Conveying Structure

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Last Time: Design Principles

Primary geometry
Description in 3D object-space
e.g. trace rays from object through image plane into they eye

Secondary geometry
Description in 2D image-space
e.g. true shape of front face, side faces recede to vanishing point, ...
Often better corresponds to drawing approach

Marginal distortions in perspective projection, Olmer [from Kubovy 03]
Combining two perspectives

Best Views
- Large display: billboard, mural
- Oblique viewing angle
- Wide range of viewpoints

Application: wall-sized displays

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

Apply Graph Cut
\[ C(L) = \sum \text{image objective} + \sum \text{seam objective} \]
Result

A Longer Street

Grocery store aisle

Cartographic Projections

Latitude-longitude projection

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

Mercator projection (equiangular)

Mercator projection
Circular craters map to circles

Sinusoidal equiareal projection

Summary

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

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

Announcements
**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: 3/14
- Project presentation: 4/4
- Final paper and presentation: 5/3

**Grading**
- Groups of up to 3 people, graded individually
- Clearly report responsibilities of each member

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**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

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

Generic vs. accidental view

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

Transparency

Blocker completely transparent
Blocker semi-transparent

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

Ghosting

Draw blockers as wireframes

Dotted lines

Leonardo Da Vinci circa 1490

Interrante – Siggraph 97
Cutaways and Sections

Cutaways: Example

Cutaways: Example

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

Shape of cutting surface

[French & Vierck 80]

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. [French and Vierck 60]

Synthesizing cut material

Exploded Views

Exploded views

Goal: Show overall structure
Direction
- Principal axes
- Sometimes zigzag to reduce occlusions
Distance
- Reduce / eliminate occlusions
Axonometric projection
- Reduces distortion
Guidelines
- When?
- Where?

Train [from Mijksenaar 99]

Principal Axes

Leonardo Da Vinci

Pivot hanger [French & Vierck 60] Manual steering gear [from Ferguson 92]

Ratchet device
Exploded view

Understanding 3D maps

Generating an exploded view

Generating an exploded view

Works with existing 3D applications

Future: Enhanced spectator mode

Real-world buildings

- Soda Hall model from Funkhouser, Séquin, Teller
- Generating an exploded view
- Quake III Arena by Id Software
- Intercept and modify OpenGL stream
  - Non-invasive (Mohr 01)
  - Apply to existing OpenGL application without modification
- Concept design for museum guide (Tufte 97)
- Locating landmarks fastest with axonometric view (Fontaine 01)
- 1. Geometric analysis - Find downward facing ceiling polygons
2. Place sectioning planes below ceilings
3. Multi-pass render each story separately
- Exploded view
- Axonometric View
- Mock-up design
- Floorplans
- Floorplans + Front View

Seattle Public Library [from Seattle Times 04]