Computer graphics
When you think about graphics, you think
When you think about graphics, you think
When you think about graphics, you think
Applications

- Science
- Art
- Engineering
- Medicine
- Entertainment
- Advertising
- Education
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Outside-In

http://www.geom.uiuc.edu/docs/outreach/oi/moregraphics.html
http://www.physics.orst.edu/~bulatov/vrml/index.html
Why interesting?

<table>
<thead>
<tr>
<th>The world</th>
<th>The screen</th>
</tr>
</thead>
<tbody>
<tr>
<td>complex</td>
<td>simple</td>
</tr>
<tr>
<td>dynamic</td>
<td>static</td>
</tr>
<tr>
<td>multi-dimensional</td>
<td>two-dimensional</td>
</tr>
<tr>
<td>continuous</td>
<td>discrete</td>
</tr>
</tbody>
</table>
Beauty

- Science – math and physics
- Engineering – software and hardware
- Artistic and aesthetic issues
- Fun!
Issues in computer graphics

- Geometric modeling
- Rendering
- Animation
- Scientific visualization
  "The purpose of computing is insight, not numbers"
  Hamming
- Virtual reality
- Human-computer interaction
- Shape analysis
Geometric modeling

How do we represent objects?
Wish list

1. Large domain
2. Unambiguous
3. Unique
4. Accurate
5. Impossible to create invalid representations
6. Easy to create and maintain
7. Closure under certain operations
8. Compact
9. Efficient
Geometric modeling

How do we represent objects?

Voxels
Geometric modeling

How do we represent objects?

Splines
Geometric modeling

How do we represent objects?

Polyhedra
Rendering

1. What pixels?
2. What’s in the pixel?
3. Which color?
What pixels = scan conversion

- **Given**: A mathematical description of a two or a three dimensional “scene”
- **Find**: A value for each pixel in the frame buffer
What pixels = scan conversion

- **Given**: A mathematical description of a two or a three dimensional “scene”
- **Find**: A value for each pixel in the frame buffer
What’s in the pixel - visibility

**Goal:** Hidden surface removal

- In object space or in image space?
- In software or in hardware?
What color?

- Illumination and shading
- Transparency, reflection
Animation

How to define / represent complex time-dependent behavior of objects?
Animation topics

- Automatic in-between
- Transformations
- Collision
- Motion
- Facial animation
- Morphing
- Physically-based simulation
Scientific visualization

- Visualize symbolic data
- Visualize the invisible
- Visualize huge amounts of data
Applications

- Engineering
- Medicine
- Mathematics
- Chemistry
- Biology
Example – air flow

Harrier Jet flow during landing (NASA Ames)
Example - mathematics

Outside-In (Munzner)

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Example - mathematics

Outside-In (Munzner)

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http://www.physics.orst.edu/~bulatov/vrml/index.html
Information visualization
CHI

- Look and feel
- Fast startup time
- Feedback
- Allow corrections
Shape analysis – Why? Why now?

Development of effective techniques for representing, analyzing, searching, and reusing large repositories of 3D data more accessible

- Data storage
- Computing power
- Modeling techniques
Shape analysis: Segmentation

Let $S$ be an orientable mesh.
Goal: decompose $S$ into connected sub-meshes $S_1, S_2 \ldots S_k$ that are face-wise disjoint, and whose union gives $S$. 

\[ S = S_1 \cup S_2 \cup \ldots \cup S_k \]
Shape analysis: Retrieval of 3D Models
Shape analysis: Feature lines
Computer graphics in context

- Image processing: image → image
- Computer vision: image → model
- Computer graphics: model → image

Today - mix
This course

- Geometric modeling
- Rendering (Graphics pipeline)
- Advanced issues (geometry, GPU)
- Animation (homework)
This course

- Geometric modeling
  - Transformation
  - Solid modeling
  - Curves
This course

- Graphics pipeline
  - 3D viewing
  - Scan conversion
  - Hidden surface removal
  - Compositing & dithering
  - Clipping
  - Color & shadows
  - Texture mapping
This course

- Advanced issues
  - Animation
  - Computational geometry
  - GPU computing