

CPSC 532E — Week 6: Lecture

Surface Perception; Completion

- Reflectance functions
- Shape from shading; shape from texture
- Visual Completion
- Figure/Ground

ACM Transactions on Applied Perception - Call for papers

Numerous breakthroughs in computer science have come out of the assimilation of results from other disciplines. Recently, there has been an increasing appreciation of the gains that can be made through the application of findings from the field of experimental psychology.

The purpose of ACM Transactions on Applied Perception is to further the development of inter-disciplinary research that crosses the boundaries between perception and computer science disciplines such as graphics, vision, acoustics and haptics...

Visual:

- ~ perceptually based techniques in computer graphics,
- ~ scientific/data/information visualization,
- ~ digital imaging and computer vision.

1. Reflectance Functions

Colour is a surface property

- structure at the molecular level (nanometers - 10^{-9} m)

Texture is a surface property

- structure at the macroscopic level (millimeters - 10^{-3} m)
(variations in surface orientation; colour patches)

Other surface properties also exist

- “microstructure” level (micrometers - 10^{-6} m)
(variations in surface roughness,
alignment of surface elements, etc.)

CPSC 532E

3

For example,

Isotropic surface properties:

- gloss
- silver
- “plastic” appearance

Nonisotropic surface properties: iridescence

- e.g. oil films, insect wings, clouds
- formed via diffraction of light

These are described in terms of a

bidirectional reflectance distribution function (BRDF).

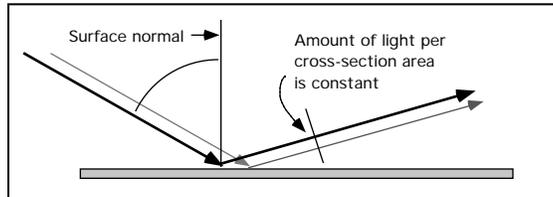
This describes how outgoing light is related to incoming light.

CPSC 532E

4

BRDFs can have many forms:

Lambertian: light is scattered equally in all directions
- light in incoming beam has equal distribution
at all outgoing angles

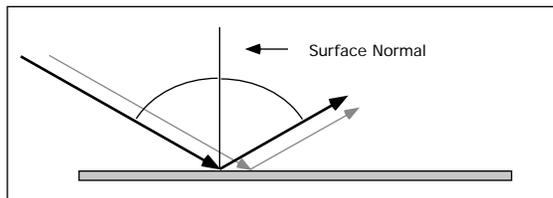


- luminance doesn't depend on viewer angle
- does depend on incoming angle $I = k \cos$
- matte surfaces
- most common surface model

CPSC 532E

5

Specular: light from incoming beam at angle
is reflected as outgoing beam at angle



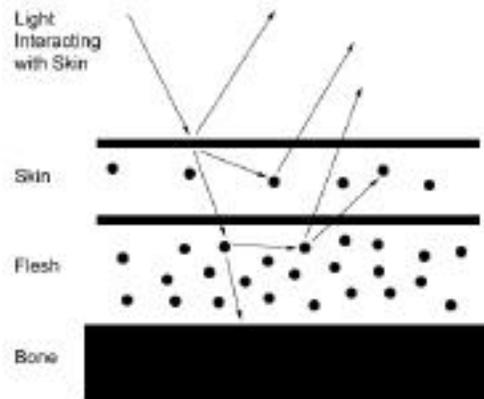
- luminance does depend on viewer angle
- luminance seen only when
angle from source to surface
= angle from surface to viewer
- useful for revealing small imperfections (scratches)

CPSC 532E

6

Volume interactions: translucence (e.g. marble, milk)
- formed via partial penetration of light into material

e.g. skin



CPSC 532E

7

Translucence can be an important part of surface appearance...



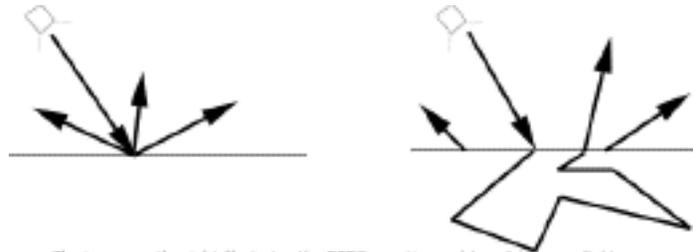
Translucence absent

Translucence present

CPSC 532E

8

Translucence is described by a
**bidirectional surface scattering reflectance
distribution function (BSSRDF).**



The image on the right illustrates the BRDF equation and how it bounces light rays off of a material. The image on the left illustrates the BSSRDF equation and how it scatters light.

These properties have the potential of providing

- more realistic rendering of objects, materials, etc
- more dimensions for region boundaries
- more dimensions for region identification (labels)

Relatively little is known about the psychological mechanisms involved

-> potentially interesting research area

2. Shape from Shading; Shape from Texture

Surface properties (at least luminance & texture) have the ability to support the perception of **depth**

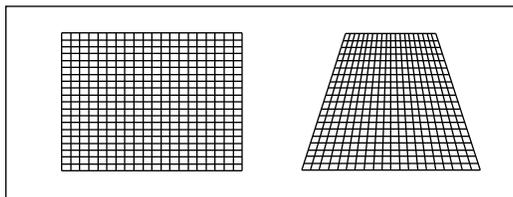
Shape from Shading

- Assume surface reflectance is Lambertian,
 $I = k \cos$
(β is angle of surface to incoming light)
- Can get changes in orientation of local surface patch via changes in local intensity

Shape from Texture

- Assume surface statistics (e.g. average size and shape of texture element, average spacing) is constant.
- Can get changes in orientation of local surface patch via changes in local surface statistics (texture gradient)

Note: Because the 3D orientation is factored out,
the texture pattern that is perceived is
that of the world, and not of the image
-> inhomogeneities due to perspective
are not easily noticed

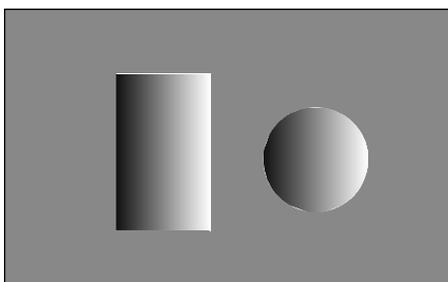


CPSC 532E

13

Surface properties & Surrounding Contour

- Recovery of 3D slant requires interaction
with surrounding contour
- > Perceived surface can depend greatly
on the shape of the surrounding contour

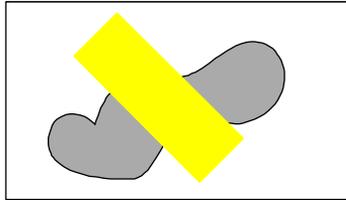


CPSC 532E

14

3. Visual Completion

Surfaces at different depths can occlude each other
- can use occlusion for estimating depth order

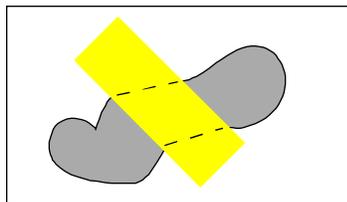


Need to “undo” the effects of occlusion somehow
- vision is concerned with the structure of the world, not with the pattern of light on the retina

CPSC 532E

15

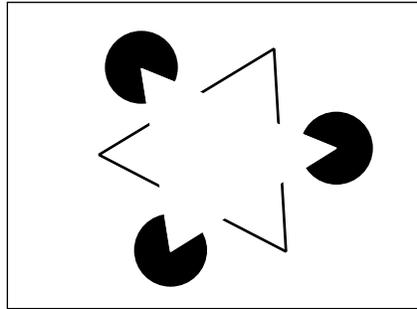
To determine the structure of objects in the world:



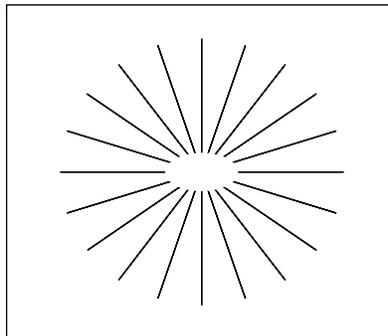
- i) need to determine which patches in image belong together
- ii) need to determine the original (unoccluded) shape of the object

Two important types of completion:

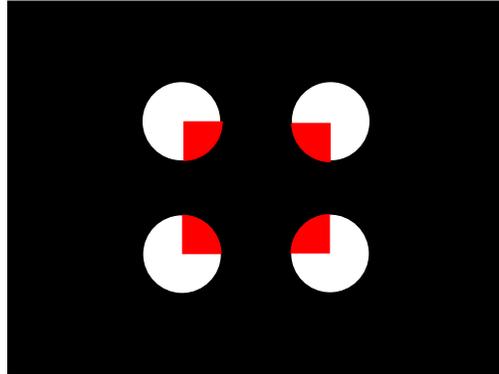
i) modal completion: completion of pieces is accompanied by modal (=visual) experience of edges & surfaces



Illusory contours often result
- these are edges of an inferred occluder



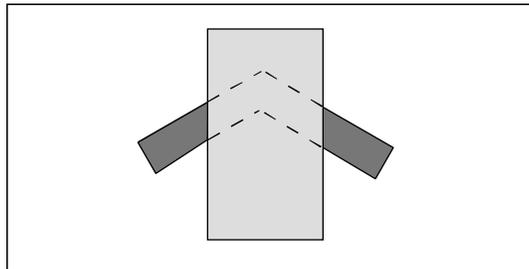
Neon effects are also possible by attributing a non-background color to the inferred occluder



CPSC 532E

19

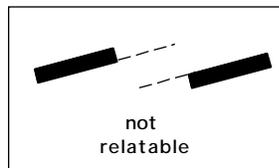
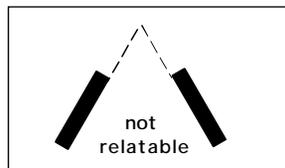
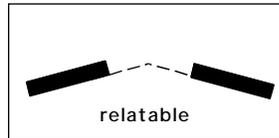
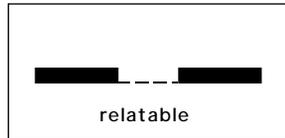
ii) amodal completion: completion of pieces accompanied by amodal (= nonvisual) experience



- don't visually experience the completed part
- do "perceive" that the parts are linked

In both cases, surface fragments are linked if their edges are **reliable**:

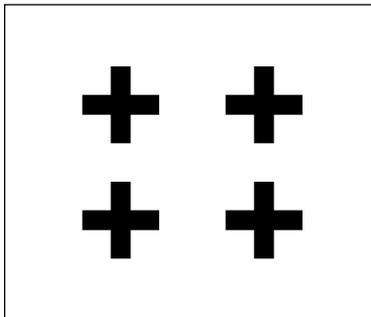
- if intersections intersect at an angle 90°



CPSC 532E

21

Note that this won't always work:



Here, notches belong to the figure itself, and not some other (occluding) figure

CPSC 532E

22

Problem:

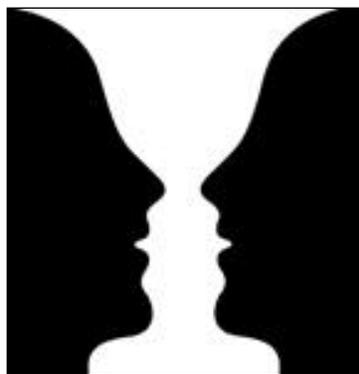
How to determine which figure an edge belongs to?

-> The problem of **border ownership**

CPSC 532E

23

4. Figure / Ground



The edge between black and white “belongs” to the figure

CPSC 532E

24

The ownership of a border can determine whether and edge helps or hinders pattern recognition

