Conveying Structure

Maneesh Agrawala

CS 294-10: Visualization
Fall 2007

Final project

Design new visualization method
- Pose problem, Implement creative solution

Deliverables
- Implementation of solution
- 8-12 page paper in format of conference paper submission
- 2 design discussion presentations

Schedule
- Project proposal: 10/24
- Initial problem presentation: 10/24, 10/29 or 10/31
- Midpoint design discussion: 11/19, 11/21 or 11/26
- Final paper and presentation: To be determined

Grading
- Groups of up to 3 people, graded individually
- Clearly report responsibilities of each member
11/19
Wesley
Robert

11/21
Robin
Mark
Jimmy Andrews
Amanda

11/26
Jerry and Jimmy
Ken-ichi Andrew and Nate
David Purdy and Daisy Wang
Jonathan
Kenghao

Using Space Effectively: 3D
Perspective distortion

Wide angle projection
Does not preserve subjective size

Fish-eye vs. wide angle
Multiviewpoint Panoramas

How to Depict All Buildings on Street?
How to Depict All Buildings on Street?
How to Depict All Buildings on Street?

Pushbroom panorama [Roman 04]

A Better Approach

Michael Koller  www.seamlesscity.com
Why is this better?

Perhaps because local sense of perspective is preserved

Input – 107 Hand Held Photographs
Approach

1. Estimate camera pos. & depths of feature pts (SFM)

2. Project images onto user chosen picture plane

3. Use graph cut to “seamlessly” merge images
Projected Sources
Average Projected Sources

Apply Graph Cut

$$C(L) = \sum \text{image objective} + \sum \text{seam objective}$$
Result

A Longer Street
Cartographic Projections

Latitude-longitude projection

[Figure 1.3, Flattening the Earth, Snyder]
Azimuthal equidistance

[Figure 3.4, Flattening the Earth, Snyder]

Mercator projection (equiangular)

\[ x = R \varphi \]
\[ y = R \log \tan \left( \frac{\pi}{4} + \frac{\varphi}{2} \right) \]

[Figure 1.35, Flattening the Earth, Snyder]
**Mercator projection**

Circular craters map to circles

![USGS Map of Mars](image)

**Sinusoidal equiareal projection**

[Figure 1.39a, Flattening the Earth, Snyder]
Summary

Tension between properties of projections
- Orthographic projections preserve different properties than perspective projections
- Equiarea implies not equiangular
- Modern projections seek compromise

People tolerate distortion -- to an extent
- Maintain important information
- Avoid extremes

Conveying Structure
Complex 3D objects

- Architectural models
- Mechanical assemblies
- Biological specimens
- ...

Photographs and illustrations

Reveal external shape, do not expose internal structure
Problem: Occlusion

Can’t see beyond frontmost surface
- Fundamental property / limitation of vision

Exterior surfaces hide internal structure
- Normally we exploit this in computer graphics

Exploded views, cutaways, ghosting…

How it’s built / How it works / What it does
Topics

Framework for conveying structure
Choosing good views
Layering
Cutaways and sections
Exploded views

Framework
Framework for conveying structure

Goal: Expose important internal features

Requirements
- Internal features
- Viewpoint
- Blockers

Procedure
- Transform blockers so internal features visible

Internal Features

- Which internal features should be visible?
  - Presentation
    - Features support story
  - Exploration
    - Show all internal parts
    - All of the important features may not be known a priori

Lincoln’s assassination at Ford’s theater [Lorenz 88]
Viewpoint

Where is observer looking from?

Blockers

Blockers are the objects or surfaces that occlude internal features from the viewpoint.
Blocker transformation

Choose transformations that de-emphasizes blockers and emphasizes internal features?
- Cull
- Move
- Transparency
- Modify drawing style
- Rotate object (or transform viewpoint)

Visualization should clearly indicate transformation

Choosing Good Views
Generic vs. accidental views

**Generic:** A view of an object that does not change drastically under small changes in viewpoint

**Accidental:** A special view of an object for which small perturbations in viewpoint drastically change appearance

Accidental view

**Alignment of trash and sea**

[Turner]
Generic vs. accidental view

Which view is best? [Palmer, Rosch, Chase 81]

Rate views
**Canonical view** [Palmer, Rosch, Chase 81]

- Features must be salient
- Generic view
- Oblique view
  - Frontal view from above
  - ¾ up view

**Canonical Views** [Blanz, Tarr Bulthoff 99]
What is a good view?

Canonical views
- Oblique views from above
- Avoid accidental views

In our case – to reveal internal structure
- Separation of internal features in image plane

Viewpoint transformations

Sometimes a good viewpoint will expose features
- Street view does not show overall city plan
- Overhead view exposes more of the city plan
Layering

Transparency

Blocker completely transparent

Blocker semi-transparent

Location of battery in army radio [Feiner & Seligmann 92]
Transparency

MoMA design entry [Tschumi 99]

Ghosting

Army radio [Feiner & Seligmann 92]  Bus [Thomas www.jitechart.com]
Draw blockers as wireframes

Video camera [from Homes 93]

Airplane engine [from Holmes 93]

Dotted lines

Dotted lines expose hidden features
Leonardo Da Vinci circa 1490

Interrante – Siggraph 97

Blocker surface indicated via thin lines in direction of principal curvature
Cutaways and Sections

Cutaways

Blockers partially visible

Edges
- Raggedness emphasizes cut
- Contrast also adds emphasis
- Shape focuses attention
- Spatializes internal stuff

Manually operated reciprocating water pump [Agricola 1556]
Cutaways: Example

Midget submarine [from Holmes 93]

Cutaways: Example

Hubble repair [from Holmes 93]
Sections

Split along cutting surface
- Usually planar cut
- May not cut all objects in plane

Orientation
- Principal planes
- Symmetry planes
- Structural elements

Convey shape
- Shape of cutting surface
- Auxiliary view showing cut location
- Shape & material of cut volume
- Orthogonal view allows measurement

Architecture

Engine in a large building [Boulton & Watt]
Technical illustration

Two sections of engine

Showing cut location

[French & Vierck 60]
Shape of cutting surface

[French & Vierck 60]

Shape of cutting surface

Physical cutaway [CalCo www.calcocutaways.com]
Shape of blocking surface

Control room of Midget Submarine
[from Holmes 93]

Material of cut volume

Ear canal [from Mijksenaar 99]
Material of cut vol. 

[Image: A detailed drawing of a sectioned view of a geological structure, with text: "Material of cut vol." and "[French and Vierck 60]", and an image of a drilling rig and underground scene with text: "Extracting sulphur from deposits [from Herdeg 81]."

Synthesizing cut material

[Image: A diagram showing the process of synthesizing cut material, with steps labeled: "Cutting the model", "Control map", "Reference images", and "Textured cross-section" followed by the text: "Volumetric illustration [Owada 04]."]
Interactive Cutaway Illustrations of 3D Objects

Interactive Cutaway Illustrations of Complex 3D Objects. Wimot Li, Lincoln Ritter, Maneesh Agrawala, Brian Curless and David Salesin. SIGGRAF 2007
Illustration Conventions

Geometry-based conventions

Object-aligned box cut

Window cut

Wedge cut

Transverse tube cut
Viewpoint conventions

Insetting cuts
Shading conventions

Video Demo