Using Space Effectively: 3D

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CS 294-10: Visualization
Spring 2010

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: 3/29
- Initial problem presentation: 3/31
- Midpoint design discussion: TBD
- Final paper and presentation: TBD

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

Multi-dimensional Scatter plot

Variable 1, 2 → X, Y
Variable 3, 4, 5 → R, G, B

Do people interpret color blends as sums of variables?
**Color Weaves**

6 variables = 6 hues, which vary in brightness

Weaving versus Blending (APGV06 and SIGGRAPH poster)
Haleh Ragh-Shenas, Victoria Interrante, Christopher Healey and Sunghee Kim

**Controlling Value**

Get it right in black & white

Value
- Perceived lightness/darkness
- Controlling value primary rule for design

Value defines shape
- No edge without lightness difference
- No shading without lightness variation

Value difference (contrast)
- Defines legibility
- Controls attention
- Creates layering

Controls Legibility

<table>
<thead>
<tr>
<th>Color Usage</th>
<th>RGB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helvetica</td>
<td>0 127 127</td>
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Color usage.arc.nasa.gov
**Legibility**

- Drop Shadow
  - Drop shadow adds edge

**Readability**

- If you can't use color wisely, it is best to avoid it entirely
- Above all, do no harm

**Why does the logo work?**

Why does the logo work?

**Value Control**

Value Control
Legibility and Contrast

Legibility
- Function of contrast and spatial frequency
- "Psychophysics of Reading" Legge, et. al.

Legibility standards
- 5:1 contrast for legibility (ISO standard)
- 3:1 minimum legibility
- 10:1 recommended for small text

How do we specify contrast?
- Ratios of foreground to background luminance
- Different specifications for different patterns

Contrast and Layering

Value contrast creates layering

What Defines Layering?

Perceptual features
- Contrast (especially lightness)
- Color, shape and texture

Task and attention
- Attention affects perception

Display characteristics
- Brightness, contrast, "gamma"

Contrast

General formulation
- Luminance difference ($L_f - L_b$)
- Depends on adaptation and size

Small symbols, solid background (Weber)
- $C = (L_f - L_b)/L_b$
- Adapted to background

Textures, high frequency patterns (Michelson)
- $C = (L_f - L_b)/(L_f + L_b)$
- Adapted to average

Luminance is intensity modulated by wavelength sensitivity
Grid Example

Grid sits unobtrusively in the background  
Grid sits in foreground, obscuring map

Great Grids: How and Why? (APGV06 and SIGGRAPH poster)
Maureen Stone, Lyn Bartram and Diane Gromala

Additional Resources

My website
- http://www.stonesc.com/Via06
- Final copy of slides, references
A Field Guide to Digital Color
- A.K. Peters

Using Space Effectively: 3D

Topics

Linear projections
Non-linear projections
Cartographic projections
Primary geometry
Description in 3D object-space
e.g. trace rays from object through image plane into 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

Linear projections
Straight lines and alignments are preserved
Parallel
Perspective
Parallel projections

No vanishing points or foreshortening
Can represent some aspects of true shape
Can shrink or stretch lengths

Projection direction
- Orthogonal to image plane or not
- Along principal axes of object or not

Orthogonal
- Fold-out oblique
- Horizontal oblique
- Vertical oblique

Non orthogonal
- Oblique
- Axonometric

Orthographic
- Isometric
- Others
Orthogonal Direction

- Perpendicular to image plane
- Along one principal direction

True shape for faces parallel to image plane

Orthogonal Direction

- Perpendicular to image plane
- Along one principal direction

True shape for objects parallel to image plane

Typically engineering

Amphora, 6th century BC

Orthogonal Telephoto

As the hijack bargaining goes on under the sweltering sun...

Fig. 2.4. Newspaper photograph of a hijacked aircraft. Courtesy of Express Newspapers.
Orthogonal
Child drawing

Fold-out oblique
Horizontal oblique
Vertical oblique
Direction
45°, parallel to one principal face (top or side)

True shape for 2 faces with 45° projection rays
- Horizontal: Shrink/stretch top face at other angles
- Vertical: Shrink/stretch side face at other angles

Mainly interesting for secondary geometry

Horizontal oblique
Folk art
Horizontal oblique

Icons

Horizontal oblique

Child drawing

Vertical oblique

Soriguerola, 13th

Vertical oblique

Soriguerola, 13th
**Vertical oblique**

Juan Gris, *Breakfast*, 1914

**Non orthogonal**

Direction
- non orthogonal to picture plane

Oblique
- Picture plane parallel to front
- True shape for front face

Axonometric
- True shape for top face
- True length for up direction
- Direction 45° of the picture plane
**Oblique**

- Picture plane parallel to front
- True shape for front face
- Can use true length for 3rd direction

**Oblique**

- Henry Lapp, 19th century

**Oblique**

- Chinese paintings 12th century

**Axonometric**

- Like vertical oblique, but object turned 45° to picture plane
- True shape for top face
- True length for up direction
Axonometric
Le Corbusier was a big fan

James Stirling, 1953

Orthographic
Direction
- Orthogonal to picture plane
- Along no principal axes

Isometric
- Direction along the average of the principal axes
- True lengths along 3 axes

Others
- Generic orthographic
- Nothing preserved, rarely used

Isometric vs. axonometric
Isometric
- No true shape
- True lengths in 3 directions
- Less distortion

Axonometric
- True shape for top face
- True length for up direction
Isometric

Brooks-Greaves
St Paul’s Cathedral
1928

Isometric

Linear perspective
Foreshortening
The spectator is “immersed”

One point
Two points
Three points

Primary geometry
Trace rays from object, through image plane, into eye
1-point perspective

Central focus
Preserves horizontals and verticals

Jean Vredeman de Vries, 1604

Optical center is not always the center of the image
Requires view camera to adjust angle of film plane
2-point perspective
Objects stand out of the picture
Preserves verticals

3-point perspective
Dramatic 3D effect
The generic case, nothing preserved
Historically, seldom used in art or technical drawing

Perspective Distortion

Marginal distortions in perspective projection, Olmer [from Kubovy 03]
Perspective distortion

Wide angle projection
Does not preserve subjective size

Perspective distortion

Wide angle projection
Does not preserve subjective size

Perspective distortion

Wide angle projection
Distorts shape

Perspective distortion

Portrait: distortion with wide angle and telephoto

Wide angle  Standard  Telephoto
Perspective distortion

The sphere is projected as an ellipse
Symmetry is not preserved

Perspective distortion

The sphere is projected as an ellipse
Symmetry is not preserved

Perspective distortion

The sphere should be projected as an ellipse
But a circle is used

Non-Linear Projections
Fish-eye vs. wide angle

- Preserve verticals

Panorama

Curved perspective

Rotating lens panoramic camera
Perspective Projection

Cylindrical Projection

Spherical Projection

Perspective vs. Cylindrical/Spherical

<table>
<thead>
<tr>
<th>Perspective</th>
<th>Cylindrical / Spherical</th>
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<tbody>
<tr>
<td>Close to human perception</td>
<td>Straight lines → curved</td>
</tr>
<tr>
<td>Straight lines → straight</td>
<td>Feels flat</td>
</tr>
<tr>
<td>Wide angle distorted</td>
<td>Whole FOV possible</td>
</tr>
<tr>
<td>Best for narrow angles</td>
<td>Best for wide angles</td>
</tr>
</tbody>
</table>
HD View

http://research.microsoft.com/ivm/HDView/HDGigapixel.htm

Optimizing the Projection

Viewing Sphere
Linear Perspective Projection

Stereographic Projection

Cylindrical Projection
**Goal**

*Given a wide-angle image, produce a projection that preserves straight lines in the scene and the shapes of objects.*

**Our Approach**

1. Mesh the viewing sphere
2. Define mapping constraints
3. Optimize energy function
   - Conformality
   - Straight lines
   - Smoothness

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*Optimizing Content-Preserving Projections for Wide-Angle Images*

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