computational color

How ~~computer~~ vision sees color ~~etc~~

What we can learn about physical world, i.e. illuminants & surfaces from ~~[illegible]~~ sensor data?

color constancy ~~[illegible]~~

How does humans so successfully discount the illuminant in the world around them?

color appearance

How can we predict the impact of surround and adaptation on the human viewer's perception of the appearance of colors?

Hsien Lee book

B.A. Wandell, Foundations of Vision

- only text covering computational color issues
- bit low-level

Last class:

introduced low dimensional linear models for reflectance & illuminant

example:

If illuminant is known & surface is adequately modeled by a 3-D model (i.e 3 basis functions), can recover surface reflectance from a single trichromatic measurement

Interaction of light & materials

So far: focussed completely on

Spectral representation

$$S(\lambda) = R(\lambda)\, I(\lambda)$$

stimulus — surface reflectance — illuminant

does not account in detail for:

- material properties
- surface geometry

Physics-based reflection models

Glenn Healey U.C. Irvine

Schafer, CMU (Microsoft now)

About the authors (1/2)

Steve Shafer · 2nd

Senior Software Developer at Talyst

Seattle, Washington, United States ·

Contact info

Swisslog Healthcare

Carnegie Mellon University

About the authors (2/2)

Glenn Healey

Professor
Electrical Engineering and Computer Science

Location:
4434 Engineering Hall

Email:
ghealey@uci.edu

Phone:
(949) 824-7104

Fax:
(949) 824-2321

Address:
Samueli School of Engineering
University of California, Irvine
Irvine, CA 92697

ZOT Code:
2625

Consider non-homogeneous, dielectric materials

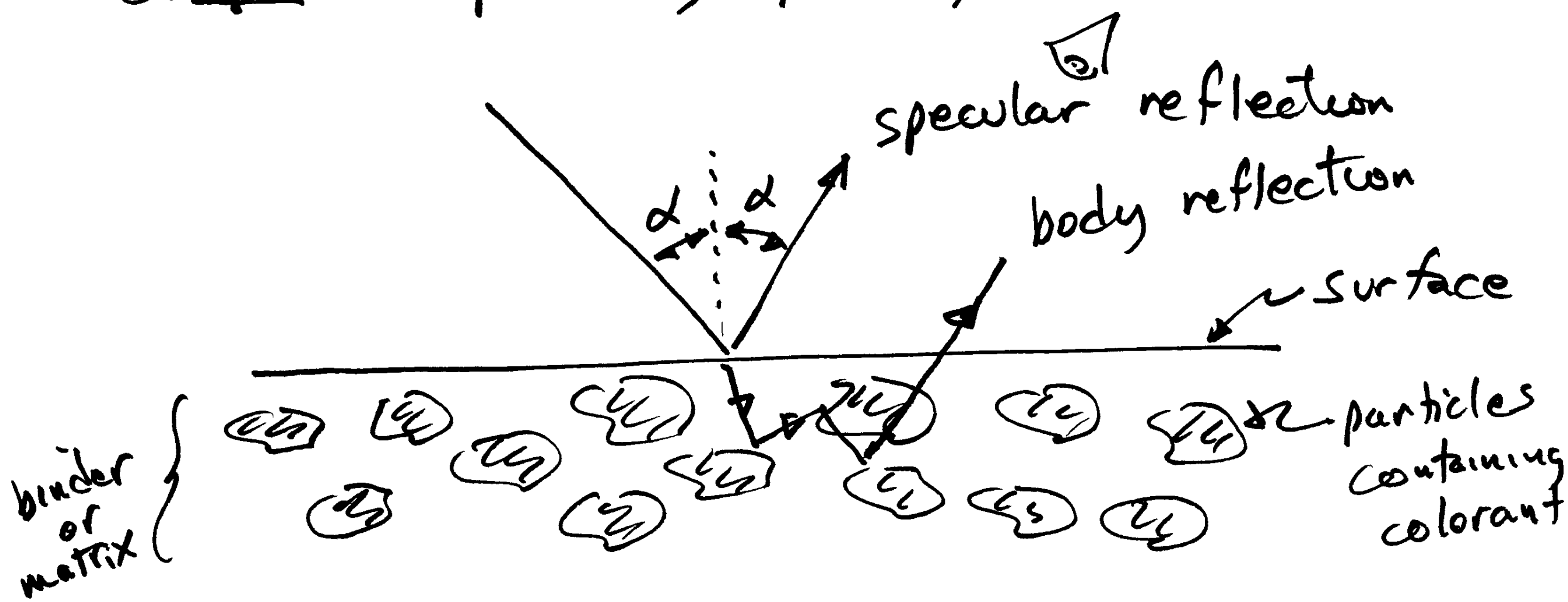
non-homogeneous

dispersion of colorant particles in a matrix (binder)

dielectric

non-conducting

examples plastics, paint, wood, stone



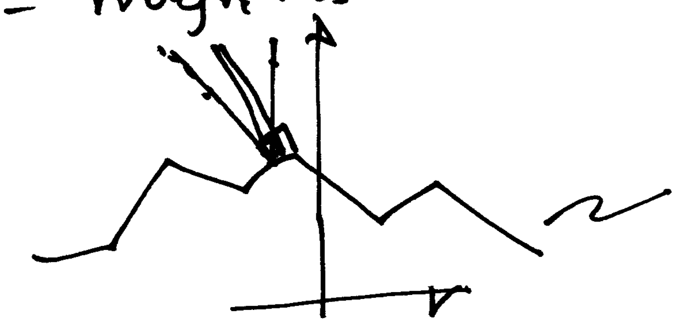
General model

$$S^{p}(\lambda) = S_S(g_p, \lambda) + S_B(g_p, \lambda)$$

p - spatial position coordinates (x, y)

g_p - vector describing geometry of reflection at point p

- angle of incidence
- angle of exitance (reflection)
- micro surface geometry
- roughness



Note that this is related to the bidirectional reflectance function (BRDF) and ties in with the concept of surface appearance, which is currently an active research area, i.e. 2.5D and 3D printing!!

g_ρ - summarizes all structural & geometric factors in the reflectance model

λ - wavelength

S_s - surface reflection

S_b - body reflection

physics:

surface reflection — Fresnel equations

body reflection — Kubelka - Monk equations

Patrick Emmel

general model

$$S^P(\lambda) = S_S(g_p, \lambda) + S_B(g_p, \lambda)$$

Healey's simplification

Geometric factors defining interaction of light & surface are not wavelength dependent

Thus:

$$S_S(g_p, \lambda) = m_S(g_p)\, S_S(\lambda)$$

$$S_B(g_p, \lambda) = \underbrace{m_B(g_p)}_{\text{geometry}}\, \underbrace{S_B(\lambda)}_{\text{wavelength-dependence}}$$

then

$$\underline{\underline{S^P(\lambda)}} = m_S(g_p)\, \underline{\underline{S_S(\lambda)}} + m_B(g_p)\, \underline{\underline{S_B(\lambda)}}$$

Response of a trichromatic sensor under Healey's simplification

$$\underbrace{R}_{\text{sensor response}} = \int q_R(\lambda)\, S^P(\lambda)\, d\lambda$$

$$= m_S(g_P) \underbrace{\int q_R(\lambda)\, S_S(\lambda)\, d\lambda}_{R_S} + m_B(g_P) \underbrace{\int q_R(\lambda)\, S_B(\lambda)\, d\lambda}_{R_B}$$

repeat for G, B channels of sensor

$$\begin{pmatrix} R \\ G \\ B \end{pmatrix} = m_S(g_P) \underbrace{\begin{pmatrix} R_S \\ G_S \\ B_S \end{pmatrix}}_{\text{surface color}} + m_B(g_P) \underbrace{\begin{pmatrix} R_B \\ G_B \\ B_B \end{pmatrix}}_{\text{body color}}$$

blue

body

Model for specular component

$\underline{S_s(\lambda)}$ - surface $\underline{\text{reflectance}}$

$\underline{\text{recall}}$ $\quad \underset{\substack{\uparrow \\ \text{stimulus} \\ \text{seen} \\ \text{by} \\ \text{sensor}}}{I(\lambda)} = \underset{\substack{\uparrow \\ \text{illuminant}}}{E(\lambda)} \cdot \underset{\substack{\uparrow \\ \text{reflectance} \\ \text{surface}}}{S_s(\lambda)}$

If $I(\lambda) \equiv E(\lambda)$, must have

$S_s(\lambda) \approx \gamma$ independent of wavelength

$$\begin{pmatrix} R_S \\ G_S \\ B_S \end{pmatrix} = \gamma \begin{pmatrix} R_E \\ G_E \\ B_E \end{pmatrix}$$

"color" or ~~chromatic~~ tristimulus vector for illuminant