Visualization and Nonphotorealistic Rendering

Adrien Treuille
Carnegie Mellon University
• Visualization
• Non-photorealistic Rendering
• Cutaway Illustration
• Contour Drawing
• Good photographs.
• Map Drawing
• Painting
• Visualization
  • Non-photorealistic Rendering
  • Cutaway Illustration
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  • Map Drawing
  • Painting
Visualization

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

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

http://www.faculty.iu-bremen.de/linsen/publications/ParkYuHotzKreylosLinsenHamann06.jpg
3D Volume Data

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

NCRR Center for Bioelectric Field Modeling, Simulation, and Visualization

Scientific Computing and Imaging (SCI) Institute

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Volume Rendering

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

CT Scan - White means higher radiodensity.

OUTPUT

INPUT
• A cube of density values.
Large Datasets

CT Scan - White means higher radiodensity.

- CT or MRI:
  - e.g. $512 \times 512 \times 200 \approx 50\text{MB}$

- Visible Human:
  - $512 \times 512 \times 1734 \approx 433\text{MB}$

Saturday, February 27, 2010
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”
Two Options

• Surface Rendering

• Volume Rendering
Two Options

- Surface Rendering
- Volume Rendering
• Some data better visualized as a volume, not a surface.

• **Idea:** Use voxels and transparency.
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

Mantle Convection

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Three Options

- Ray Casting
- Splatting
- 3D Textures
Three Options

- Ray Casting
- 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
Trilinear Interpolation

Bilinear interpolation

Trilinear interpolation
Three Options

- Ray Casting
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Three Options

- Ray Casting
- Splatting
- 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

• Ray Casting
• Splatting
• 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

- Ray Casting
- Splatting
- 3D Textures
Three Options

• Ray Casting
• Splatting
• 3D Textures
Two Options

- Surface Rendering
- Volume Rendering
Two Options

• Surface Rendering
• Volume Rendering
Visualization
Outline

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- Non-photorealistic Rendering
- Cutaway Illustration
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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

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

A Rough Sea at a Jetty, 1650. - Jacob van Ruysdael.
• Perhaps we can do better graphics...
• By doing non-photorealistic graphics!

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

- NPR Research often follows this pipeline...

(1) Study Existing Rendering or Illustration Technique

(2) Extract General Aesthetic Rules

(3) "Algorithmicize" These Rules
Outline

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Goal
Box Cut

Object-aligned box cut
Window Cut
Wedge Cut
Wedge Cut
Transverse Tube Cut
Transverse Tube Cut

primary axis

Transverse tube cut
Cut Taxonomy

- (a) Object-aligned box cut
- (b) Transverse tube cut
- (c) Wedge tube cut
- (d) Freeform window cut
- (e) Four-sided window cut

Parameter space cutting volume
Model space cutting volume
Max extents
Results

Interactive Cutaway Illustrations of Complex 3D Models

Wilmot Li¹ Lincoln Ritter¹
Maneesh Agrawala² Brian Curless¹ David Salesin¹,³

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

(Source: Li et al. Interactive Cutaway Illustrations of Complex 3D Models)
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Contours

\[ n(p) \cdot v(p) = 0 \]
Suggestive Contours

\[ \text{min } n(p) \cdot v(p) \]
Examples

Suggestive Contours for Conveying Shape

Doug DeCarlo¹  Adam Finkelstein²  Szymon Rusinkiewicz²  Anthony Santella¹
Forrester Cole, Aleksey Golovinskiy, Alex Limpaecher, Heather Stoddart Barros, Adam Finkelstein, Thomas Funkhouser, and Szymon Rusinkiewicz

Where Do People Draw Lines?
• Visualization
• Non-photorealistic Rendering
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Goal
Problem
Idea
Interactive Digital Photomontage

Aseem Agarwala, Mira Dontcheva
Maneesh Agrawala, Steven Drucker, Alex Colburn
Brian Curless, David Salesin, Michael Cohen
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Reality
Figure 3: Generalization can cause four types of undesirable effects. Each column in the table represents a different aspect of the comparison between the original route and its generalized version. The table includes columns for the original route, length, angle, and shape, with images illustrating the effects of generalization.

(a) False intersections: Original routes with intersections that are not preserved after generalization. The original and generalized routes are compared to show where intersections are added or removed.

(b) Missing intersections: Original routes with intersections that were present but are not visible in the generalized version. The table shows where intersections are missing.

(c) Inconsistent turn direction: Original routes with turn directions that are not consistent between the original and generalized versions. This highlights the need for accurate turn direction representation.

(d) Overall route shape: Comparison of the overall shape of the route before and after generalization. This aspect is crucial for maintaining the visual integrity of the route map.

The table and images are intended to illustrate the challenges and potential solutions in designing effective route maps through generalization. The goal is to simplify maps while preserving essential information and maintaining usability.

References:
- Rendering Effective Route Maps: Improving Usability Through Generalization
- Maneesh Agrawala
- Chris Stolte
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Goal

A photograph  An abstracted painting
A low detail painting (no interaction)  A high detail painting (no interaction)
Example

Impressionist
Example

IMPaSTo
A Realistic, Interactive Model for Paint

William Baxter
Jeremy Wendt
Ming Lin

The University of North Carolina at Chapel Hill
Next Class

- Exam Review!