CS 332 Visual Processing in Computer and Biological Vision Systems

Analysis of Color

CS332 Visual Processing
Department of Computer Science
Wellesley College

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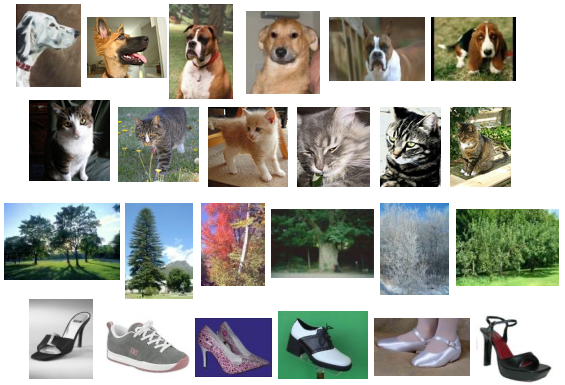
Content-based image retrieval



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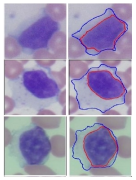
Applications of color image segmentation






medicine,
surveillance,
inspection,
recognition, …



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Color constancy




Color of a surface looks (roughly) the same under different illuminations…

… although colors can be influenced by context

http://www.echalk.co.uk/amusements/OpticalIllusions/illusions.htm

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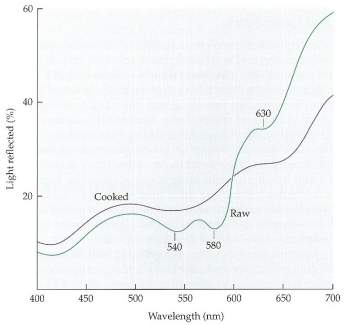
Surface reflectance



Surface reflectance varies with position and wavelength

$R(x, y, \lambda)$

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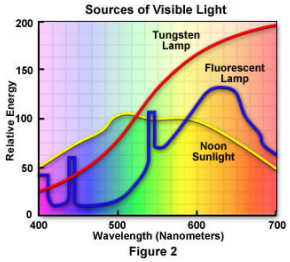
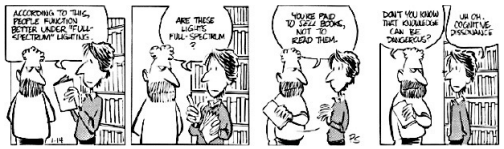
Illumination



Even with uniform scene illumination, cast shadows and reflection of light from other surfaces creates spatially non-uniform surface illumination

$E(x, y, \lambda)$



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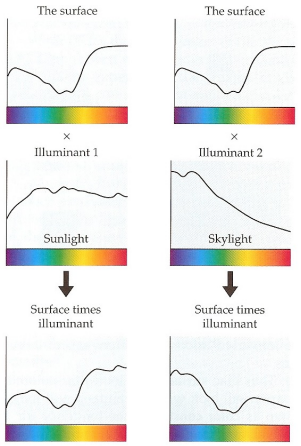
Surface reflectance meets illuminant



$R(x, y, \lambda)$

$E(x, y, \lambda)$

$L(x, y, \lambda) =$

$E(x, y, \lambda) * R(x, y, \lambda)$

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"The Dress" – what color is it?

white-gold? (30%) ??? blue-black? (57%)

Lafer-Sousa, Hermann, Conway (2015)

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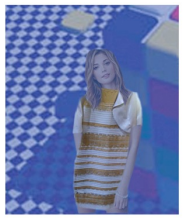
It depends on the illuminant...

cool illuminant (blue sky)



more likely to see white/gold

warm illuminant (incandescent)

more likely to see blue/black

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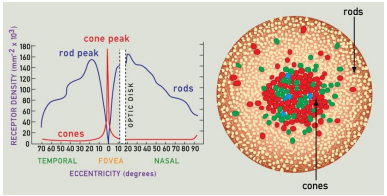
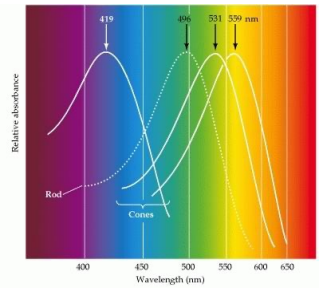
Measuring color by retinal cones



Absorption spectra for S (short), M (medium), L (long) wavelength cones



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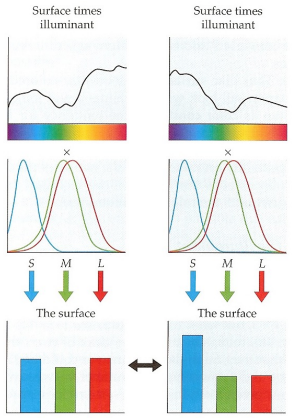
Luminance meets the cones



$L(x, y, \lambda)$

$S(\lambda)$ $M(\lambda)$ $L(\lambda)$

$$I_S(x, y) = \int L(x, y, \lambda) S(\lambda) d\lambda$$

$$I_M(x, y) = \int L(x, y, \lambda) M(\lambda) d\lambda$$

$$I_L(x, y) = \int L(x, y, \lambda) L(\lambda) d\lambda$$

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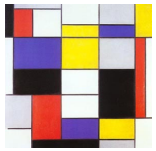
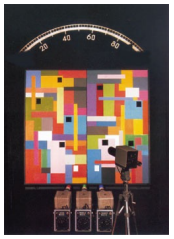
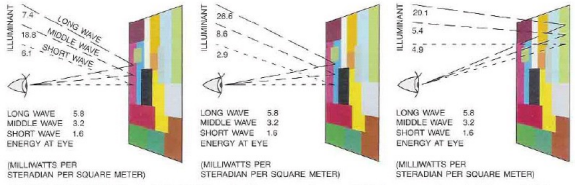
Land's color "Mondrian" experiments

Edwin Land



Piet Mondrian
Composition A, 1923





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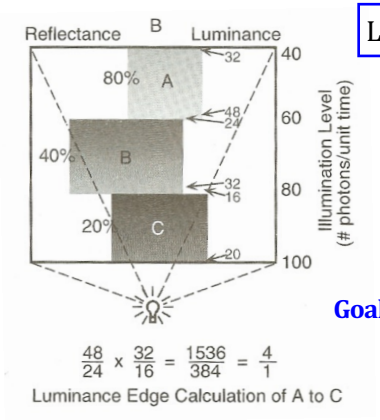
Land's Retinex theory*



$L(x, y) = E(x, y) * R(x, y)$

L(x, y): luminance

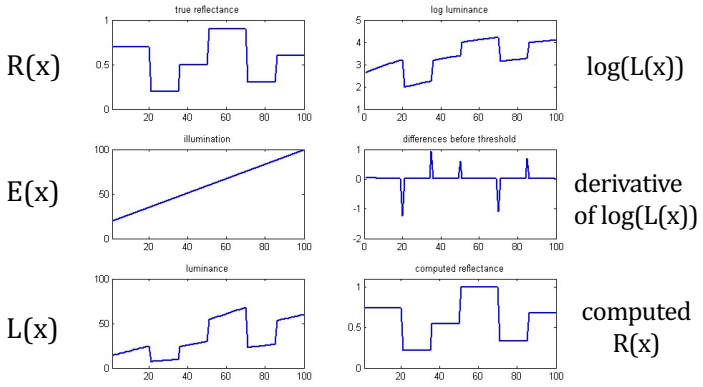
E(x, y): illuminant

R(x, y): surface reflectance

Goal: recover surface reflectance

* ignore color for now…

Land's Retinex theory (1D)



Retinex theory for 2D color analysis

2D extensions:

- Land & McCann: multiple 1D paths
- Horn: 2D analysis based on Laplacian $\nabla^2 L$
- Jobson, Rahman & Woodell: applied to image enhancement

Color:

- Perform same analysis for $I_S(x, y)$, $I_M(x, y)$, $I_L(x, y)$
- Triplet of values $R_S(x, y)$, $R_M(x, y)$, $R_L(x, y) \Rightarrow$ color

Restrictions (Assumptions):

- Reflectance changes abruptly, illumination changes slowly
- Matte (Lambertian) reflectance characteristics

Image enhancement, Retinex style

Robson, Rahman & Woodell
Morel, Petro & Sbert