Conveying Shape: Shading, Lighting and Texture

Maneesh Agrawala

CS 294-10: Visualization
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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 (Wed)
- Final presentation: in class 4/26 and 4/28
- Final paper: Friday 5/7

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

Conveying shape

Lines
Shading

From Gooch²

Topics

Shading
Shape from shading
Lighting
Texture
Shading

Diffuse shading [Gooch et al. 99]

- Dark regions hide details
- Gray silhouettes merge with background
- Surface orientation not emphasized

Edges + highlights

- Edge lines divide object into parts
- Highlights convey light direction and curvature
- Can’t see some regions of high curvature

Edges + highlights + diffuse + ambient

- Some details lost in dark gray regions, but can see curvature better in claws
Constant luminance tone rendering

Cool colors (blue green) recede, warm colors (red, orange) approach
Hue shift conveys subtle sense of depth

Luminance and hue/tone

Shifting luminance and hue/tone gives stronger sense of depth

Anisotropic metallic objects
Metallic shading

Phong  Metal  Metal+Edges  Metal+Tone

Reflection lines

From Farin and Harnsford

Photo-retouching

Fig. 12.18  Photo before retouching. (North American Aviation, Inc.)

T. A. Thomas, Technical Illustration

Photo-retouching

Fig. 12.19  Photo after retouching. (North American Aviation, Inc.)

T. A. Thomas, Technical Illustration
Shape from Shading

V.S. Ramachandran

Spheres or cavities?

Brain assumes light comes from above

Separating convex/concave is very fast – preattentive?
Separating convex/concave is very fast – preattentive?

Effect diminishes at 90° rotation

More difficult to separate convex/concave
Rotation of head l/r set preference for light direction l/r
- Preference based on retinal orientation, not vestibular orientation
- Shape from shading is relatively early in visual system

Spheres or cavities

Common fate: All are convex or all are concave
Single light source constraint

Difficult to see all objects as convex or as concave
When one row is convex the other row is always concave
Brain only accepts 1 light source for entire image

Effect diminishes without gradients

Illusory contours and gradients

Edges interact with interpretation of shape from shading
Partial occlusion stronger evidence for existence of object than mere outline
Background brightness & color

Change in background brightness
Change in background hue, brightness constant

Effect strong when edge defined by change in brightness
Diminishes when change is due to hue, not brightness

Complex shape seen as convex
Complex shape seen as convex

Boundary occlusions reinforce convex interpretation
Disks interpreted with respect to lighting of tube

Hollow masks lit from above

Mask lit from right side

http://www.ubin.tuebingen.mpg.de/segm/masks/index.html

Single light source and pointing

A. Single light source so all seen in same way
B. Inconsistent lighting, but all seen in same way due to pointing
C. Single light source so we can see mask
D. Inconsistent lighting, no pointing so difficult to interpret 3D shape - seen as 2D
Symmetry

Horizontal shape symmetry
Horizontal shading symmetry

Shape from shading extracted before symmetry

Estimating orientation

Subject place gauge figures on photo so that ellipse appears to lie flat
Results from one subject averaged over several sessions
Integrate normals to get surfaces (i.e. depth estimates)

From Koenderink, van Doorn, Kappers (1992, 1996)

Results of estimating orientation

Little variability between subjects estimates of surface orientation
Variability independent of subjects familiarity with object
Subjects use global information over significant portion of object surface

From Koenderink, van Doorn, Kappers (1992, 1996)
Lighting

Categories of light
- Single source light
- Double source light
- Flat, diffused light
- Moonlight
- Sculptural light

B. Hogarth. Dynamic Light and Shade

Goals of lighting

Power of lighting
- Show form and orientation of surface
- Emphasize high curvature with highlights
- Show silhouette clearly
- Separate object from background
- Rake bumps and surface textural details

Unintended side effects
- Over- and under-exposure
- Unintended shadows
- Distracting highlights and glare

Lighting design

**Lighting design**

Multiblitz lighting system, RTS Inc.

Basic Portrait Lighting Set-Up Guide, Warehouse Photography

**Highlights and Shadows**

Remove distracting highlights and shadows

**Creases, Ridges and Valleys**

[Imhof 83]

Sharp dark/light transitions to emphasize boundaries [www.shadedrelief.com]

**Silhouettes**

[From Hodges 89]

Constrains shape of surface ➔ important shape cue
Increase contrast at silhouettes to emphasize shape
Photomontage composite

Input images from Debevec

Interactive Digital Photomontage [Agarwala 04]

Multiple Scales

Blend between depictions at multiple scales [www.shadedrelief.com]
Multiscale bilateral decomposition

Differences between successive levels

Detail reconstruction + base image
Artists often creating shading studies a sphere
Shows shading for all visible surface orientations
Then adapt shading to complex surface

Applying idea to 3D models
After drawing sphere by hand, can look up surface color based on normal to render 3D model
Texture

Visual cues

SGI flight 1987
GE Apollo Simulator 1963

Texturing

Lines in one direction of principal curvature

Diffuse shading only

From V. Interrante
http://www-users.cs.umn.edu/~interran/texture/index.html

Texturing

Diffuse shading only
Lines in one direction of principal curvature generated using line integral convolution (LIC)

From V. Interrante
http://www-users.cs.umn.edu/~interran/texture/index.html
Texturing

From V. Interrante
http://www-users.cs.umn.edu/~interran/texture/index.html

Texturing results

Gauge figure studies
Significant main effect of texture type \( p=0.0002843 \)

From V. Interrante
http://www-users.cs.umn.edu/~interran/texture/index.html

Summary

Goals of lighting and shading
- Reveal shape
- Separate foreground from background
- Show surface detail

Lighting design is extremely challenging
Surface-oriented texture is powerful cue