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...
Outline

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

- Visualization
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Visualization

- 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
Flow Visualization

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

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

The Biolmage 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. $512 \times 512 \times 200 \approx 50\text{MB}$

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

Scientific Computing and Imaging (SCI)
University of Utah
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
- Splatting
- 3D Textures
Three Options

• Ray Casting
• Splatting
• 3D Textures

Draw back to front
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

Draw back to front
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

Draw back to front
Two Options

- Surface Rendering
- Volume Rendering
Two Options

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- Volume Rendering
Outline

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

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

Perhaps a better match of "subjective reality."
Better illustration of "what was going on."

Text
(1) Study Existing Rendering or Illustration Technique

(2) Extract General Aesthetic Rules

(3) “Algorithmicize” These Rules

• NPR Research often follows this pipeline...
• Visualization
• Non-photorealistic Rendering
• Cutaway Illustration
• Contour Drawing
• Good photographs.
• Map Drawing
• Painting
Goal
Box Cut
Object-aligned box cut
Window Cut
Window Cut

Window cut
Wedge Cut
Wedge Cut
Transverse Tube Cut
Transverse Tube Cut

Transverse tube cut
For object-aligned box cuts, we map a parameter space to model space cutting volumes, which we represent as cutting volumes specified as simple parametric ranges that get local coordinates of the structure to be cut. Under these mappings, the parameter space that is mapped to a volume in model space is the constructive solid geometry (CSG) subtraction. Each volume cuts by removing volumetric regions — the structure is a separate geometric object. Our system cuts the model structure into parts that makes it easy to create different views of the parts.

In this section, we introduce a parametric representation for cutting volumes. In our system, a cut is represented as a parameter space cutting volume that is defined in a one-, two-, or three-dimensional parameter space. The system precomputes the primary axis for the parameter and model space. The model space mappings are fully parameterized using a 9D parameter space.

Shading is a strong cue for conveying surface orientation and depth. Cast shadows are a strong cue for conveying the distance of an object from the light source. Diffuse shading provides information about the surface orientation and depth. Edge shadows are a strong cue for conveying edge orientation and the relative distance of structures. Some illustrators suggest diffuse shading, but the overall darkness depends on the surface orientation. The width and softness of the darkened region may vary, but in general, when the edge is close to one another, the shadow is lighter, and overlapping structures are often divided at edges. The width and softness of edge shading usually vary with the distance to the viewer. When the edge is close to the viewer, the edge is usually darker.

While simple diffuse shading provides information about the model's surface orientation, it can obscure important details. Edge shadows are a strong cue for conveying edge orientation and the relative distance of structures. Some illustrators suggest diffuse shading, but the overall darkness depends on the surface orientation. The width and softness of the darkened region may vary, but in general, when the edge is close to one another, the shadow is lighter, and overlapping structures are often divided at edges. The width and softness of edge shading usually vary with the distance to the viewer. When the edge is close to the viewer, the edge is usually darker. Some illustrators suggest diffuse shading, but the overall darkness depends on the surface orientation. The width and softness of the darkened region may vary, but in general, when the edge is close to one another, the shadow is lighter, and overlapping structures are often divided at edges. The width and softness of edge shading usually vary with the distance to the viewer. When the edge is close to the viewer, the edge is usually darker.
Results

Interactive Cutaway Illustrations of Complex 3D Models

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(Source: Li et al. InteractiveCutawayIllustrationsofComplex3DModels)
Outline

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

Abstract

Keywords:

Convey shape more effectively than contour alone.

Contour generator is the set of points on the surface, visible in viewpoint. We provide two methods for calculating suggestive contours: lines drawn on clearly visible parts of the surface.

Suggestive contours are lines drawn on clearly visible parts of the surface, in contrast to being merely a feature where a surface bends away from the viewer and becomes invisible. As in the rendering at left (valleys in the image), our image-space algorithm takes a broadly similar form (though of course without the robustness required for hand-drawn pictures).

Figure 1: An example showing the expressiveness added by suggestive contours. The left image is drawn using contours alone, while the right integrates with true contours in a seamless and consistent way.

1.1 Related work

There is significant variability in terminology—these are often called contours, silhouettes [Markosian et al. 1997; Hertzmann and Zorin 2000]. Our image-space algorithm takes a broadly similar form (though of course without the robustness required for hand-drawn pictures). Consider a drawing of a face. In perspective on these techniques.

We offer several intuitive characterizations of lines that can integrate with true contours in a seamless and consistent way.

Concave parts have negative curvature. Zero curvature corresponds to outward-pointing surface normals. At a point defined only along the contour generator, where curvature is zero and where the surface bends away from the viewer and becomes invisible, instead, it can read lines merely as features where a surface bends away from the viewer. In this paper, we describe new NPR techniques based on suggestive contours. The left image is drawn using contours alone, while the right integrates with true contours in a seamless and consistent way.

1.2 Suggestive contours

In characterizing suggestive contours, we will also use the notion of the tangent plane at a point [Koenderink 1984], which is the normal curvature tangent plane of a curve. The curvature is defined as:

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

\[ \min n(p) \cdot v(p) \]
Examples

Figure 1: An example showing the expressiveness added by suggestive contours. Our system produces still frames, such as those in the right image, which use both contours and suggestive contours. When artists design imagery to portray a scene, they do not just render visual cues veridically. Instead, they select which visual cues to portray and adapt the information each cue carries. Such imagery exaggerating a rendering, by using lines that are almost contours, gives added visual evidence of surface geometry. Our perception of outlines and suggestive contours, including an algorithm that finds the zero crossings of the dihedral angle, which is small. For more highly-tessellated modeling ridge and valley lines, we implemented an algorithm that finds discontinuities in cues for shape. First, inspired by the work of Saito and Takahashi to two methods whose goal is also to draw lines that are visually evocative of terrain. Finally, the suggestive contours convey shape more effectively than contour alone.

Examples

•

We offer several intuitive characterizations of lines that can formalize which of them are suggestive contours. Our system produces still frames, such as those in the right image, which use both contours and suggestive contours. When artists design imagery to portray a scene, they do not just render visual cues veridically. Instead, they select which visual cues to portray and adapt the information each cue carries. Such imagery exaggerating a rendering, by using lines that are almost contours, gives added visual evidence of surface geometry. Our perception of outlines and suggestive contours, including an algorithm that finds the zero crossings of the dihedral angle, which is small. For more highly-tessellated modeling ridge and valley lines, we implemented an algorithm that finds discontinuities in cues for shape. First, inspired by the work of Saito and Takahashi to two methods whose goal is also to draw lines that are visually evocative of terrain. Finally, the suggestive contours convey shape more effectively than contour alone.

Suggestive Contours for Conveying Shape

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Outline

• Visualization
• Non-photorealistic Rendering
• Cutaway Illustration
• Contour Drawing
• Good photographs.
• Map Drawing
• Painting
Goal
Problem
Idea
Interactive Digital Photomontage

Aseem Agarwala, Mira Dontcheva
Maneesh Agrawala, Steven Drucker, Alex Colburn
Brian Curless, David Salesin, Michael Cohen
• Visualization
• Non-photorealistic Rendering
• Cutaway Illustration
• Contour Drawing
• Good photographs.
• Map Drawing
• Painting
Goal
Reality
Table showing the impact of generalization on different aspects of a route:

<table>
<thead>
<tr>
<th>Original Route</th>
<th>Length</th>
<th>Angle</th>
<th>Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Figure" /></td>
<td><img src="image2.png" alt="Figure" /></td>
<td><img src="image3.png" alt="Figure" /></td>
<td><img src="image4.png" alt="Figure" /></td>
</tr>
<tr>
<td><strong>(a) False intersections</strong></td>
<td><img src="image5.png" alt="Figure" /></td>
<td><img src="image6.png" alt="Figure" /></td>
<td><img src="image7.png" alt="Figure" /></td>
</tr>
<tr>
<td><img src="image8.png" alt="Figure" /></td>
<td><img src="image9.png" alt="Figure" /></td>
<td><img src="image10.png" alt="Figure" /></td>
<td></td>
</tr>
<tr>
<td><strong>(b) Missing intersections</strong></td>
<td><img src="image11.png" alt="Figure" /></td>
<td><img src="image12.png" alt="Figure" /></td>
<td><img src="image13.png" alt="Figure" /></td>
</tr>
<tr>
<td><img src="image14.png" alt="Figure" /></td>
<td><img src="image15.png" alt="Figure" /></td>
<td><img src="image16.png" alt="Figure" /></td>
<td></td>
</tr>
<tr>
<td><strong>(c) Inconsistent turn direction</strong></td>
<td><img src="image17.png" alt="Figure" /></td>
<td><img src="image18.png" alt="Figure" /></td>
<td><img src="image19.png" alt="Figure" /></td>
</tr>
<tr>
<td><img src="image20.png" alt="Figure" /></td>
<td><img src="image21.png" alt="Figure" /></td>
<td><img src="image22.png" alt="Figure" /></td>
<td></td>
</tr>
<tr>
<td><strong>(d) Overall route shape</strong></td>
<td><img src="image23.png" alt="Figure" /></td>
<td><img src="image24.png" alt="Figure" /></td>
<td><img src="image25.png" alt="Figure" /></td>
</tr>
<tr>
<td><img src="image26.png" alt="Figure" /></td>
<td><img src="image27.png" alt="Figure" /></td>
<td><img src="image28.png" alt="Figure" /></td>
<td></td>
</tr>
</tbody>
</table>

The table illustrates the impact of generalization on different aspects of a route: length, angle, and shape. The examples show how generalization affects the representation of intersections, turn directions, and overall shape.
Outline

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

A photograph

An abstracted painting

A low detail painting (no interaction)

A high detail painting (no interaction)
Example

Impressionist
Next Class

• Exam Review!