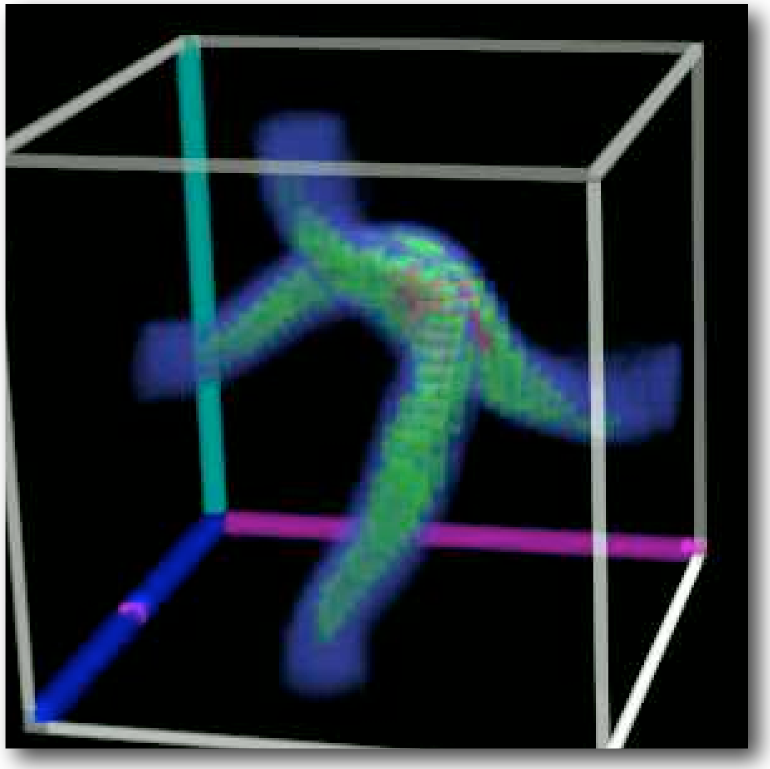
- Volume Rendering

Volume Rendering

- Some data better visualized as a volume, not a surface.
- Idea: Use voxels and transparency.



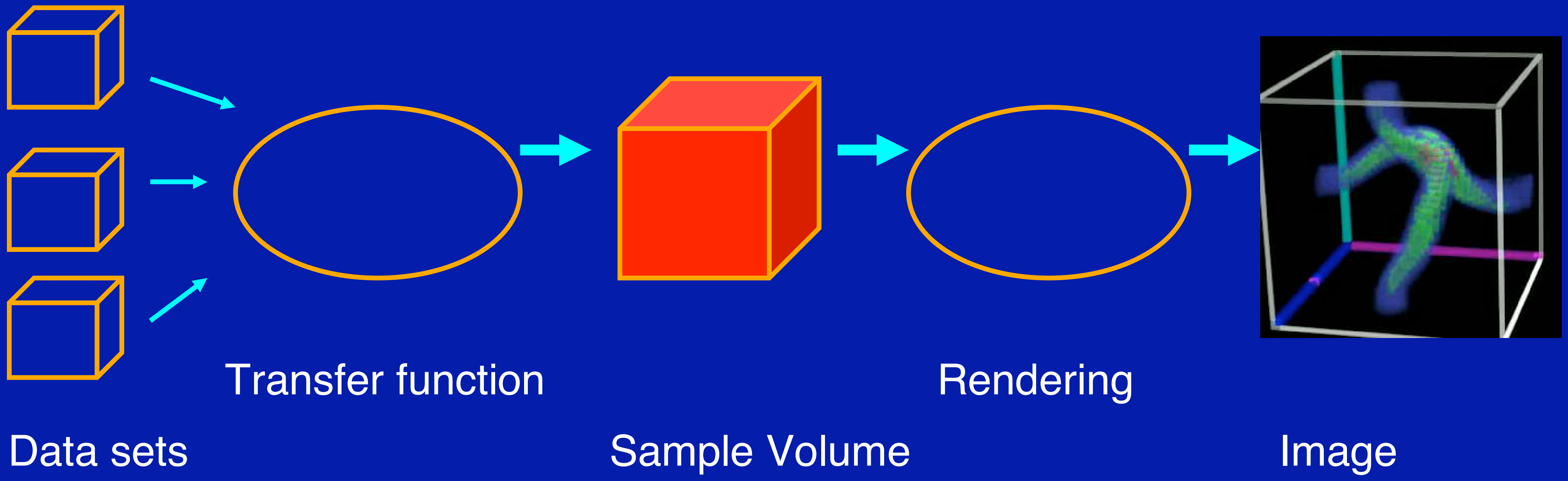
Raytraced Isosurface



Volume Rendering

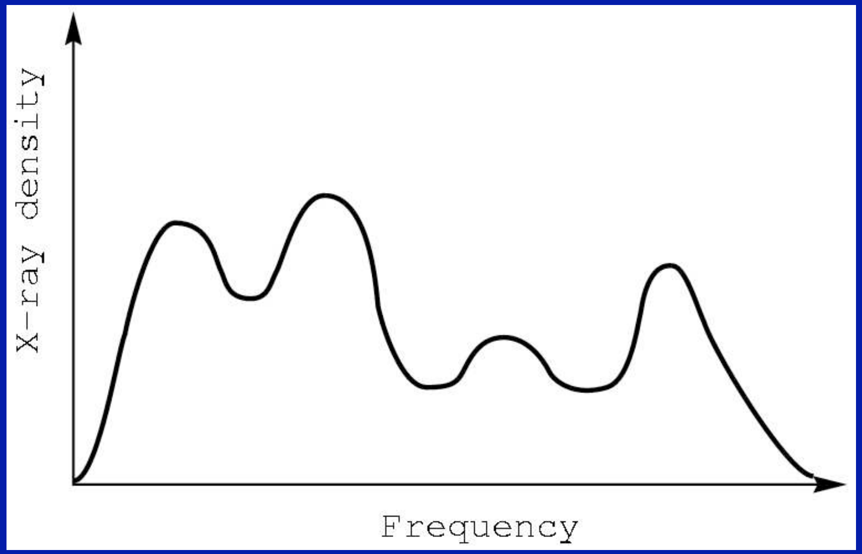
Volume Rendering Pipeline

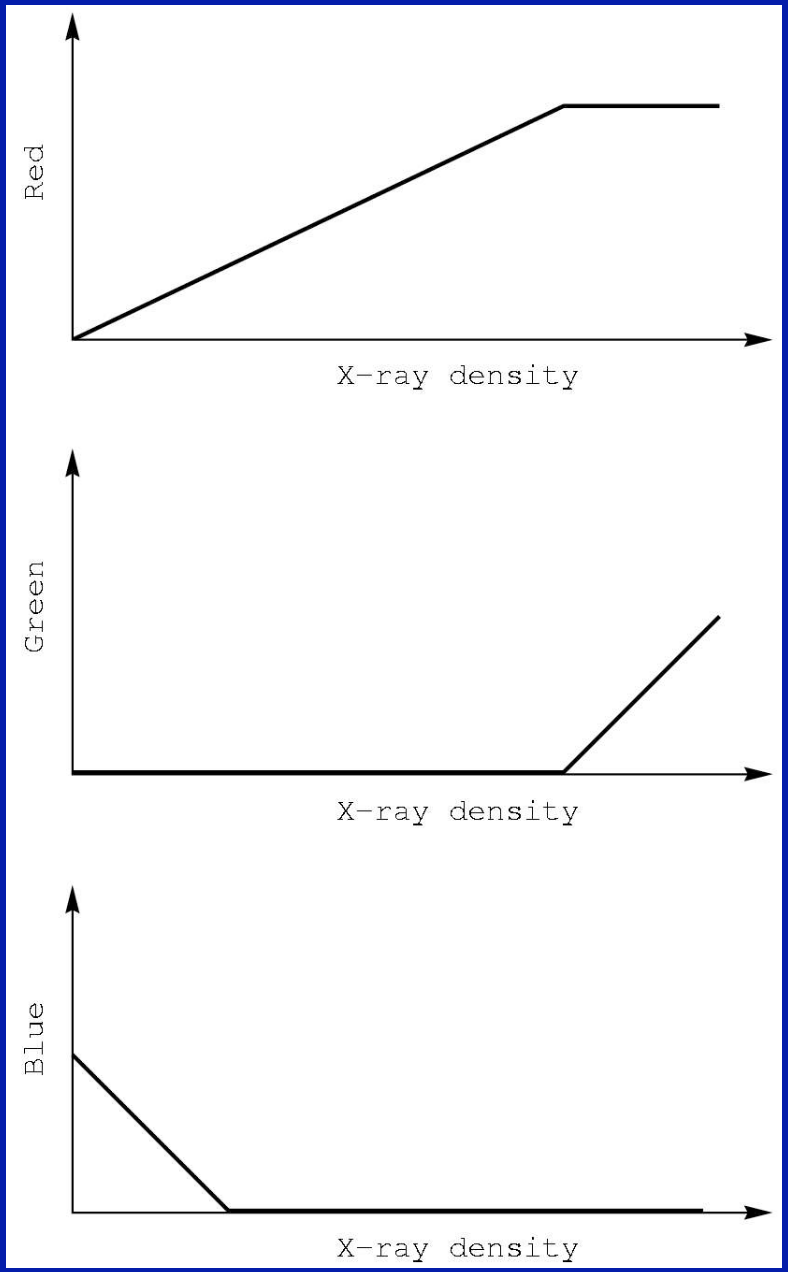
- Data volumes come in all types: tissue density (CT), wind speed, pressure, temperature, value of implicit function.
- Data volumes are used as input to a transfer function, which produces a sample volume of colors and opacities as output.
  - Typical might be a 256x256x64 CT scan
- That volume is rendered to produce a final image.



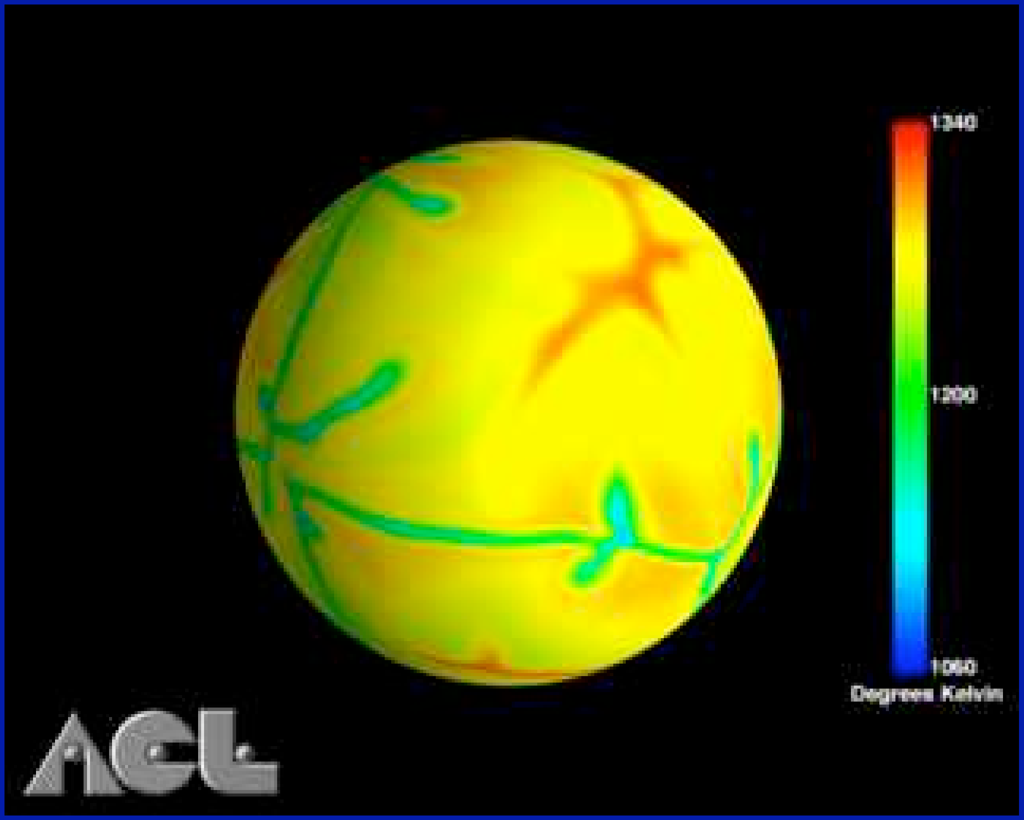
Transfer Functions

- Transform scalar data values to RGBA values
- Apply to every voxel in volume
- Highly application dependent
- Start from data histogram



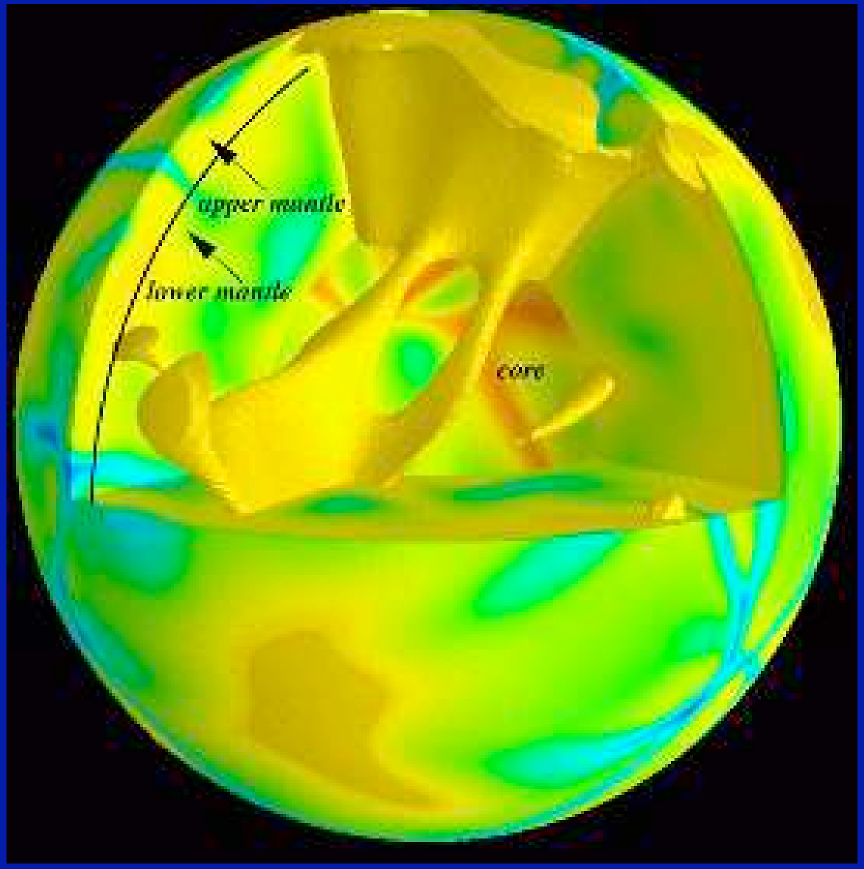


Transfer Function Example

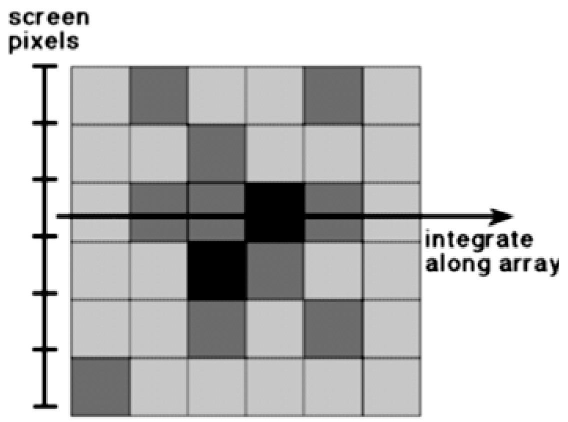


Scientific Computing and Imaging (SCI)
University of Utah

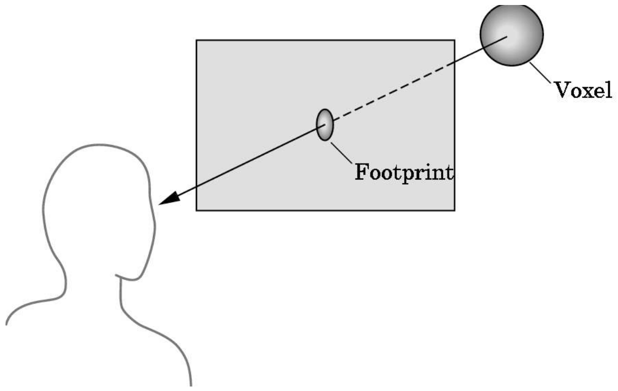
Mantle Convection



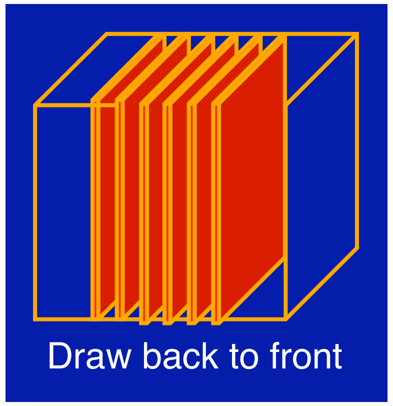
Three Options



- Ray Casting

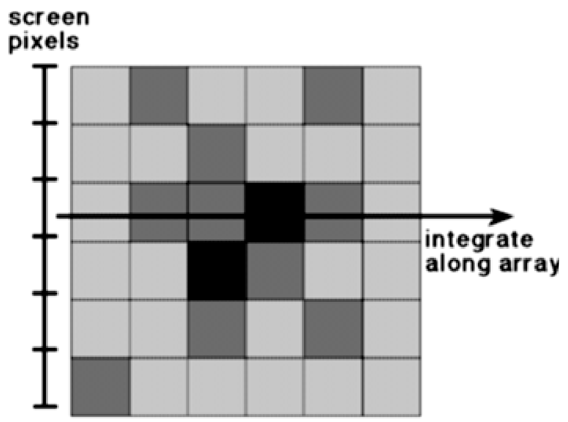


- Splatting



- 3D Textures

Three Options



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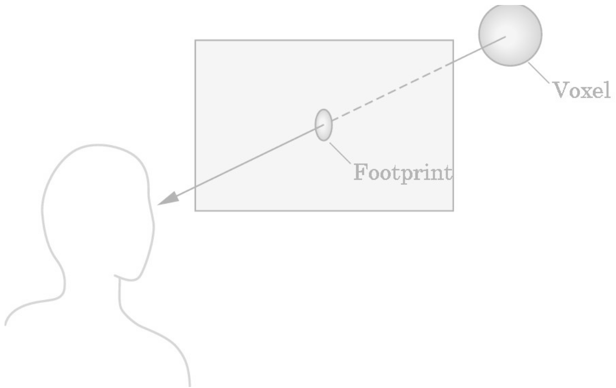
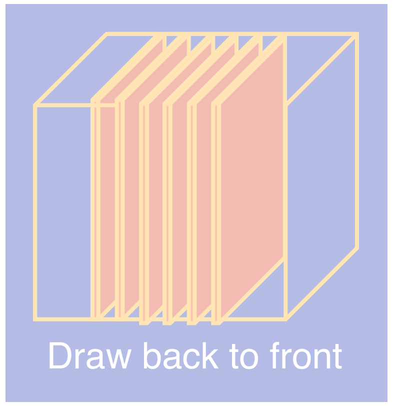


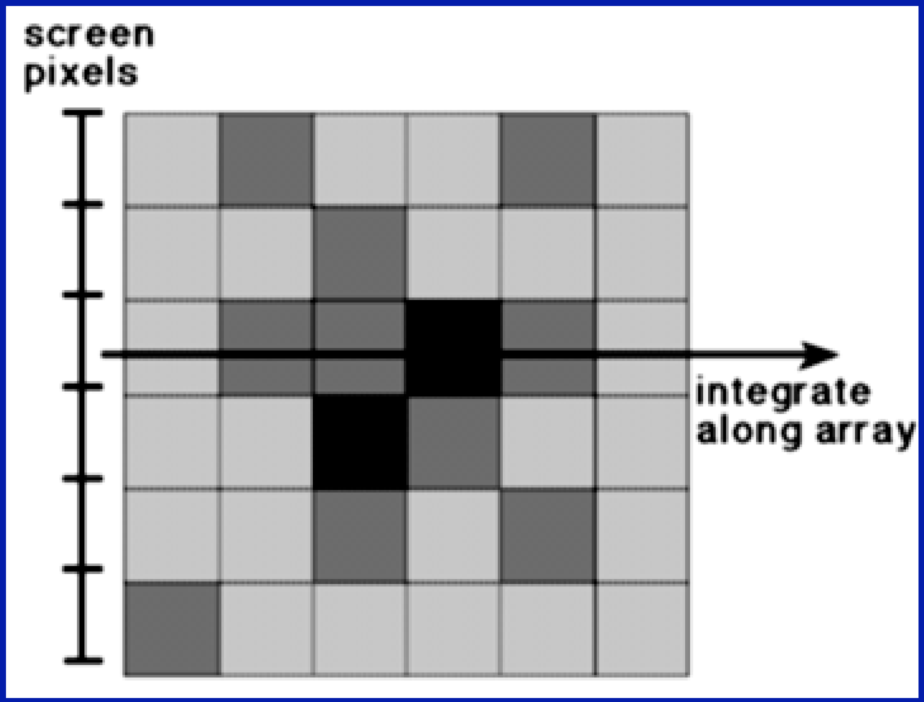
- Splatting



- 3D Textures

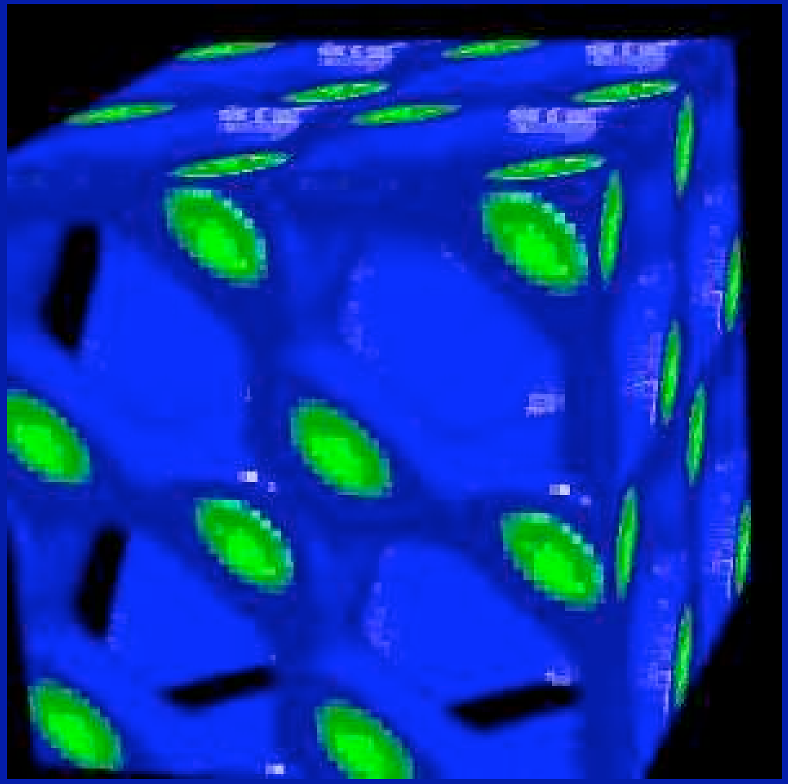
Volume Ray Casting

- Ray Casting
  - Integrate color and opacity along the ray
  - Simplest scheme just takes equal steps along ray, sampling opacity and color
  - Grids make it easy to find the next cell



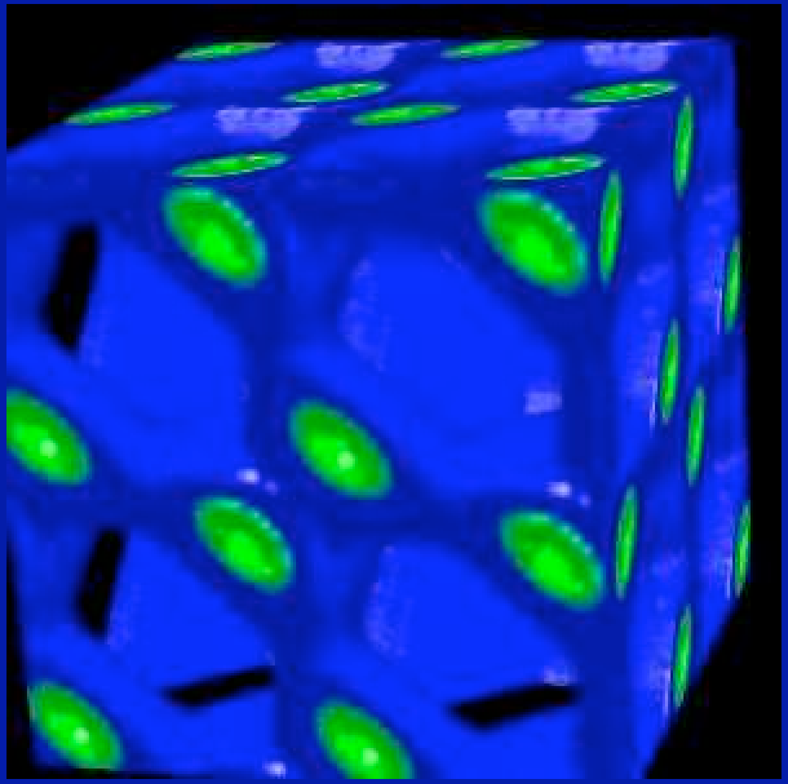
Trilinear Interpolation

- Interpolate to compute RGBA away from grid
- Nearest neighbor yields blocky images
- Use trilinear interpolation
- 3D generalization of bilinear interpolation

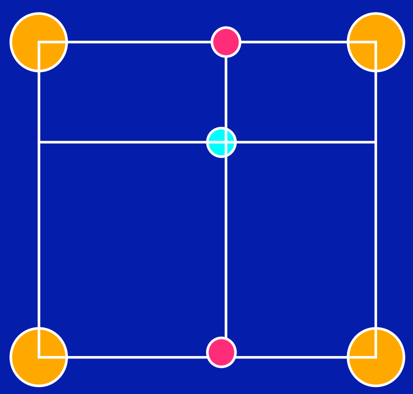


Nearest neighbor

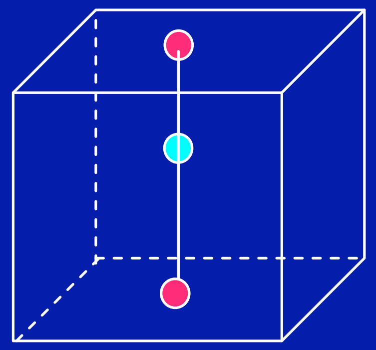
Trilinear interpolation



Trilinear Interpolation

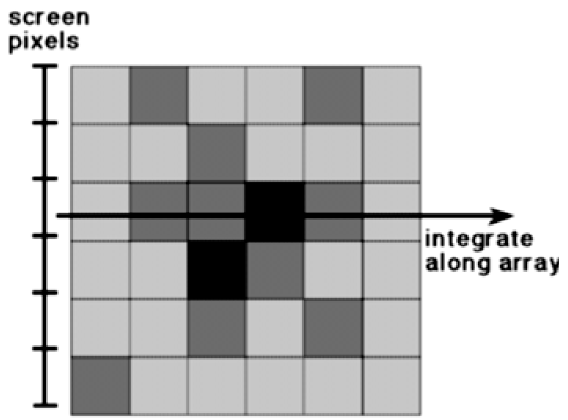


Bilinear interpolation

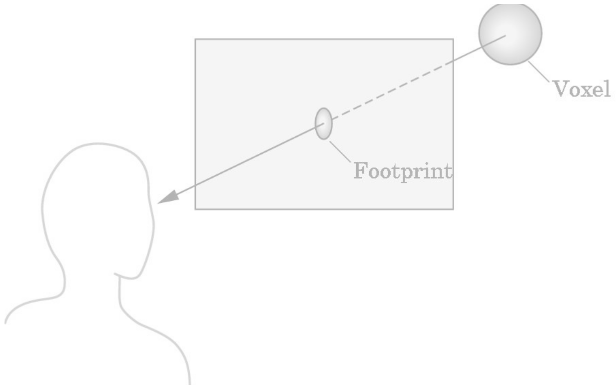


Trilinear interpolation

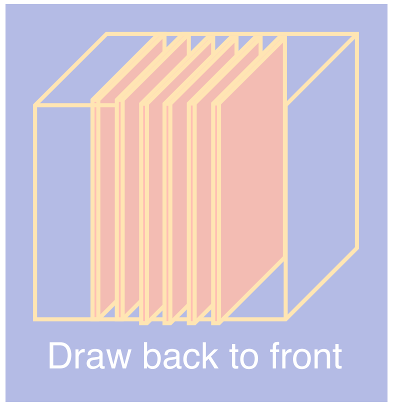
Three Options



- **Ray Casting**

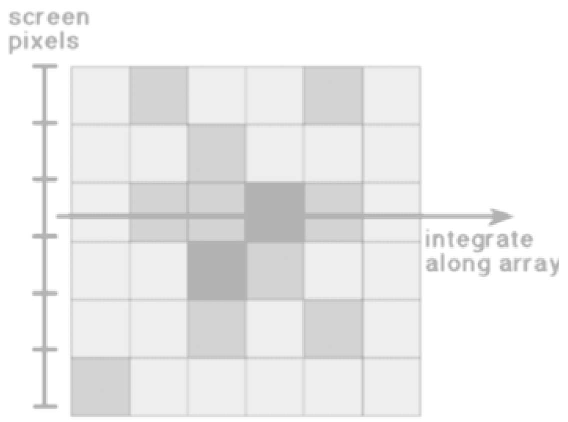


- Splatting



- 3D Textures

Three Options



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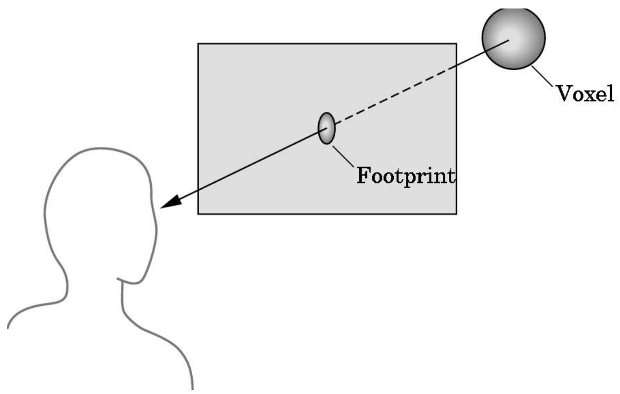

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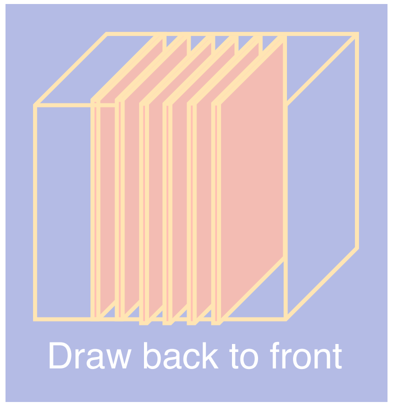
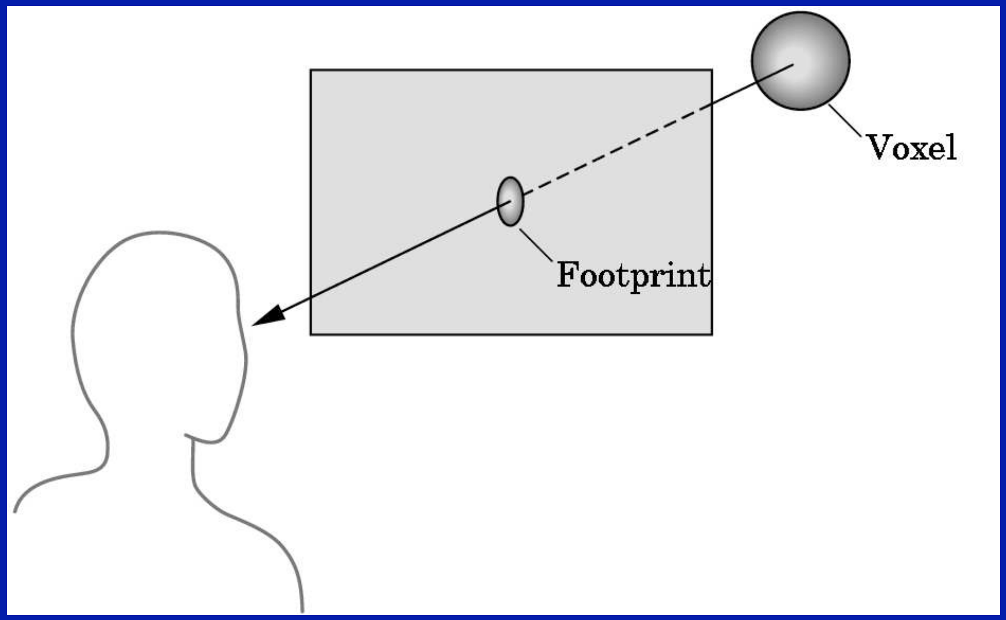
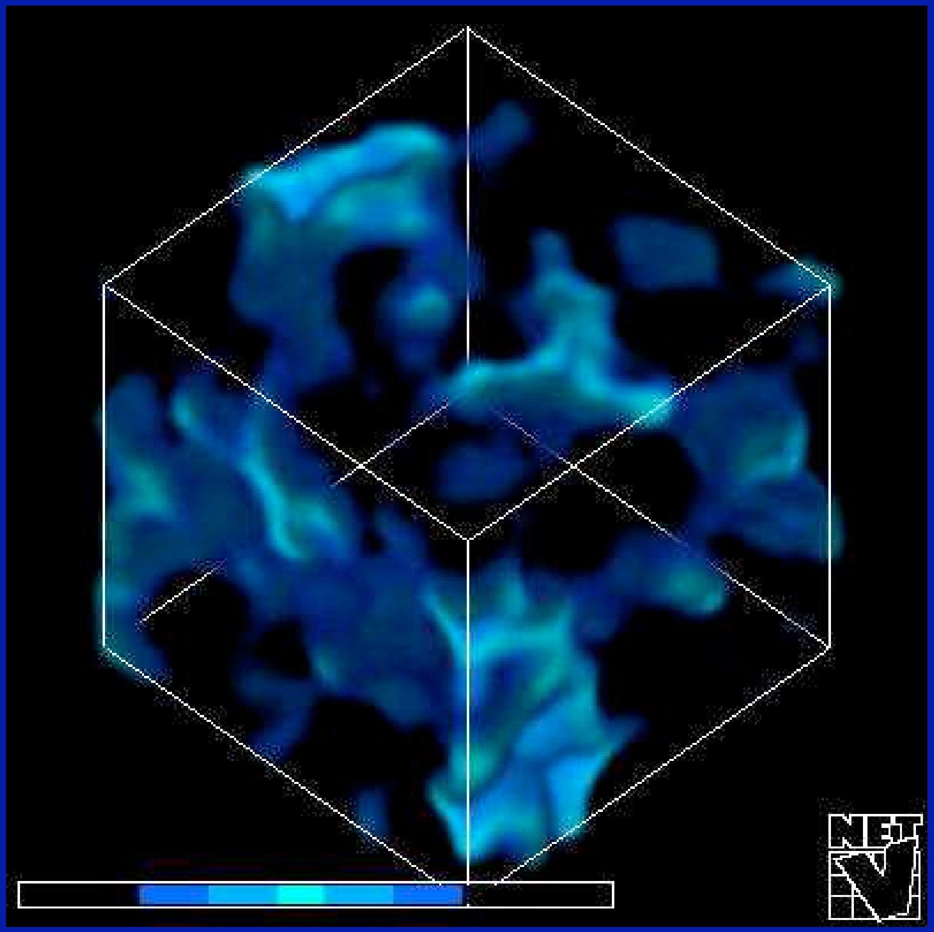


- 3D Textures

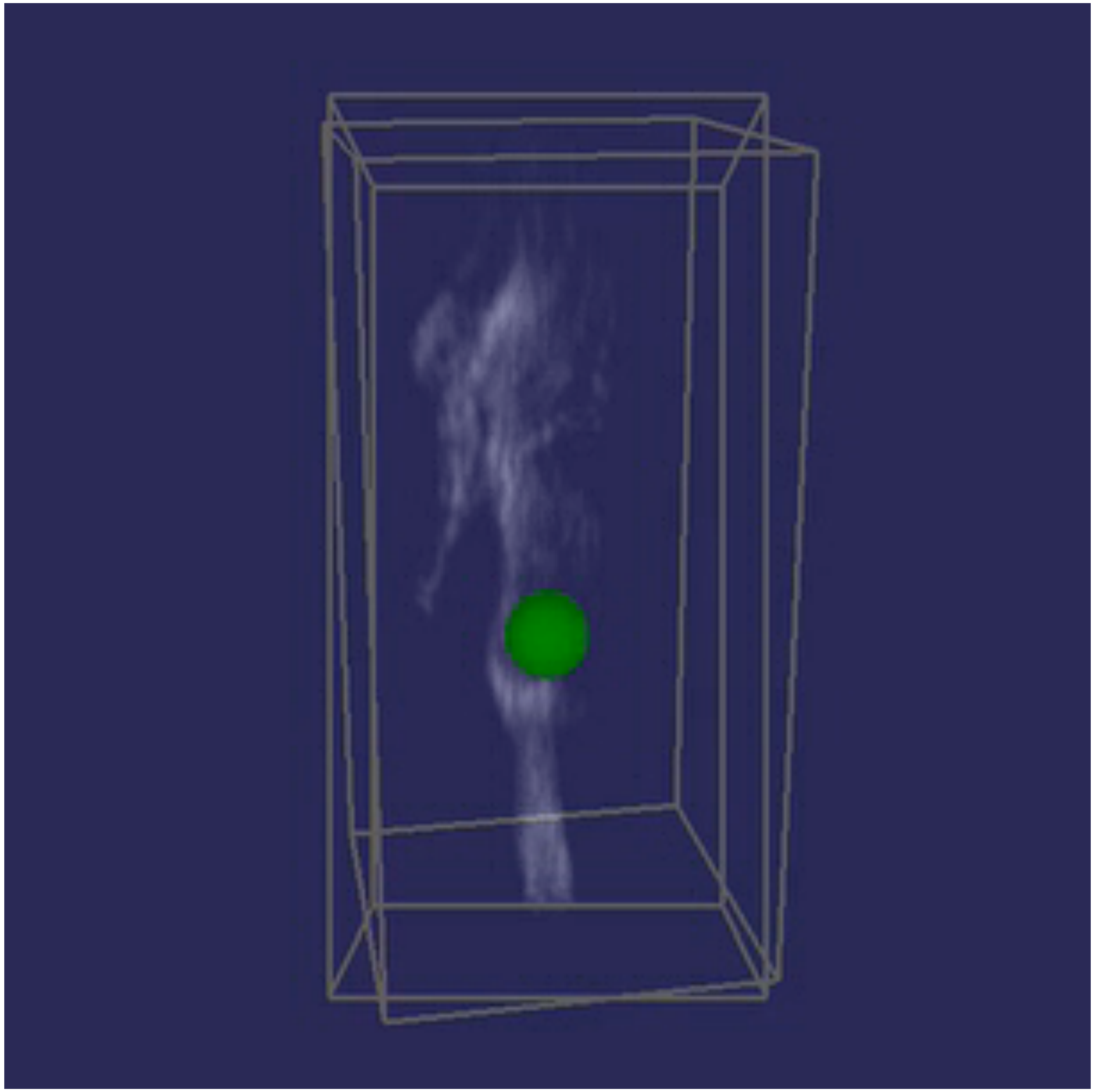
Splatting

- Alternative to ray tracing
- Assign shape to each voxel (e.g., sphere or Gaussian)
- Project onto image plane (splat)
- Draw voxels back-to-front
- Composite (a-blend)

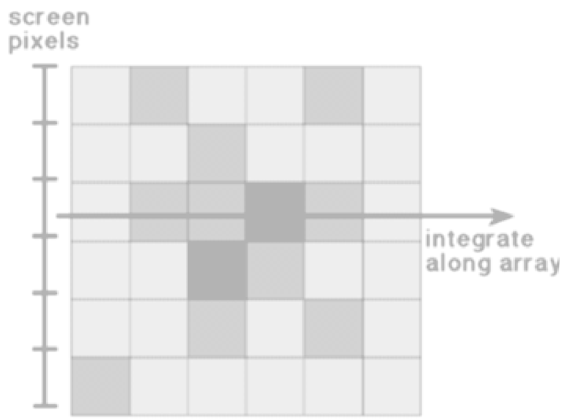




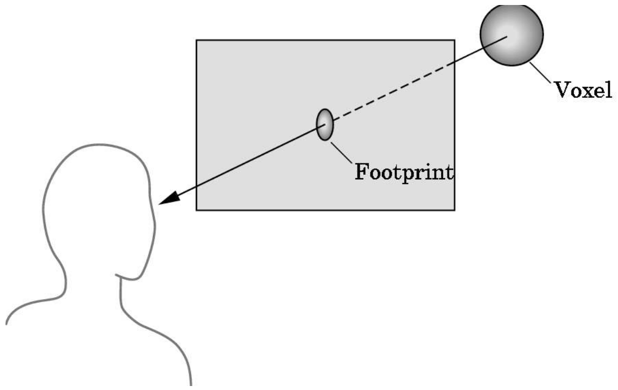
Example



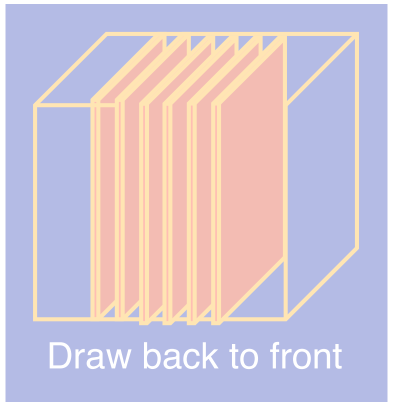
Three Options



- Ray Casting

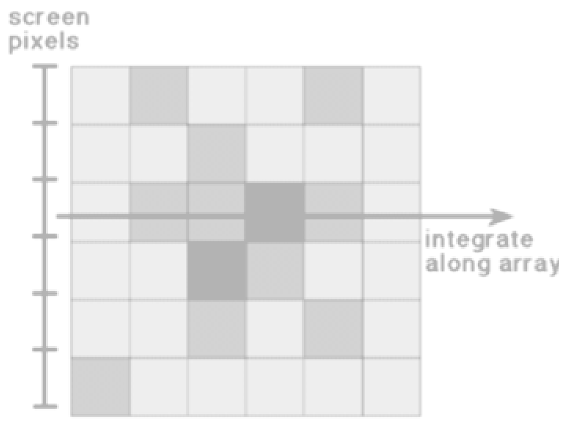


- **Splatting**



- 3D Textures

Three Options



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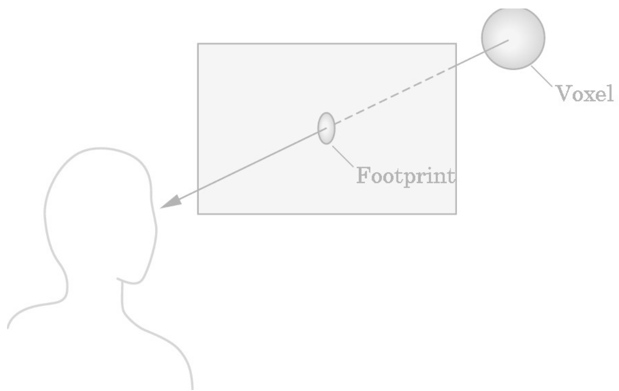

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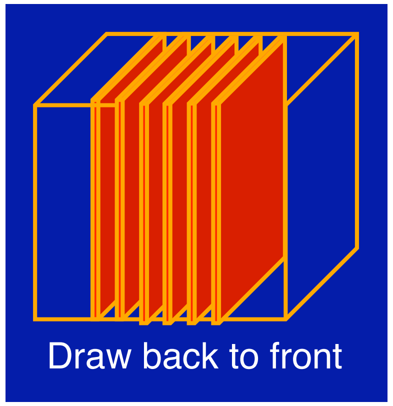
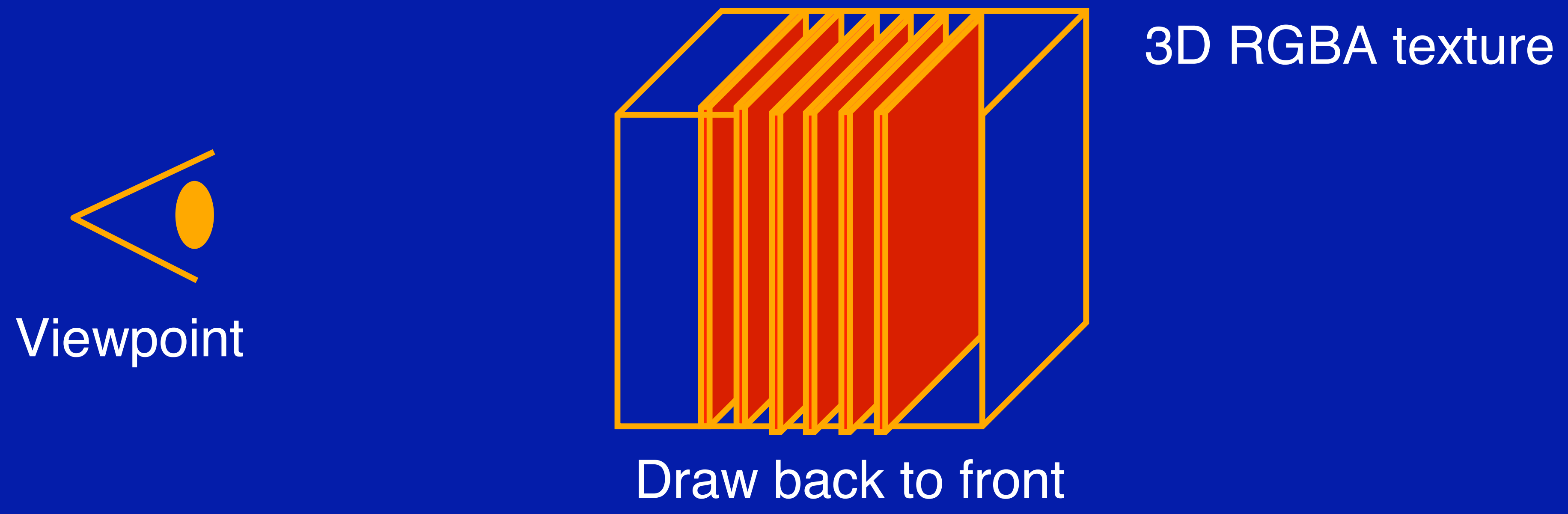


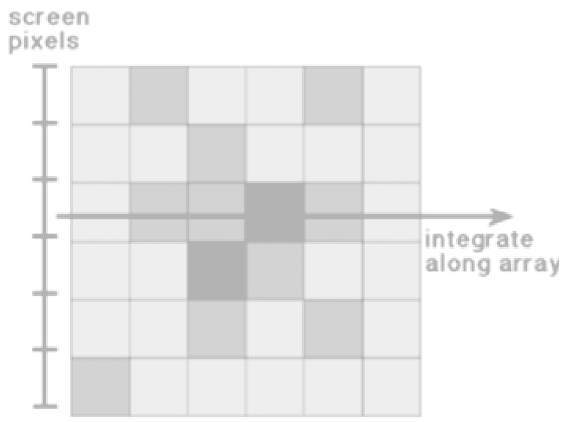
- 3D Textures

3D Textures

- Alternative to ray tracing, splatting
- Build a 3D texture (including opacity)
- Draw a stack of polygons, back-to-front
- Efficient if supported in graphics hardware
- Few polygons, much texture memory



Three Options



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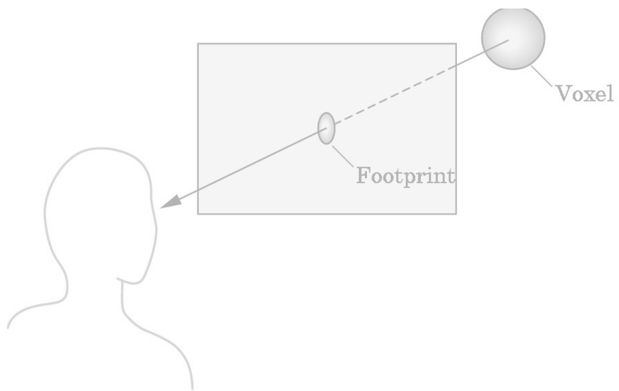

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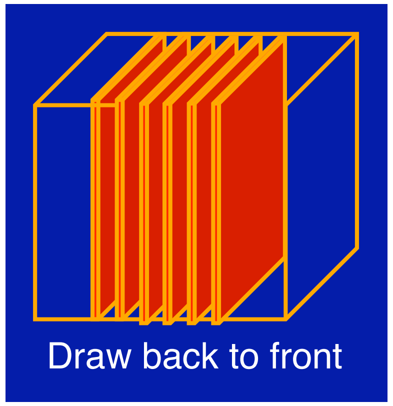
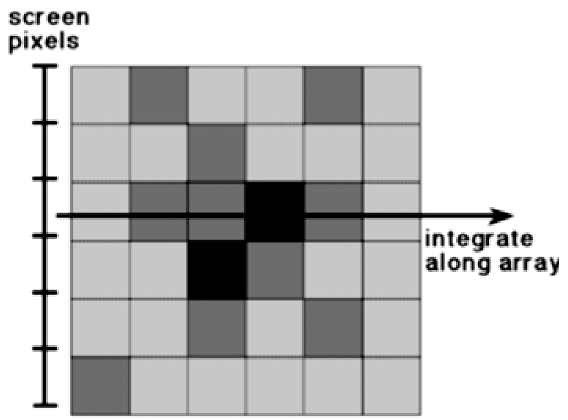


- 3D Textures

Three Options



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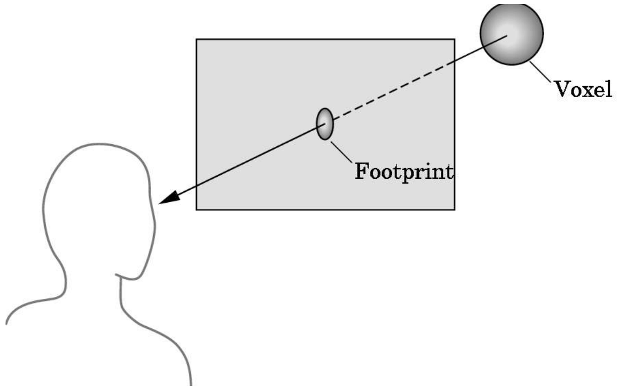

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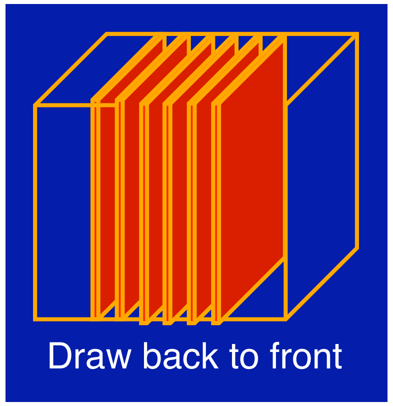
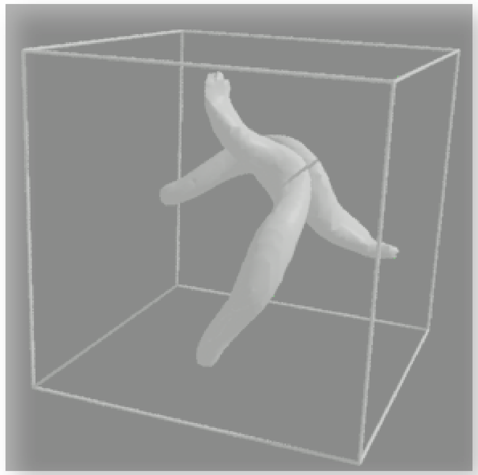
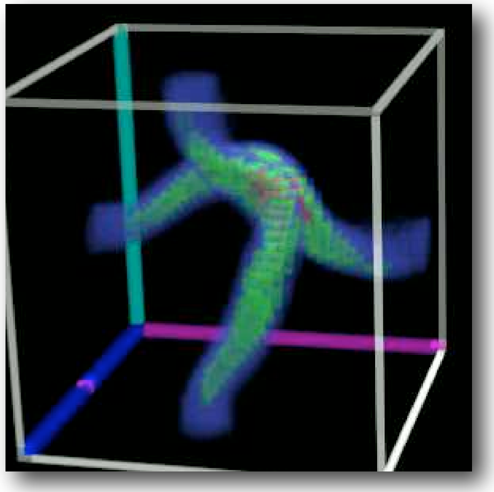


- 3D Textures

Two Options

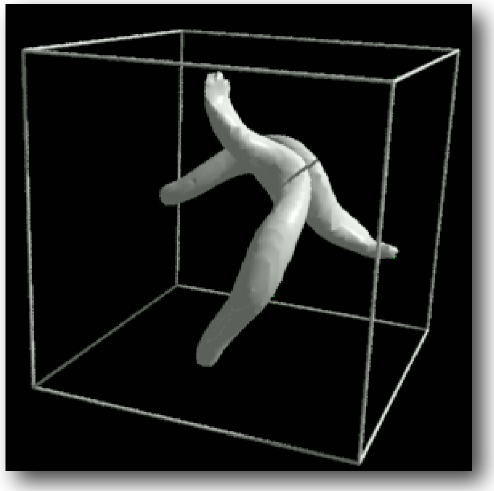


- Surface Rendering

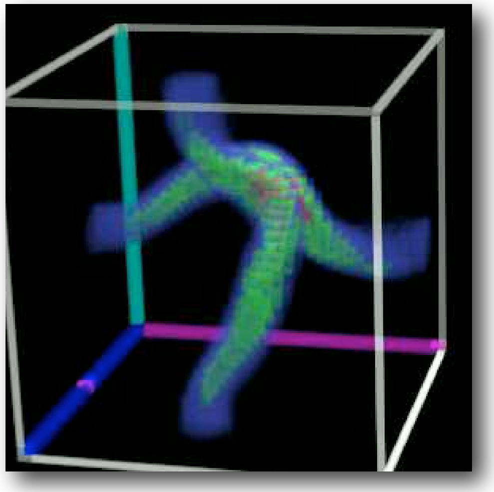


- Volume Rendering

Two Options

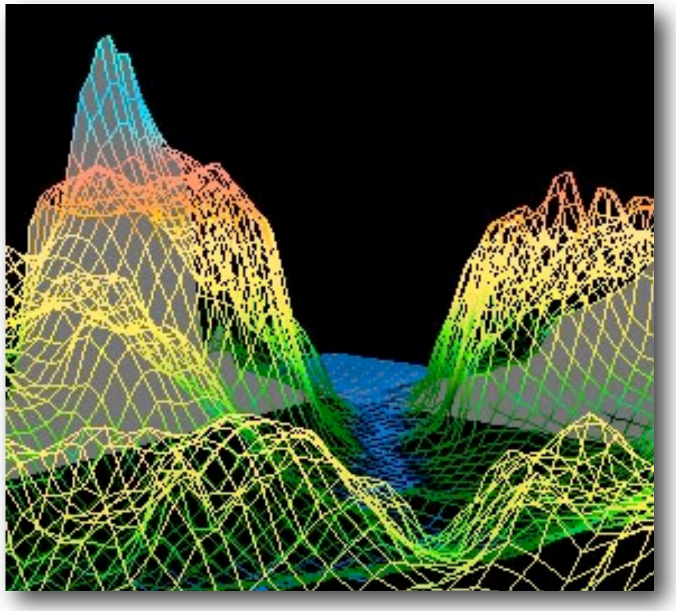
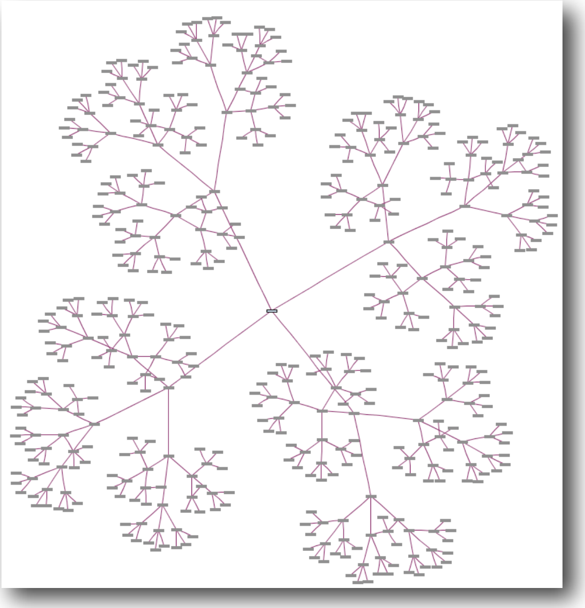
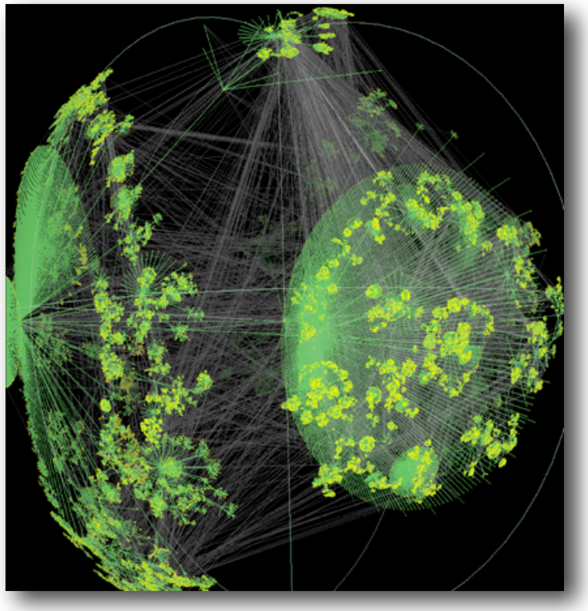
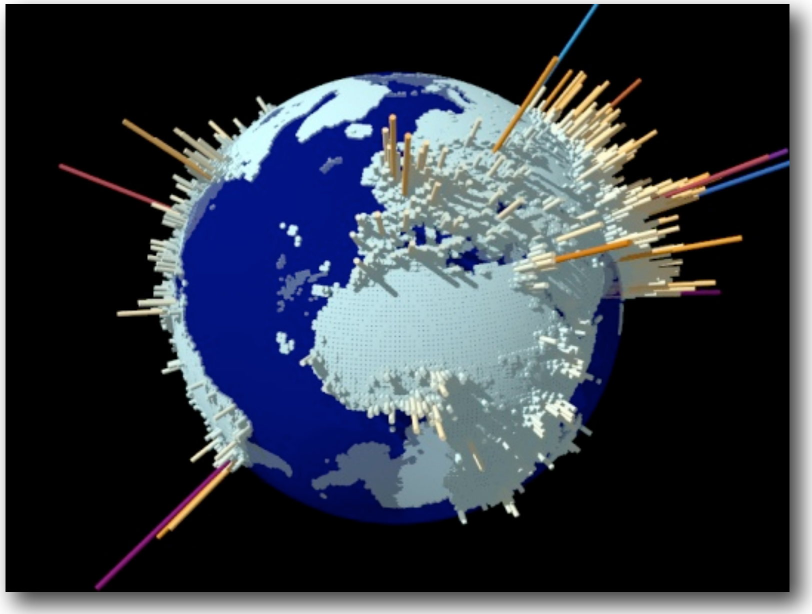
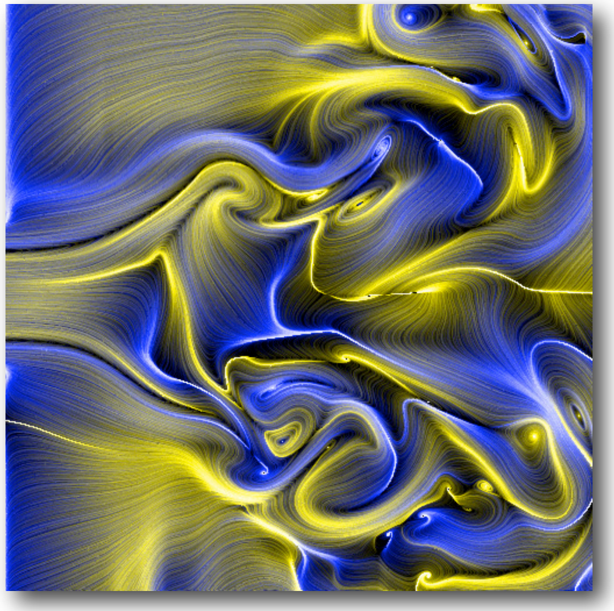
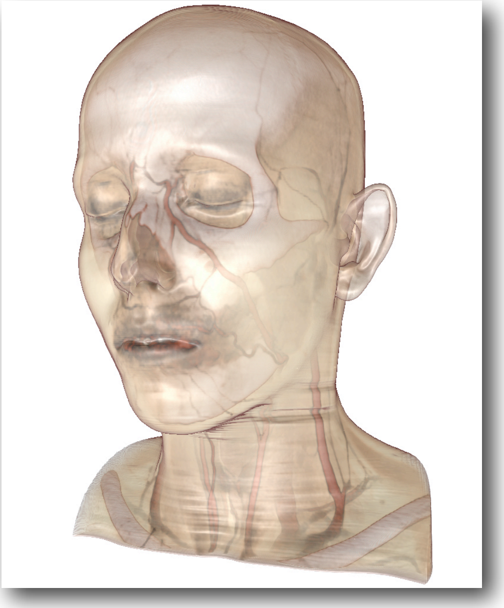


- Surface Rendering



- Volume Rendering

Visualization

Outline

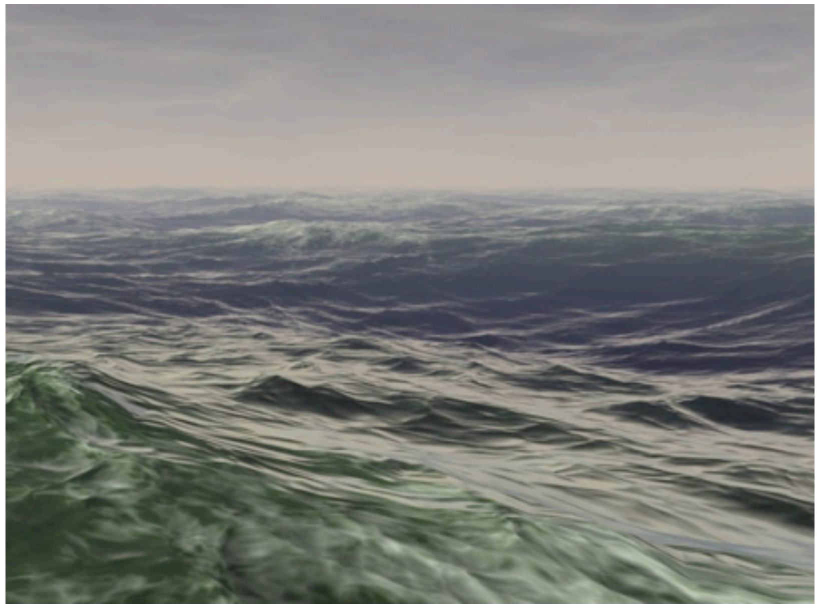
- Visualization
- **Non-photorealistic Rendering**
- Cutaway Illustration
- Contour Drawing
- Good photographs.
- Map Drawing
- Painting

Basic Idea

- **Which best conveys "reality?"**

Photograph.

Painting.
A Rough Sea at a Jetty, 1650.
Jacob van Ruysdael.



Computer Graphics
Duncan Brinsmead

source: Jos Stam. *Photography changes what we think "reality" looks like.*

Reality

A Rough Sea at a Jetty, 1650. - Jacob van Ruysdael.

- This instance in time never happened!
- Perhaps a better match of “subjective reality.”
- Better illustration of “what was going on.”

NPR

- Perhaps we can do better graphics...
- By doing **non-photorealistic graphics!**

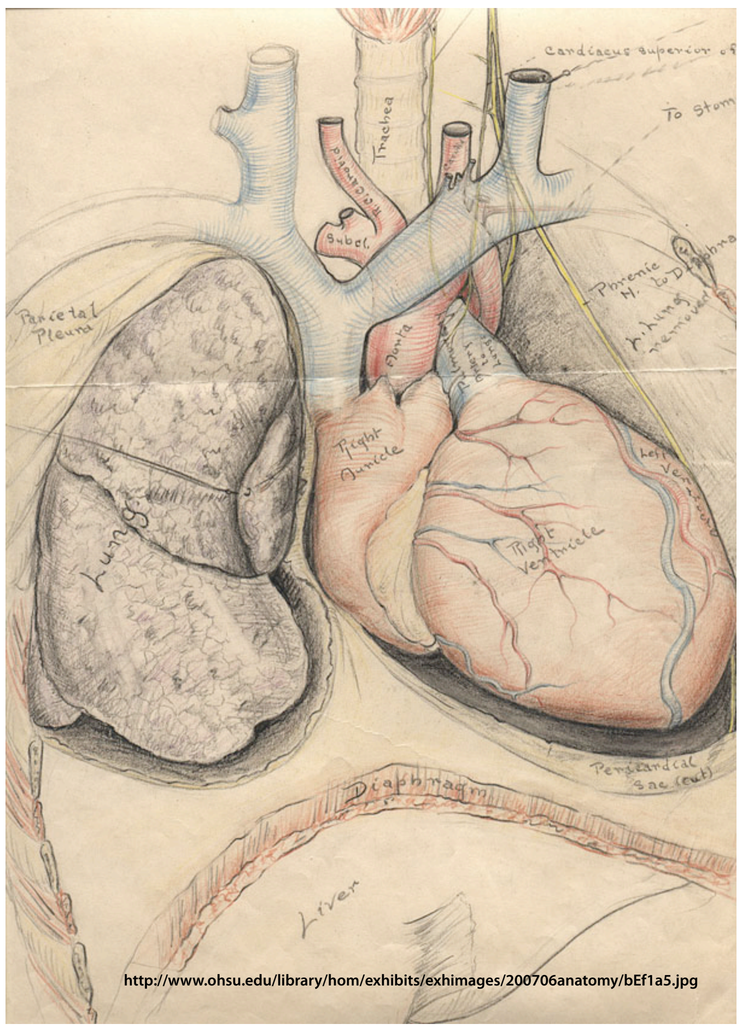
ed!

of “subjective reality.”

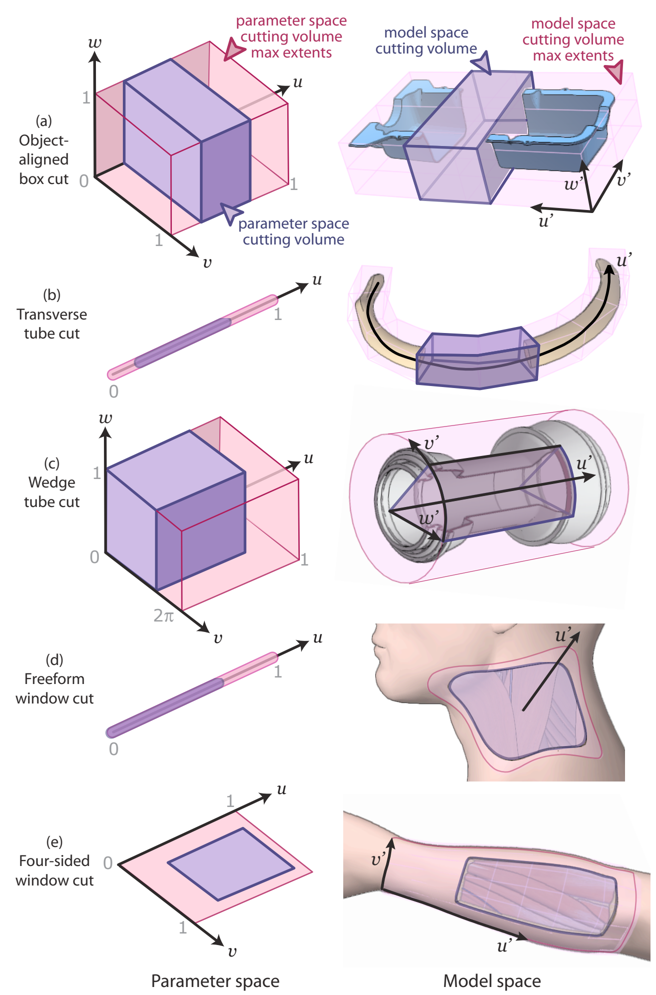
ustration of “what was going on.”

NPR Pipeline

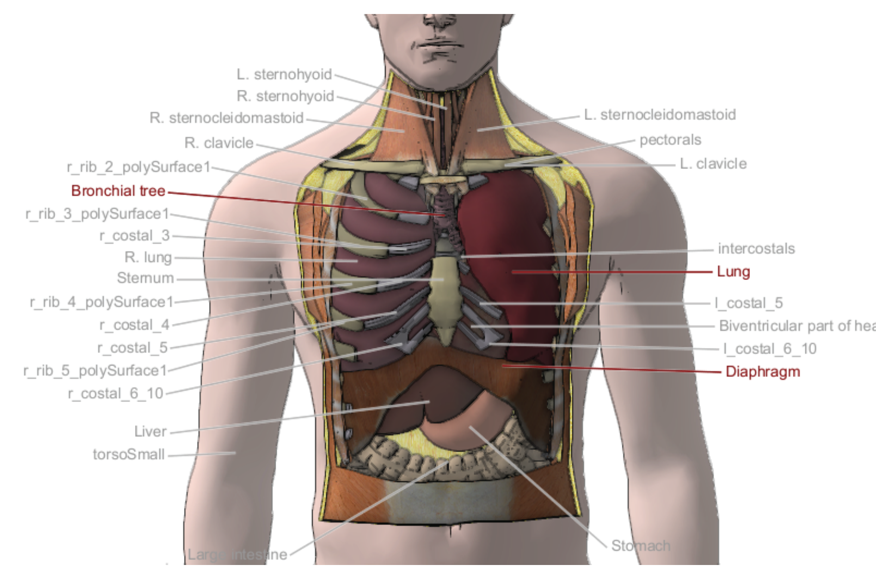
- NPR Research often follows this pipeline...



(1) Study Existing Rendering or Illustration Technique



(2) Extract General Aesthetic Rules



(b) Thorax

(3) "Algorithmicize" These Rules

Outline

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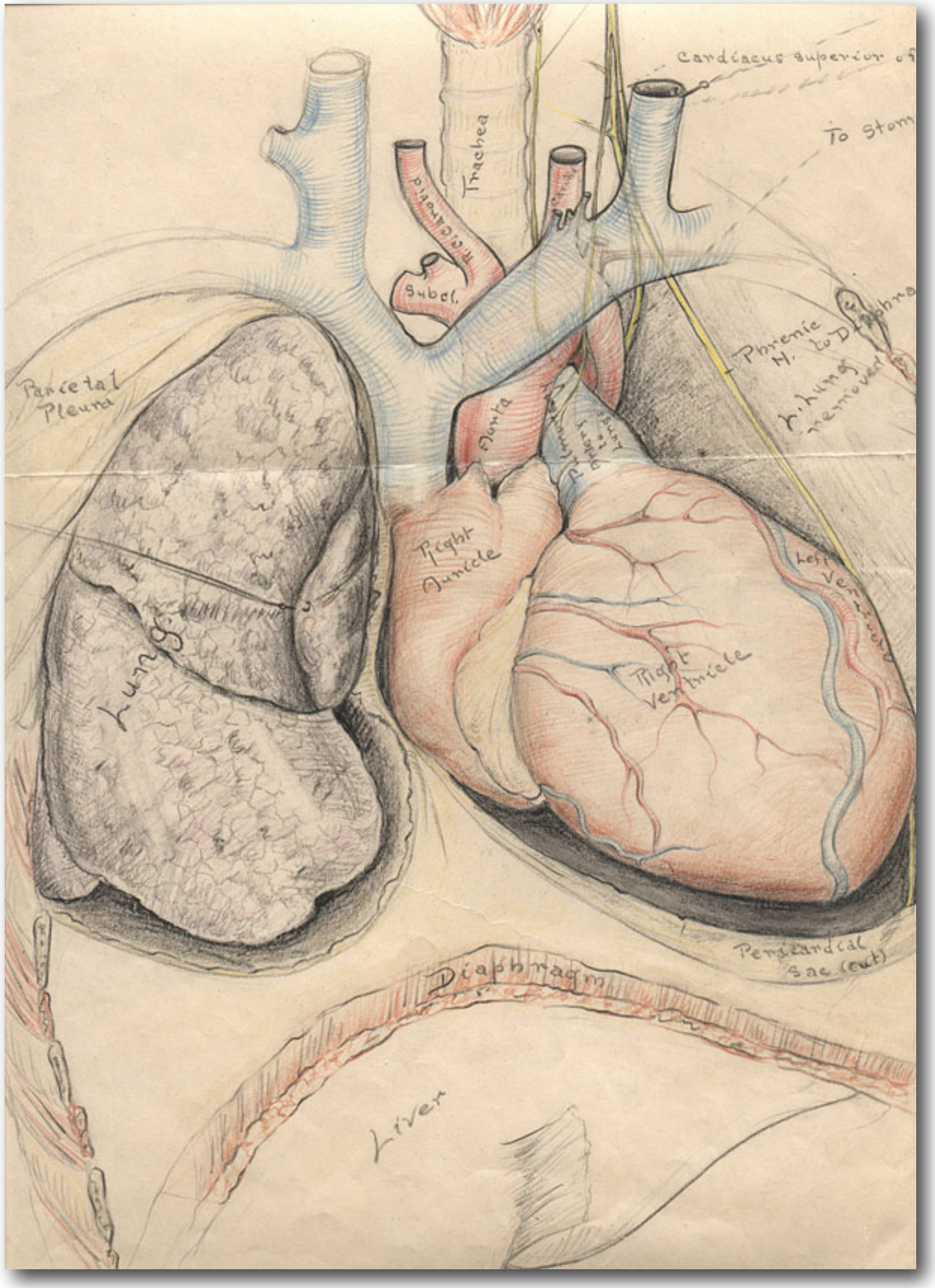
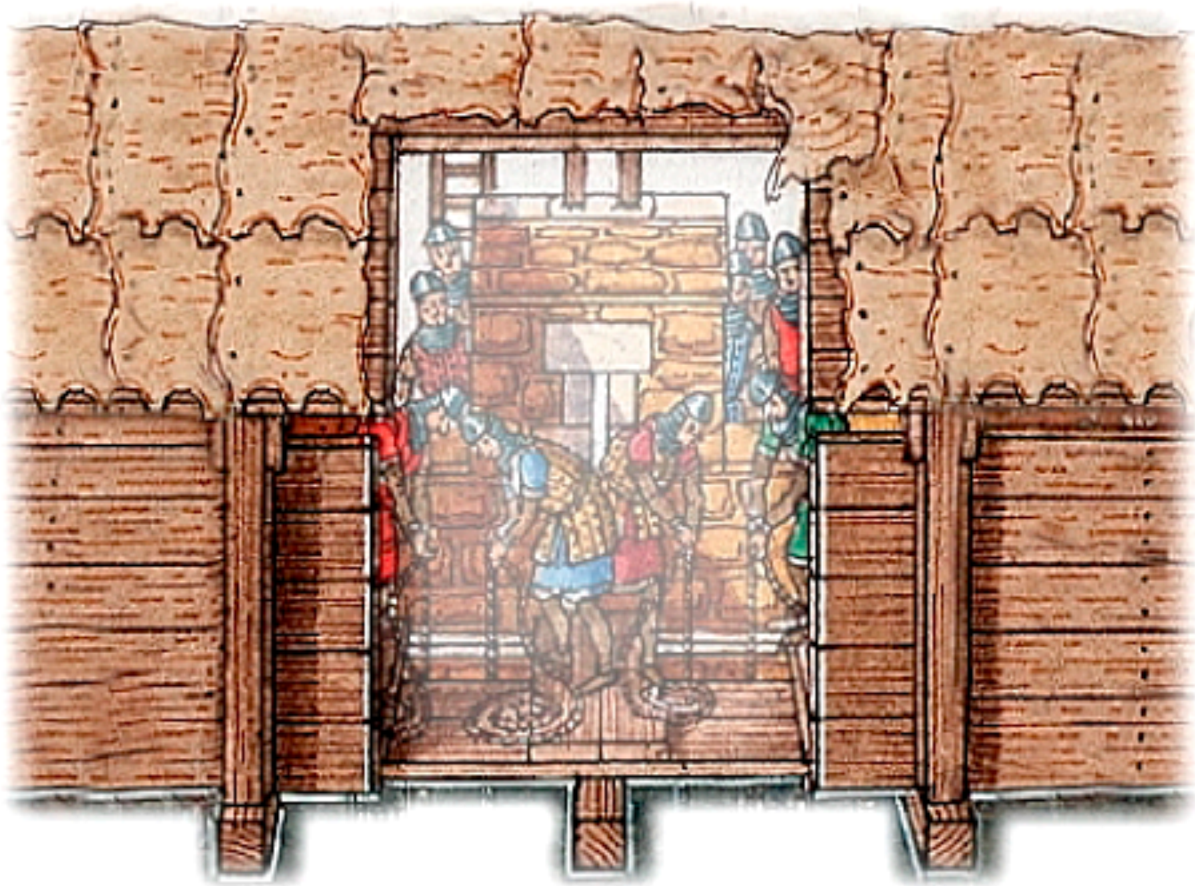
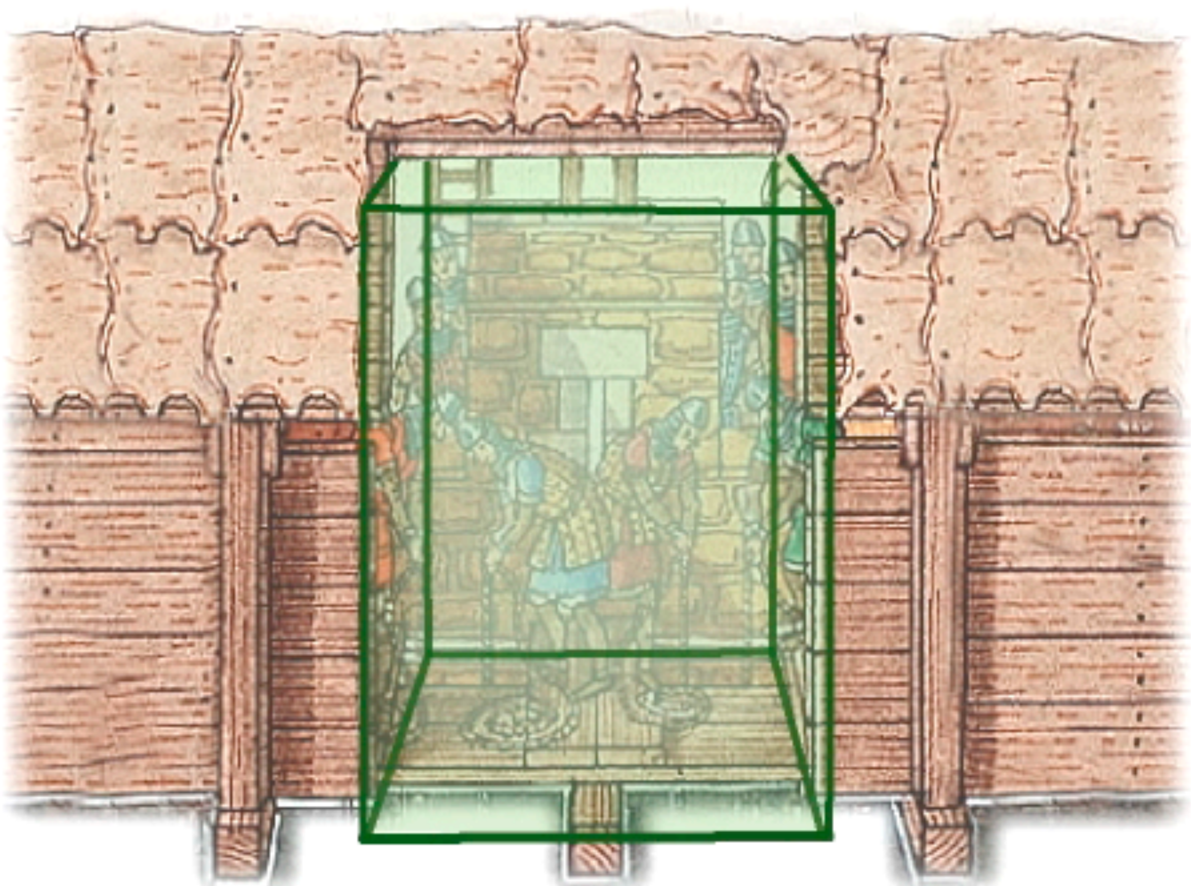
Goal


Trachea
Subcl.
Aorta
Right Auricle
Right Ventricle
Left Ventricle
Lung
Parietal Pleura
Phrenic N. to Diaphragm
Pericardial sac (cut)
Diaphragm
Liver
To Stom

Box Cut



Box Cut



Object-aligned box cut

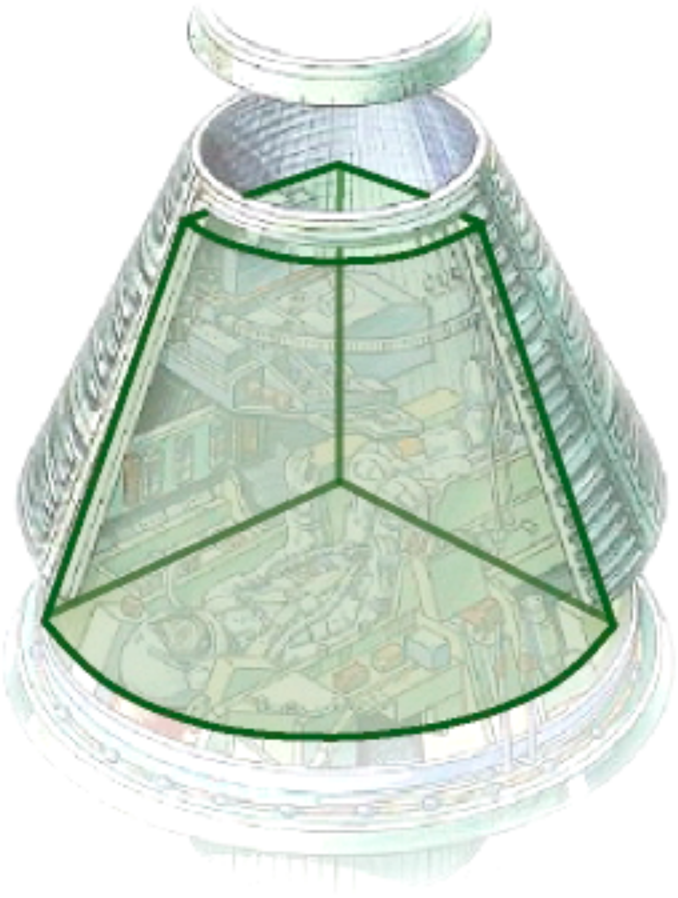
Window Cut

Window Cut

Window cut

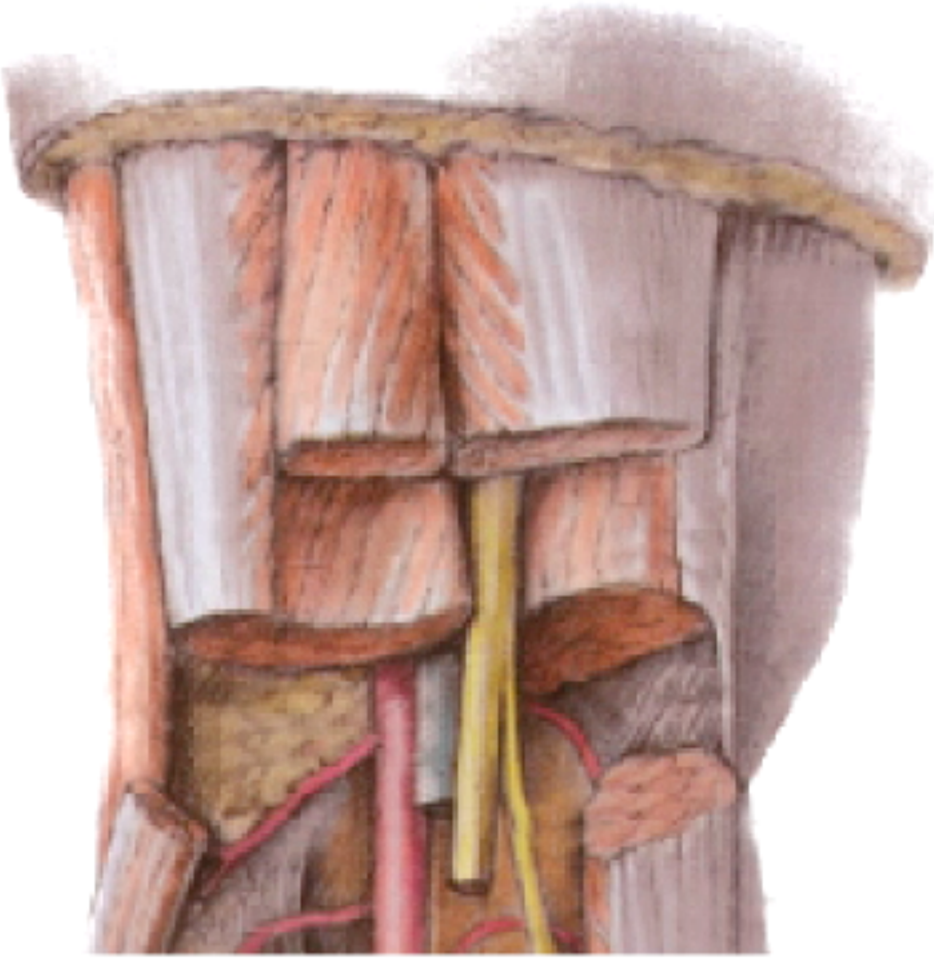
Wedge Cut

Wedge Cut

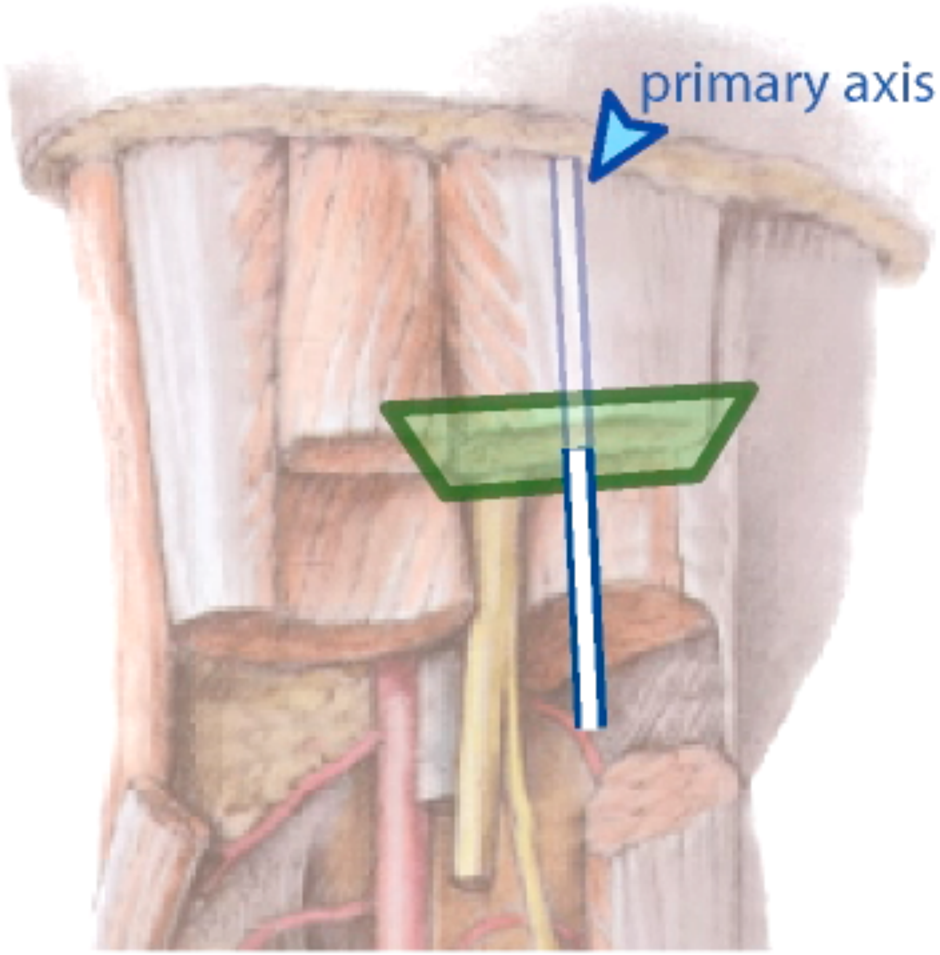


Wedge cut

Transverse Tube Cut

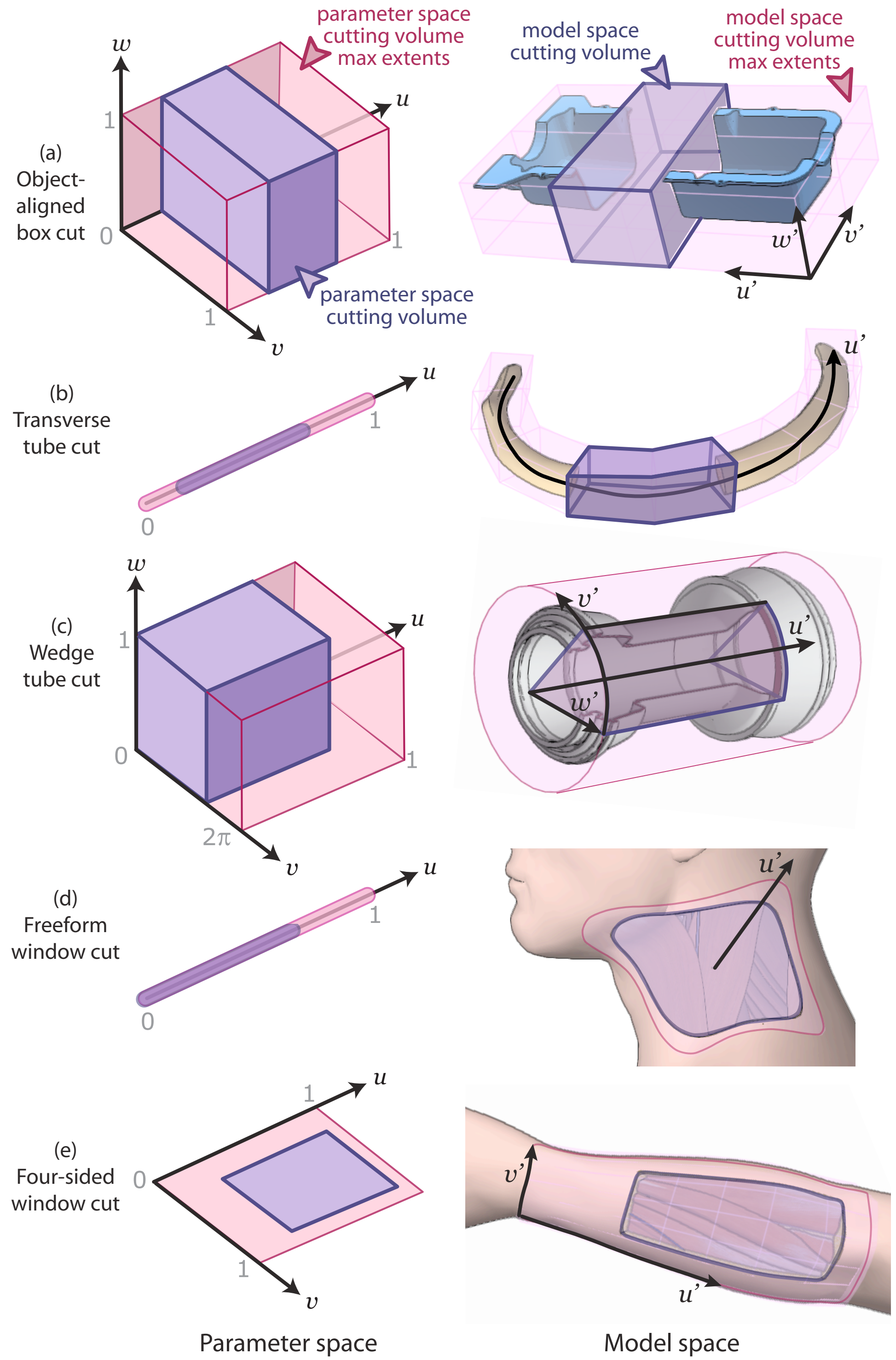


Transverse Tube Cut



Transverse tube cut

Cut Taxonomy



Results

Interactive Cutaway Illustrations of Complex 3D Models

Wilmot Li [1] Lincoln Ritter [1]
Maneesh Agrawala [2] Brian Curless [1] David Salesin [1,3]

[1] University of Washington [2] University of California, Berkeley [3] Adobe Systems

(Source: Li et al. InteractiveCutawayIllustrationsofComplex3DModels)

Outline

- Visualization
- Non-photorealistic Rendering
- Cutaway Illustration
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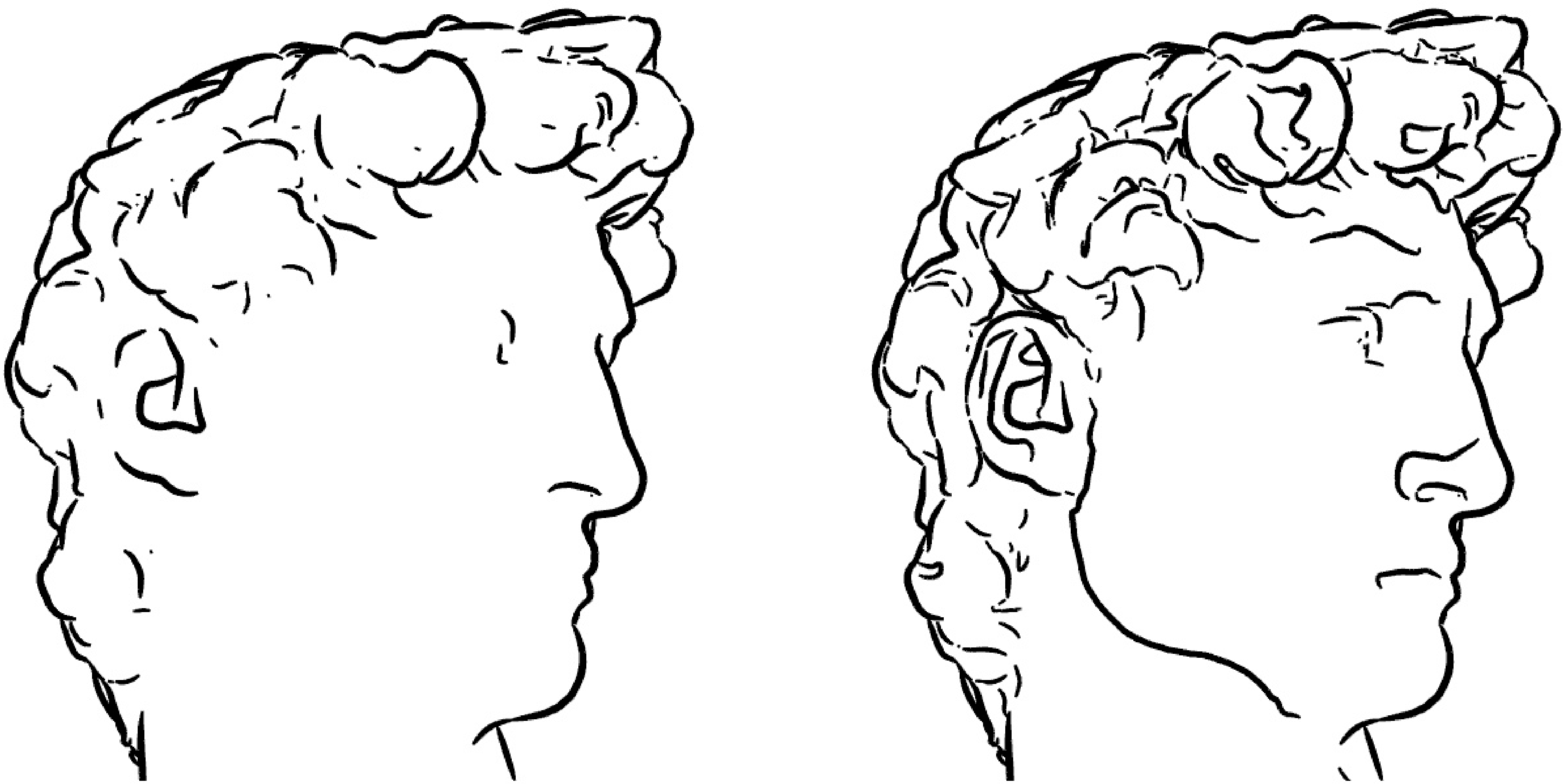
Goal

http://www.cs.princeton.edu/gfx/pubs/Cole_2008_WDP/index.php

Contours

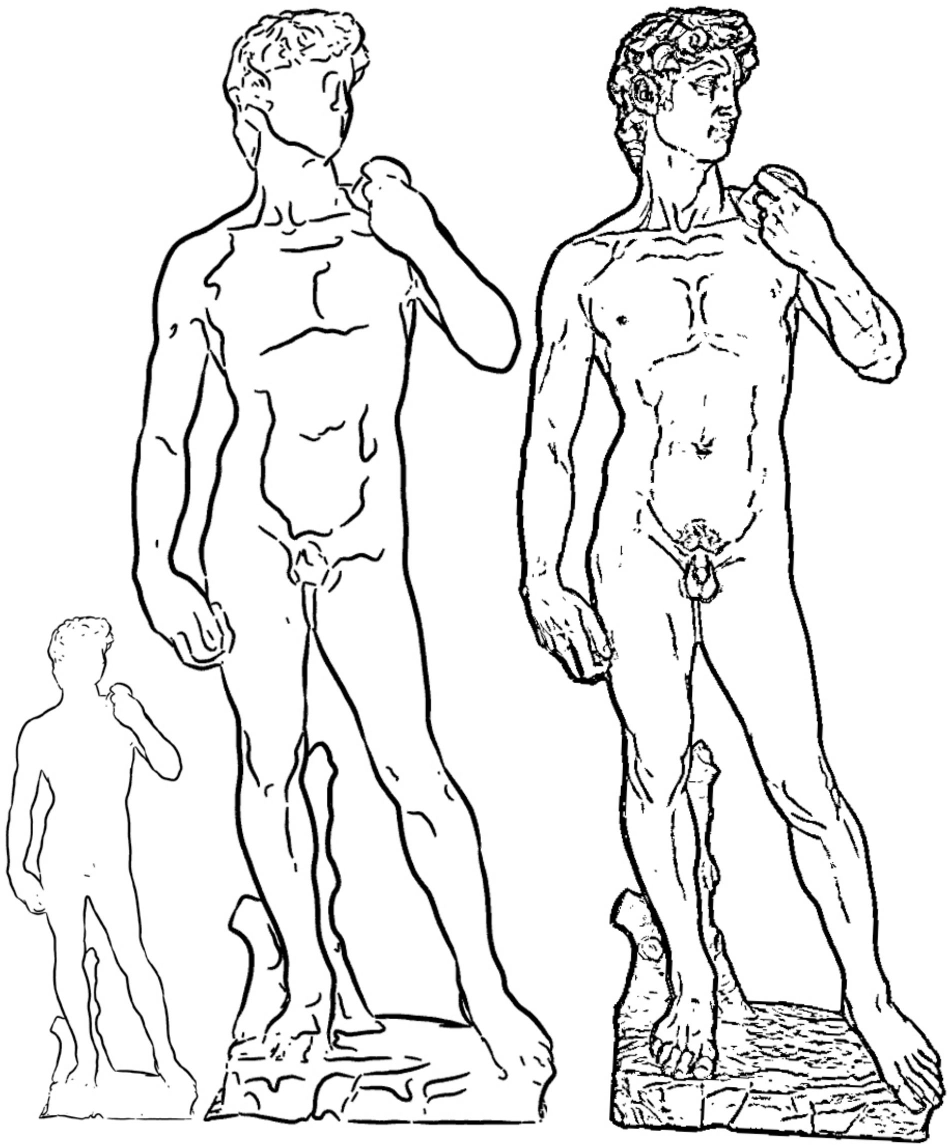
$$\mathbf{n}(\mathbf{p}) \cdot \mathbf{v}(\mathbf{p}) = 0$$

Suggestive Contours



$$\min \; \mathbf{n}(\mathbf{p}) \cdot \mathbf{v}(\mathbf{p})$$

Examples



Outline

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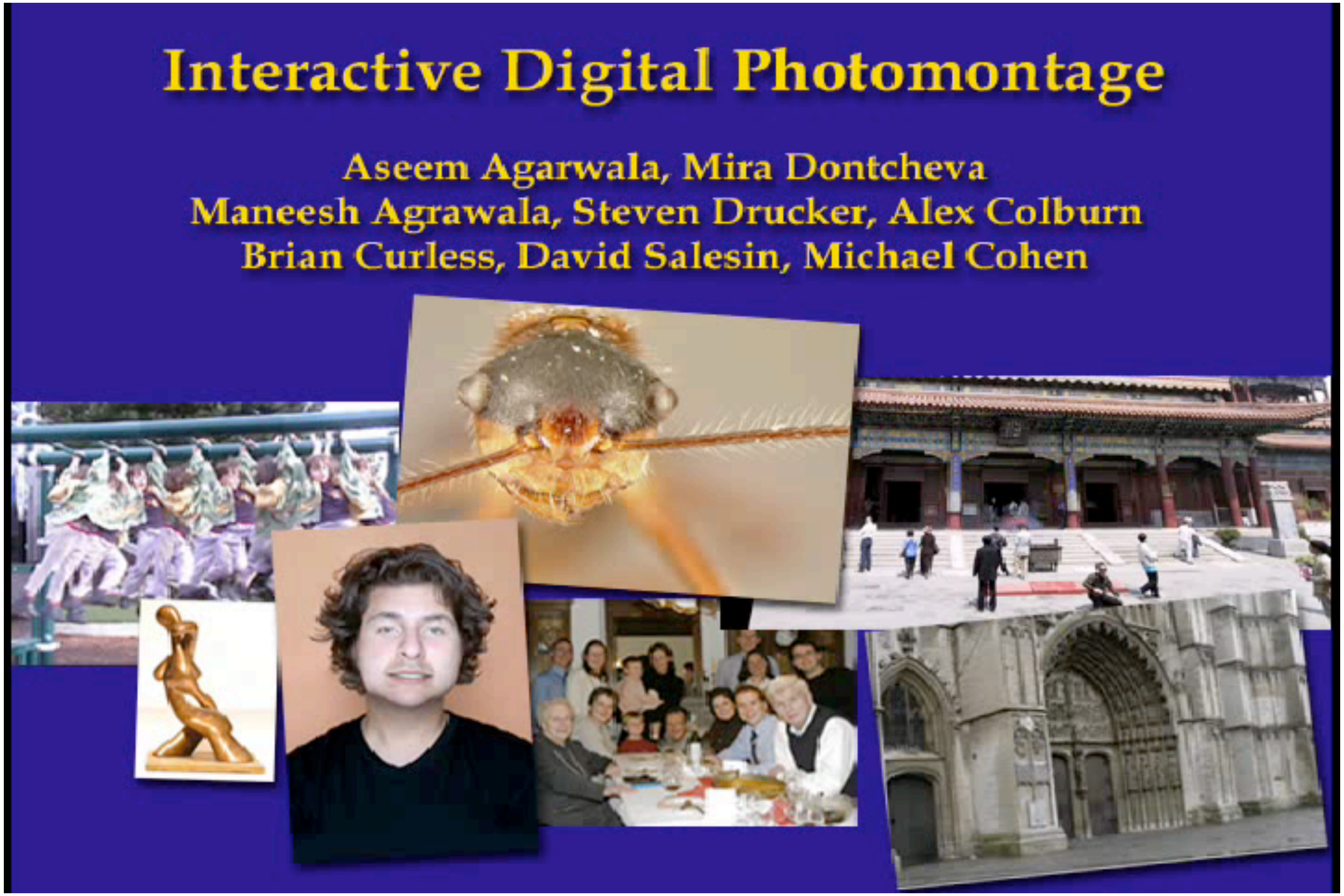
Goal

Problem

Idea

Example


Interactive Digital Photomontage
Aseem Agarwala, Mira Dontcheva
Maneesh Agrawala, Steven Drucker, Alex Colburn
Brian Curless, David Salesin, Michael Cohen

Outline

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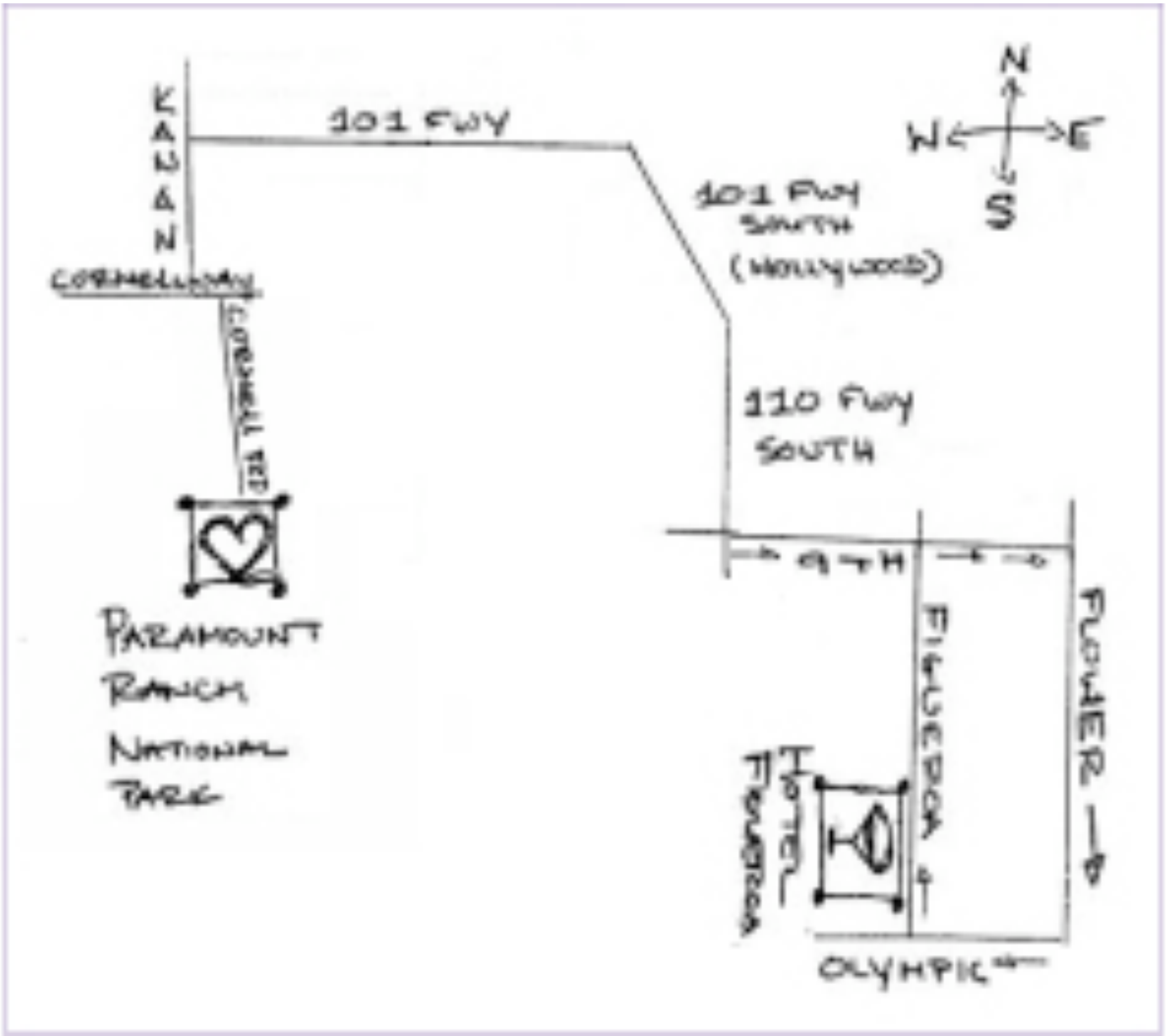
Goal



KANAN
101 FWY
N
W
E
S
101 FWY SOUTH (HOLLYWOOD)
CORNELL WAY
CORNELL RD
110 FWY SOUTH
9TH
PARAMOUNT RANCH NATIONAL PARK
FIGUEROA
FLOWER
HOTEL FIGUEROA
OLYMPIC

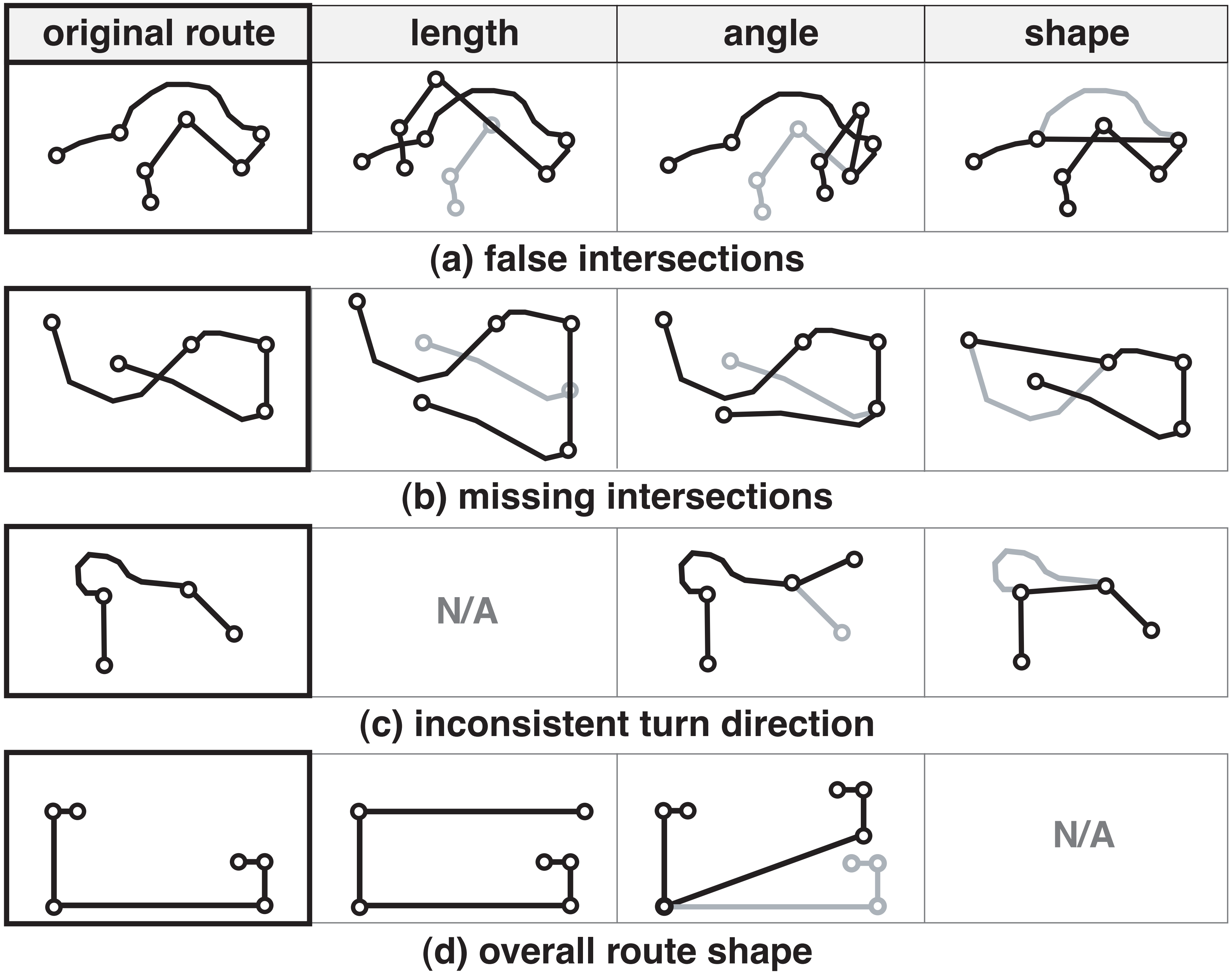
Reality


MAPBLAST!
Simi Valley
San Fernando
210
118
170
Burbank
134
Glendale
101
Cornell Rd
405
5
Beverly Hills
939 S Figueroa St
Culver City
10
Santa Monica
Inglewood
Pacific Ocean
El Segundo
110
105
5 mi

Demo

Map Blast

Algorithm



Rendering Effective Route Maps: Improving Usability Through Generalization

Maneesh Agrawala Chris Stolte

Outline

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Goal

A photograph

An abstracted painting

A low detail painting (no interaction)

A high detail painting (no interaction)

Example

Impressionist

Next Class

- **Exam Review!**